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PRELIMINARY INVENTORY AND GENERAL ASPECT OF THE DISTRIBUTION OF CULICIDAE SPECIES IN THE STEPPE REGION (M'SILA, ALGERIA)

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ABSTRACT

Mosquitoes are important living organisms that participate in the different levels of food chains. However, many families include vector species capable to transmit viruses, bacteria and parasites to both humans and animals, threatening the public health. The goal of this work was to describe the biological diversity of mosquito species in different areas in M'sila; Algeria based on the ecological nature of their habitat. The breeding sites found were 18 distributed in five areas (Berhoum, Bou Saâda, El hamel, Hammam Dhalaa and M'sila). The inventory that was carried out from September to April every year from 2017 to 2019 has revealed 14 species of Culicidae distributed through three genera. The *Culiseta longiareolata* species was the most predominant, occupying different types of permanent and temporary breeding sites. However, the distribution of species based on the ecological types of these sites revealed: *Anopheles cinereus*, *Anopheles sergentii*, *Culex brumpti*, *Culex deserticola*, *Culex hortensis*, *Culex impudicus*, *Culex laticinctus*, *Culex martinii*, *Culex modestus*, *Culex perexiguus*, *Culex pipiens*, *Culex theileri* and *Culiseta longiareolata* species presence. The study of mosquito populations in the M'sila region has never been approached ecologically, biologically and systematically. Focus of this study was devoted to the systematics of Culicidae species, as well as the characterization of their structure, using ecological parameters as well as the study of Spatio-temporal variations, of the Culicidae population.

Keywords: Inventory, Culicidae, breeding sites, biological diversity, Algeria.

INTRODUCTION

Insects are beneficial and important living organisms that participate in the different levels of food chains whether as prey, predators, scavengers or decomposers. However, many insect families include vector species capable to transmit viruses, bacteria and parasites to both humans and animals, threatening the public health. The family Culicidae (mosquitoes) is one of the most important and largest insect families, and it includes

a group of the most competent vector species (Nabti, 2020).

Culicidae are insects of the order Diptera, a suborder of the Nematocera. They constitute the largest group of vectors of pathogens transmissible to humans and animals, more than 3500 species described to date (Harbach, 2007). They live on almost all continents and habitats and perform important functions in many concentrates (Fang, 2010). Since mosquitoes are quite dangerous and are responsible for both direct and indirect damage, their fight has

always been the subject of scientific studies. (Noreen et al., 2017)

In Algeria, 50 Culicidae species from 6 different genera are grouped in the subfamilies of Anophelinae and Culicinae (Hassaine, 2002). Much work has been carried out on mosquito biodiversity in many regions of Algeria (Berrezig, 2007; Aouati, 2009 and Tahraoui, 2010). It include the region of El-Kala, (Aïssaoui, 2014) in the region of Tébessa northeast of Algeria, (Hamaidia & Berchi, 2018) Souk-Ahras, (Boukraa et al., 2013) the region of M'Zab Ghardaïa, Algeria, (Merabti et al., 2017) the region of Biskra (Benhissen et al., 2018) the region of Bou Saâda, M'sila, Algeria.

The study of mosquito populations in the M'sila region has never been approached ecologically, biologically and systematically. Our present study was devoted to the systematics of Culicidae species, as well as to the characterization of the structure of the mosquito population using ecological parameters as well as the study of Spatio-temporal variations, of the Culicidae population.

MATERIAL AND METHODS

Study Area

The Wilaya of M'Sila is located in south-east of Algiers at 248 km; limited to the north: Bouira, Bordj Bou-Arreridj and Sétif, to the East by Batna and Biskra, to the West by Djelfa and Médéa and the South by Djelfa and Biskra (Figure 1). From a geographical point of view; it is bounded on the North by the Hodna mountains, on the East by the Belzma mountains, on the West by the Ouled Naiel mountains and the South by the Zibane mountains.

The M'Sila region is located in latitude 35°40' N and longitude 04 °30' E, at an altitude of approximately 500 m (Alayat, 2011).

Study Stations

We chose 18 breeding site in the five stations (Berhoum, Bou Saâda, El Hamel, Hamma Dhlaa and M'sila).The choice depends on the location, the presence of potential larval sites and diversity of environments (Table 1).



Figure 1: M'sila geographic location map.

Table 1: Natural characteristics of the 18 breeding sites from the five study stations, M'sila.

BS	Alt (m)	Lat (N)	Long (E)	Environment	BSN	NBS	Water
Ber ₁	572	35°38'39''	5°01'31''	Rural	Valley	Permanent	R/W
Ber ₂	698	35°48'46''	4° 59'44''	Urban	Basin	Temporary	T
Ber ₃	642	35°39'22''	5° 01' 31''	Urban	Basin	Temporary	T
Ber ₄	642	35°39'22''	5°01' 32''	Urban	Basin	Temporary	T
Ber ₅	642	35°39'22''	5°01' 32''	Urban	Basin	Temporary	T
Bou ₁	566	35°12'4''	4°11'7''	Rural	Valley	Permanent	R/W
Bou ₂	843	35°08'5''	4°04'36''	Rural	Valley	Permanent	R/W
Bou ₃	512	35°13'22''	4°16'40''	Rural	Valley	Permanent	R/W
Bou ₄	704	35°08'5''	4°16'5''	Rural	Valley	Permanent	R/W
Bou ₅	779	35°07'57''	4°05'22''	Rural	Valley	Permanent	R/W
Bou ₆	562	35°13'3''	4°11'12''	Agricultural	Basin	Temporary	T
Bou ₇	1083	35°07'57''	4°05'57''	Urban	Basin	Temporary	T
Elh ₁	802	35°09' 22"	4°06' 37''	Rural	Valley	Permanent	R/W
Elh ₂	795	35°08' 57"	4° 05' 56''	Urban	Basin	Temporary	T
Hd ₁	1100	4°22'06"	35°56'33''	Urban	Basin	Temporary	T
Hd ₂	1225	4°23'57"	35°59'29''	Rural	Valley	Permanent	R/W
Hd ₃	945	35°59'44"	4°13'19''	Agricultural	Basin	Temporary	T
Hd ₄	945	35°59'45"	4°13'19''	Agricultural	Basin	Temporary	T
M ₁	486	35°43'11"	4°29'40''	Rural	Valley	Permanent	R/W
M ₂	397	35°25'20''	4°20'34''	Rural	Valley	Permanent	R/W
M ₃	494	35°41'13''	4°13'31''	Urbain	Basin	Temporary	T

BS: breeding site, Alt: altitude, Lat: latitude, Long: longitude, BSN: breeding site nature, NBS: nature of breeding site, R: rainwater, W: waste water, T: tap water.
 Ber :Berhoum ,Bou :Bou Saâda,Elh :El hamel,Hd : Hammam Dhalaa, M:M'sila.

Biological Model

The Culicidae or mosquitos are part of the order of the Diptera and the Suborder of Nematocera according to (Seguy, 1951) the mosquitoes are distinguished from the other Nematoceras by their long horn and the presence of scales on the wing veins. Their life cycle is represented by pre-imaginary aquatic stages, which begin with eggs, larvae, nymphs and an adult aerial stage characterized by a clear dimorphism (Bendali-Saoudi, 2006).

Sampling Technique

The Culicidae sampling was carried out using a ladle with a capacity of 500 milliliters; the latter is immersed in water and then moved in a uniform movement avoiding "Dipping". Sorting of the specimens was done in the laboratory and then kept for routine use (Bendali-Saoudi, 1998).

Conservation Technique

Only larvae having reached the fourth stage of Culicidae are reliably identified. The larvae once dead, are kept in alcohol 60 % to 70 %. The tubes are labeled with the location and date of sampling. On the other hand, the nymphs will be raised until the emergence, to confirm the identification of the species on the imago (Bendali-Saoudi, 2006).

Culicidae Identification Key

The generic and specific diagnosis requires the careful observation of the entire body of the larva, the pupa and the adult and particularly the morphological characters of the body of taxonomic importance, which are to be examined. The systematics of Culicidae has been carried out mainly using computer software (Schaffner et al., 2001) and dichotomous keys, that of Himmi et al., 1995.

Ecological Index and Statistical Treatment of the Data

The ecological indices that hold our attention for the exploitation of our results are the quality of the sampling, the total and average wealth (Blondel, 1975), the relative frequency or abundance (Dajoz, 1971), the Shannon & Weaver index (Dajet, 1976), and the equidispensing index (Ramade, 1984).

Concerning the statistical treatment, we used the principal component analysis (FCA) the statistical analyses were carried out using IBM SPSS software.

RESULTS

The Abundance of the Culicidae Species

The collect of 15352 individuals between 2017 and 2020 from the 18 breeding sites revealed 14 species belong to three genera (*Culiseta*, *Culex* and *Anopheles*).

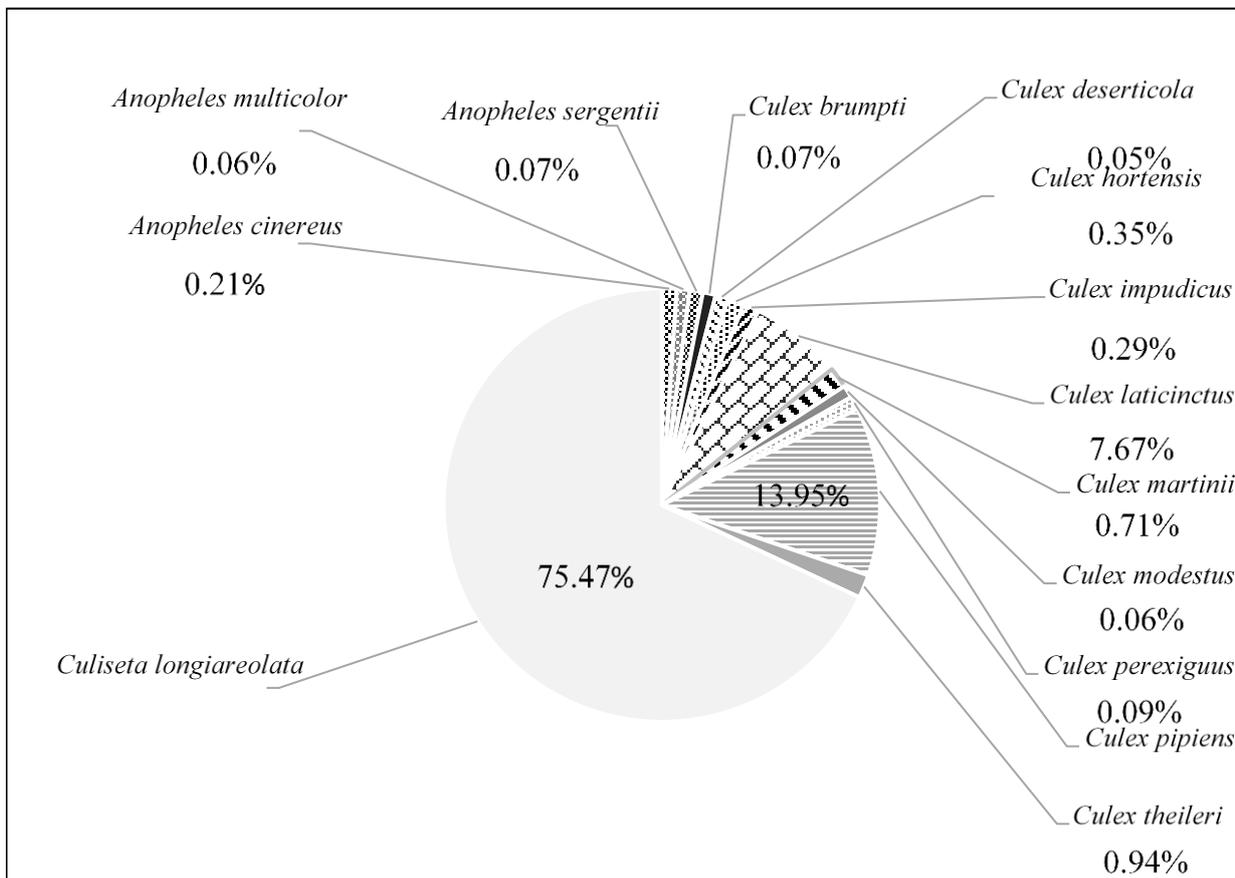


Figure 2: The percentage frequency of species of mosquitoes caught in M'sila region Algeria.

Culiseta longiareolata (Macquart, 1838) was found to be the most abandoning species with 11587 individuals with a frequency of 75.47 %, followed by species *Culex pipiens* (Linné, 1758) and *Culex laticinctus* (Edwards, 1913) with a frequency of 13.95 % and 7.67 % respectively (Figure 2).

However, the other species effective was below 1% *Culex deserticola* (Kirkpatrick, 1924) with 8 individuals *Culex modestus* (Ficalbi, 1889) and *Anopheles multicolor* (Cambouliu, 1902) 9 individuals, *Culex brumpti* (Galliard, 1931) and *Anopheles sergentii* (Theobald, 1907) with 11 and 10 individuals, *Culex perexiguus* (Theobald, 1903) 14 , *Anopheles cinereus* (Theobald, 1901) 32, *Culex impudicus* (Ficalbi, 1890) 45, *Culex hortensis* (Ficalbi, 1889) 54, *Culex martini* (Medschid, 1930) 109 and *Culex theileri* (Theobald, 1903) 145 individuals (Figure 2).

The Ecological Analysis of the Culicidae Species

The comparison between the species richness revealed that the richest site is Bou Saâda with ten species followed by M'sila with nine species then Hamma Dhalaa and El Hamel with six species for each site finally Berhoum with two species (Figure 3).

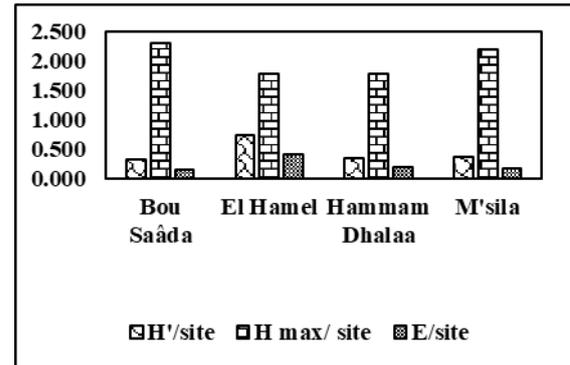


Figure 3: Ecological indices of structure of the species of Culicidae collected in M'sila region (2017-2019).

Table 2: The spatial distribution of the inventoried Culicidae species in M'sila region (2017-2020).

All the collected species	Berhoum	Bou Saâda	El Hamel	Hammam Dhalaa	M'sila
<i>Anopheles cinereus</i>					
<i>Anopheles multicolor</i>					
<i>Anopheles sergentii</i>					
<i>Culex brumpti</i>					
<i>Culex deserticola</i>					
<i>Culex hortensis</i>					
<i>Culex impudicus</i>					
<i>Culex laticinctus</i>					
<i>Culex martinii</i>					
<i>Culex modestus</i>					
<i>Culex perexiguus</i>					
<i>Culex pipiens</i>					
<i>Culex theileri</i>					
<i>Culiseta longiareolata</i>					

■ Present □ Absent

To express the diversity we used Shannon Weaner index the highest site was El Hamel ($H' = 0.733$, $H_{max} = 1.8$) and the other sites have approximately the same value but they differ in the H_{max} Bou Saâda ($H' = 0.337$, $H_{max} = 2.3$) Hammam Dhalaa ($H' = 0.343$, $H_{max} = 1.79$) M'sila ($H' = 0.36$, $H_{max} = 2.20$) (Figure 3).

When we compared the evenness, we notice that the highest value for El Hammel with 40.92 % after El Hammel comes Hammam Dhalaa with 19.12 % then M'sila 16.42 % and at last Bou Saâda 14.66 % (Figure 3).

The Spatial Distribution of the Culicidae Species

The results corresponding to the spatial distribution of the inventoried Culicidae species are presented in Table 2 with the grey color indicating the presence of the species in the station and the blank indicate their absence.

According to the Table 2, *Cs longiareolata* is present in all the stations, *Cx pipiens*, *Cx laticinctus* and *Cx theileri* almost present in all the sites we observe *Cx pipiens* was absent in EL Hamel *Cx laticinctus* also was absent in Berhoum nevertheless *Cx theileri* was absent in tow sites EL Hamel and Hammam Dhalaa.

We have also noted the genus of *Anopheles* was uniquely present in the site of Bou Saâda and the specie of *Cx brumpti* only existing in El Hamel. There are five species distributed in the sites like *Cx impudicus* (El Hamel, Hammam Dhalaa), *Culex martini* (Hammam Dhalaa, M'sila), *Cx modestus* and *Cx deserticola* (Bou Saâda, M'sila), *Cx perexiguus* (El Hamel, M'sila) and finally, *Cx hortensis* was founded in three sites M'sila, Bou Saâda and Hammam Dhalaa.

From the Figure 4 the contribution to total information for the construction of dimension 1 was 56.9 % and of dimension 2 was 29 % for a total of 86 %. This rate is higher than 50 %, so the results of the factorial correspondence analysis could be used only from dimension 1 and 2.

To further understand the mosquito distribution in the M'sila region we used of the factorial correspondence analysis the figure showed that the species of group A are more abundant in the areas of Berhoum, Hammam Dhalaa and M'sila, however, the species of group B are more distributed in El hamel and the group C are mostly founded in Bou Saâda (Figure 4).

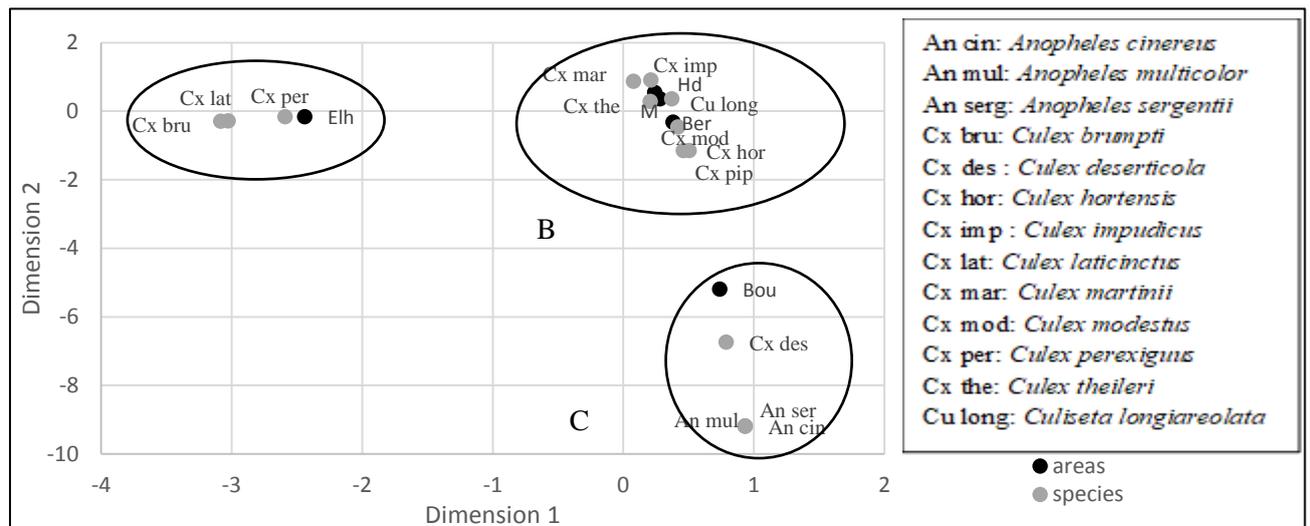


Figure 4: The factorial correspondence analysis between mosquito species and the studied areas.

DISCUSSION

The taxonomic inventory of mosquitoes from September to April every year from 2017 to 2020 in M'sila region has revealed 14 species of Culicidae distributed through three genera belongs to two sub-families Anophelinae and Culicinae. Three species of *Anopheles* were found *An cinereus*, *An multicolor* and *An sergentii* and the other 11 species belong to the Culicinae sub-family classified in two genera *Culiceta* with one species *Cs longiareolata* and the genus of *Culex* with 10 species *Cx brumpti*, *Cx deserticola*, *Cx hortensis*, *Cx impudicus*, *Cx laticinctus*, *Cx martini*, *Cx modestus*, *Cx perexiguus*, *Cx pipiens* and *Cx theileri*.

The most resembling study to this one is the work of (Benhissen et al., 2014) in Biskra region, Sahara of Algeria identified 11 species, divided into two sub-families: the Culicinae and the Anophelinae and four genera: *An. multicolor*; *Ae. caspius*; *Ae. vexans*; *Cx. pipiens*; *Cx theileri*; *Cx. deserticola*; *Cx. modestus*; *Cx. torrentium*; *Cx. pusillus*; *Cx. antennatus* ; *Cs. longiareolata*. also there are similarities with the works of (Messai et al., 2011) in Mila region establish an inventory revealed the presence of 12 species: eight of the genus *Culex*: *Cx pipiens*, *Cx modestus*, *Cx antennatus*, *Cx hortensis*, *Cx deserticola*, *Cx theileri*, *Cx laticinctus* and *Cx sp*), two of the genus *Anopheles*: *An labranchiae* and *An pharoensis*. One of the genus *Culiseta*: *Cslongiareolata* and one of *Uranotaenia*: *Uranotaenia unguiculata*. and (Aissaoui et al., 2017) announce the presence of 10 species belonging to three ; *Cx pipiens*, *Cx pipiens molestus*, *Cx modestus*, *Cx theileri*, *Cx univittatus*, *Cx perexiguus*, *Cx hortensis* and *Cx laticinctus*, *Cs longiareolata* and *Ae aegypti*, in Tebessa .

In term of frequency, the most abundant species in all the sites is *Cs. Longiareolata* with a rate of 75.74 %. This dominance is due to the bio-ecology of this species and its differential adaptations on the Spatio-temporal level. *Cs. longiareolata*, is a species with a wide distribution in the Mediterranean region (Brunnhes et al., 2001). Studies indicates its existence in polluted sites, permanent sites with stagnant water with rich or poor in vegetation and in temporary water sites stagnant or common with or without vegetation, in the regions of Tébessa and Souk-Ahras (Hamaidia, 2004).

The second specie is *Cx pipiens* is the most common mosquito in the world. It is a ubiquitous mosquito capable of adapting to different biotopes; it increases in both urban and rural environments, in polluted as well as clean water at high temperatures. Thus mainly colonizes fresh waters rich in organic matter of plant origin (Rioux and Arnold, 1955; Khalil, 1980; Himmi, 1991; Trari, 1991; Hassaine, 2002; Faraj et al., 2006; Himmi, 2007; Messai et al., 2010). The third specie is *Cx laticinctus* was noted by Senevet and Andrelli, 1960 as a Saharan species, (Hamaidia, 2004) found at temporary and permanent sites in the region of Souk-Ahras and Tébessa.

The other species, they have low frequency usually caused by water quality, reduced spawning (a consequence of a decrease in the number of female emergences), the low quantity of nutrients available (insufficient quantity or quality of food), the drying up of the breeding sites corresponding to the dry seasons, the leaching of the breeding places by precipitation, the slowing down of larval development following the drop in temperature and mortality by invertebrate predators or vertebrates (Berchi, 2000).

However, we mention *Cx. perexiguus* is a vector species of West-Nile virus, Sindbis virus and Rift Valley Fever

(Brunhes et al., 1999). Commonly it lives in freshwater but can develop in saltwater (Brunhes et al., 2001). This species has been reported in the Reghaia marsh (Lounaci, 2003) and by (Bouabida, 2012) in the Tébessa region. *An sergentii* (Theobald, 1907), a species has limited distribution in the south of the Mediterranean; it stretches from the Canaries to the northwest of India, passing through Morocco, Algeria, Tunisia and a few other countries. *An sergentii* has long been accused of playing a role in the transmission of malaria (Himmi, 2007). The Anopheles species prefer to colonize more rural breeding sites with low organic matter (Salvan and Mouchet, 1994).

The index of Shannon-Weaver expresses the status of the environment is high when the taxonomic richness is important and the distribution of individuals between taxa is balanced and the index of low values reflects a less diversified population with dominant species (Faurie et al., 2003). According to the results, the most stable population is in El Hamel with the equivalent value of 40.92 % the other sites have a less stable population with equivalence values comes Hammam Dhalaa with 19.12% then M'sila 16.42 % and at last Bou Saâda 14.66%.

CONCLUSION

Our study revealed that the species of *Cs longiareolata* was the most predominant, occupying different types of permanent and temporary breeding sites followed by species *Cx pipiens* and *Cx laticinctus*. However, the other species have a low abundance and in this inventory, the kind of *Anopheles* was presented by three species *An cinereus*, *An multicolor* and *An sergentii*.

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