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CHARACTERIZATION OF THE SITES AND POPULATION DYNAMICS OF AEDES GROUP (DIPTERA: CULICIDAE) IN THE OASES OF BISKRA, ALGERIA

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Abstract

In this work, we studied the distribution and group dynamics of *Aedes* species in the region of Biskra, which were essentially formed by three species *Aedes caspius, Aedes detritus,* and *Aedes dorsalis,* as well as the physicochemical characteristics of their breeding sites. The results showed that *Aedes caspius* was most abundant in all the three sites surveyed, with a rate of 66.43% of the total fauna indicated. While the remaining two mosquito species have different rates during the study period. From the estimates of the main physicochemical parameters of the water, we were able to show the relationship between the abundance of these mosquito species and the typology of breeding sites. These mosquitos were present in alkaline sites, with medium mineralization and high oxygen levels. Thus, these species likely choose salty water environment.

Keywords: *Aedes caspius*; *Aedes dorsalis*; *Aedes detritus*; Distribution; Physicochemical analyzes.

INTRODUCTION

Aedes mosquito belongs to Nematocera of the Diptera order from the Aedini tribe. It belongs to the Culicidae family and the Culicinae subfamily. This genus is mainly located in the Palearctic region, but is also found in the Ethiopian and eastern regions, in Africa and the Middle East; it is also well established in Asia, Russia, and the European continent (Carron 2007). Because of their ability for adaptation, mosquitoes can thrive in multiple environments, such as temporary habitat (Becker 1989). Adaptations to the latter are particularly pronounced in the species of the genus *Aedes* (Clements 1992). Their larvae colonize multiple environments, both natural and artificial, all undergoing impoundment temporary flooding caused by rain, sea overflow, or irrigation (Rioux 1958). They, therefore, develop, in most cases, in brackish water (from 1 to 5 g/l^{-1} of NaCl), but can sometimes be found in freshwater or, on the contrary, in water very heavily concentrated with salt (up to 70 g/l^{-1} of NaCl) (Gabinaud 1975).

The physicochemical elements of water can play an essential role, not only in the biology of a species, but also in the structure and dynamics of the entire comminute (Berchi 2000). The development of Culicidae is conditioned by temperature and by the biological and chemical composition of water (Messai *et al*. 2016).

Mosquito species belonging to the genus *Aedes* are aggressive especially at dusk, being able to cause significant inflammatory skin reactions, Rift Valley fever, chikungunya (Fortin *et al.* 2012), dengue fever (Bhatt *et al.* 2013), and Zika virus (Boubidi 2016).

In Algeria, there are some alerts triggered by health officials, such as the report in 2016 on the presence of the tiger mosquito in several districts of the capital, the national committee for arboviruses put on alert to monitor the changing situation (Benhissen *et al.* 2018).

Good knowledge of *Aedes*, through the study of taxonomy, abundance, and its ecology is very important before carrying out mosquito control campaigns (Fortin *et al.* 2012). In the present work, we established an inventory of the Aedini populations in the region of Biskra (Southern Algeria), by a systematic study and typology of the breeding sites. The results of our study will be used for the planning of future necessary vector control undertakings.

MATERIAL AND METHODS

The study area

Sampling was carried out in three sites distributed in two municipalities in the south-west of the wilaya of Biskra (Ouled-Djellal and Elhajeb) (Fig. 1). This area is characterized by an arid bio-climate.

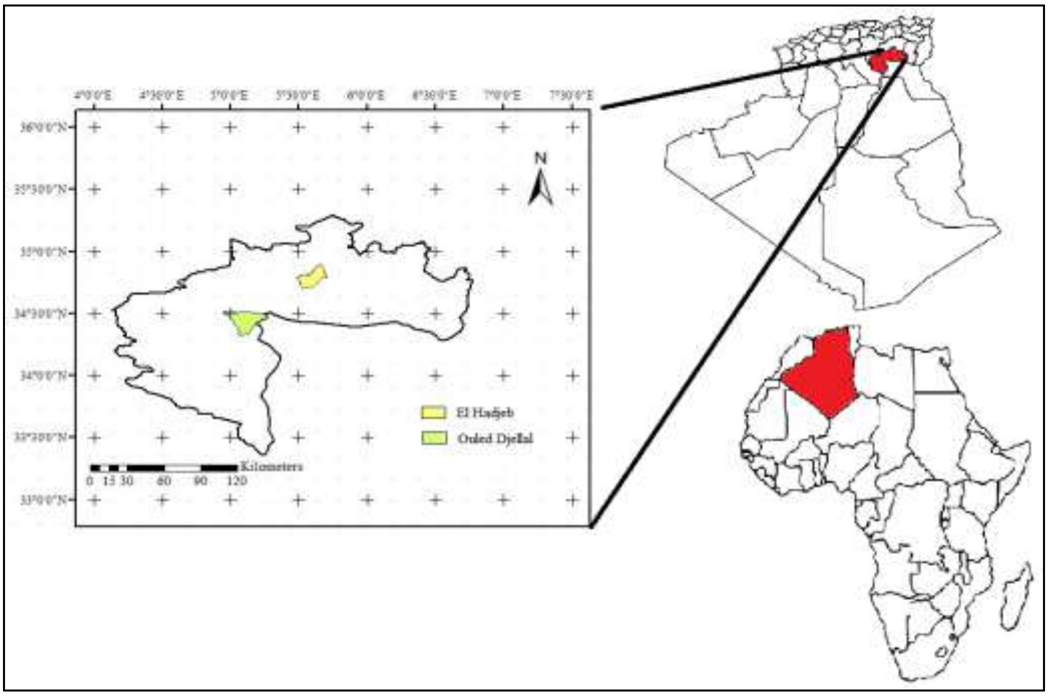

Fig. 1. Geographical location of the study region.

The study sites were selected mainly by the presence of vegetation likely to attract the female mosquitoes for egg laying, the presence of permanent or seasonal water, and running or stagnant water. The main characteristics of harvest points are summarized in the Table 1.

Table 1. General characteristics of the sites in *Aedes* sampling years (2011-2015).

Sites	Location	Altude	Latitude	Longitude	Environment	Type of site	Water type
1	Ouled-Djellal	188m	34°25'18,79'	5°06'46.43'	Oasis	drainage pit	E/irrigation
2	Ouled-Djellal	163m	34°27'37,36'	5°08'27.84'	Oasis	Wadi	E/rain
3	Elhadjeb	333m	34°46' 31,65'	5°35' 23.39"	Oasis	drainage pit	E/irrigation

Prospected sites

Mare Elhamra (S1): It is a pond in a palm grove; the water of this site is made up of irrigation water; and it is characterized by saline crusts. The vegetation cover is characterized by dense grasses and date palms (*Phoenix dactylifera*) (Fig. 2).

Elmalha swamp (S2): It is located 15 km east of Ouled-Djellal. The swamp is fed with the floods of Oued Djedei, especially during the winter (rainy period). It is also fed with underground streams. Many aquatic plants grow there (Fig. 2).

Gaiou (S3): The study was carried out in the temporary salt-water pond, in the area of Gaiou, which is located 4.5 km from the region of Elhadjeb, this lodging resulting from overflows of irrigation seguias. The vegetation cover consists of weeds and some algae (Fig. 2).

Fig. 2. The sites surveyed in the two communes of Ouled djellal and Elhadjeb. S1- Mare Elhamra, S2- Elmalha swamp, and S3- Gaiou.

Sampling of larva and their identification

Mosquito larvae were sampled from several sites using a dipper. Most larvae were brought back to the laboratory, some of them were dead, and they were preserved in glycerin for identification. And the living ones were used for mass rearing in the laboratory to obtain adult mosquitoes. Culicidae species were determined using a stereo microscope, an optical microscope, and Mediterranean African mosquito's identification software (Brunhes *et al.* 1999), which allowed identification based on a set of very specific microscopic criteria and descriptors for disinfected larvae.

Analysis of the physicochemical parameters of the waters sampled from the study sites

Assessment of the water quality of the sites studied was based on the evaluation of numerous physicochemical parameters, such as pH, conductivity, temperature, and TDS. The physicochemical analysis of the water was made using the HI 9812-5 multi-parameter device. We also examined some microbiological parameters; this analysis was made in the laboratory of mineral water and soft drink manbaa Elghozlane in Biskra (Algeria).

Method of exploiting the results

The results allowed us to identify culicidian populations by calculating ecological indices (Dajoz 1971); the graphical representations used in this study were prepared using Excel (2013).

RESULTS AND DISCUSSION

Physico-chemical characterization of sites

The physicochemical parameters of the site waters showed a large spatio-temporal variations. The mean values were presented in Table 2. The water pH measurements at the different harvesting sites varied between 8.75 and 8.07 indicating that the water in the region was alkaline. Water salinity was high at the site 3 (46 g/l), while at the site 1 there was a low salinity (16.3 g/l). The conductivity values noted were generally low in the site 1 (27.3 µs/cm) and higher in the site 3.

It also emerges from Table 2 that the oxygen at the various sites varied between 9.73 and 7.92. The microbiological study of the three sites revealed low to high bacterial contamination of human and/or animal origin (Table 2).

Table 2. Physicochemical parameters recorded from the three study sites.

Settings / Sites	pH	Salinity	Electric Conductivity	O2	Bacteriology
S1	8.22	16.3 g/l	27.3 µs/cm	9.73	contaminated water
S2	8.75	36.6 g/l	36.9 µs/cm	7.92	contaminated water
S3	8.07	46 g/l	54.2 µs/cm	8.05	contaminated water

Presentation of three Aedes species

Ae. caspius (Pallas, 1771)

The species was recognized by observing the head and siphon of its larva, and the thorax and abdominal tergites of its adult. On the head of the larvae, the number of the cephalic seta 6-C was of a single branch while the siphon comprised a tuft of median setae (Fig. 3A) of which the comb of segment VIII was much longer middle tooth (Fig. 3B). On the thorax of adults, the scutum was adorned with two white bands whose scales were creamy yellow in color (Fig. 3C). The abdominal tergite IV was characterized by the bands of pale scales (Fig. 3D).

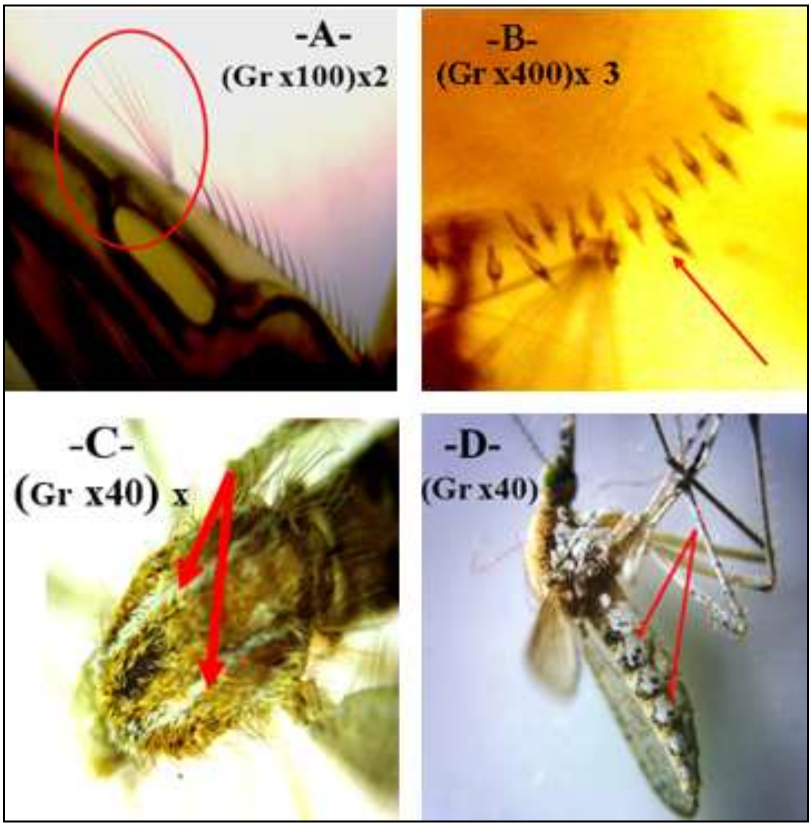

Fig. 3. Diagnostic morphological characters of *Ae. caspius.*

Ae. dorsalis (Meigen, 1830)

Abdominal tergite IV of the adult mosquito was adorned with a clear basal, median and sometimes apical band (Fig. 4A) and the median tooth of the segment VIII was short (Fig. 4B).

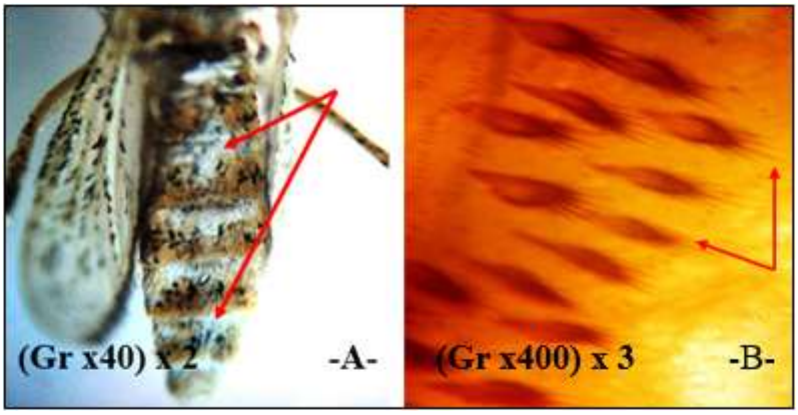

Fig. 4. Diagnostic morphological characters of *Ae. dorsalis.*

Ae. detritus (Hal,1833)

It was particularly well represented in the two breeding sites of Elhamra (palm grove G1 and pond G3). The larvae were abundant in these roosts during the spring. In the larva of *Ae. detritus*, the cephalic setae 5-C and 6-C of the head were long and formed of many branches (Fig. 5A). The antenna was made up of several spicules (Fig. 5B). In adults, tergite IV was formed by a light basal band, and a dark mottled area (Fig. 5D) and the middle tooth of segment VIII was of medium size (Fig. 5C).

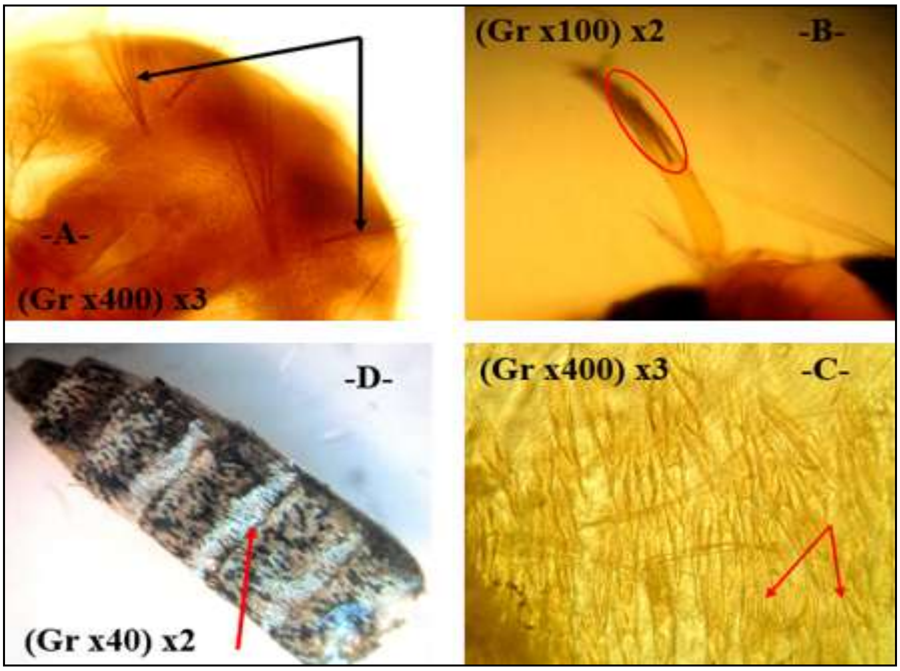

Fig. 5. Diagnostic morphological characters of *Ae. detritus.*

Abundance of Aedes species in the dry and the rainy season

The abundance of the three *Aedes* species during the study period is shown in Fig. 6. The most abundant species in all the three sites during the periods was *Ae. caspius* with an abundance of 68.32% in dry season and 66.43% in wet season. For the abundance of *Ae. dorsalis*, the results show that the rainy season favors the reproduction of this species, on the other hand, for *Ae. dertitus* the dry season was the most favorable to increase its number.

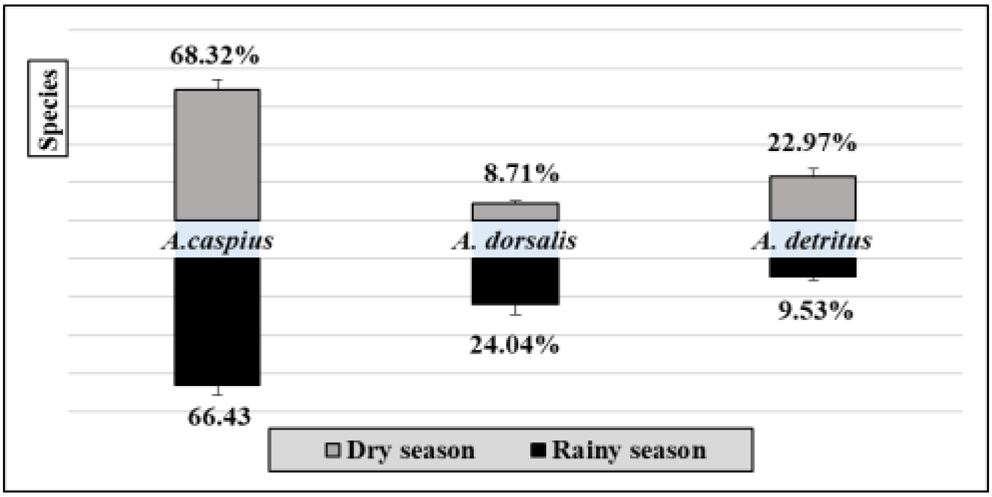

Fig. 6. The abundance of *Aedes* species in the two periods: dry and rainy seasons.

Seasonal Variation of Aedes Group

The study of the evolution of the frequency of the three *existing Aedes species* according to the seasons of the year was resumed in Fig. 7. *Ae. caspius* was present in all seasons with a maximum number of individuals (663), but minimum number was found in the site 3 during autumn and summer. In general, the most suitable season for *Ae. dorsalis* was the autumn in the two sites (1 and 2); it was present during the other two seasons with minimal numbers; and it was almost absent in the site 3 thruoghout all the year.

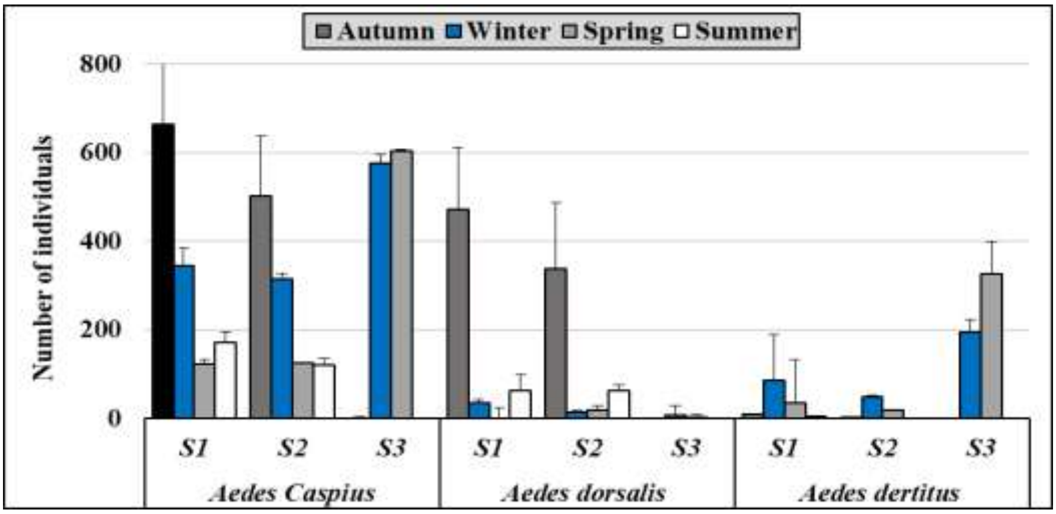

Fig. 7. Seasonal abundance of *Aedes* species in three sites in the region of Bisker.

Concerning the presence of *Ae. dorsalis* throughout all the seasons in all the three sites and in comparison with other *Aedes* mosquito species, it was present in fewer numbers. But, an increase in the number of individuals of this species was seen in the site 3 during the spring season, which means that this site during this period favored the reproduction of this species (Fig. 7).

Monthly variation of the Aedes group

Fig. 8 shows the variation in relative abundance of *Aedes* mosquitoes over the months of the year in the Biskra region. *Ae. caspuis* had abundance greater than 40% during all months of the year. Concerning *Ae. dorsalis*, it had a percentage lower than 20% from January to June, but during the next three months of July, August and September the abundance of this species reached 46% in September and then decreased in the following months to return to less than 20% in December. For the last species *Ae. detitus* in the period between January and March, the abundance was between 30% and 40%, followed by decreased in the month of April to be less than 20%, then an increase recorded for the following month May to reach a maximum of 49%, after this month the decrease was recorded again (below 20%) from June to December (Fig. 8).

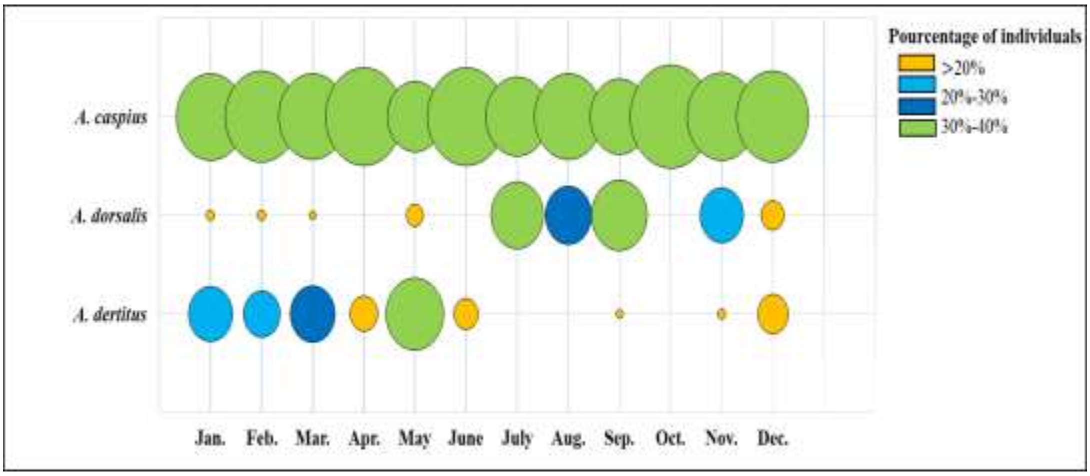

Fig. 8. The monthly abundance of *Aedes* species during the study period (indicated by the size of the circles).

Seasonal Occurrence of Aedes Species

The occurrence of the frequency of seasonal change of *Aedes* species in the Biskra region is presented in Table 3. The results show that *Ae. caspius* was common during the spring and autumn, constant in winter, but accidental in summer. While *Ae. dorsalis* was very accidental in spring and accidental in other seasons. And for *Ae. detritus*, it was very accidental in both seasons summer and autumn, and considered as an accidental species in winter and common one in the spring.

Table 3. Occurrence of the frequencies of *Aedes* species and their status (*Constant species-Cst; Common species-Cmt; Accidental species- Acc; Very accidental species-Vac; F-Frequency*).

Aedes Species	Seasonal occurrences							
	Winter		**Spring**		**Summer**		**Autumn**	
	F%	**Class**	**F%**	**Class**	**F%**	**Class**	**F%**	**Class**
A. caspius	58.33	Cst	44.44	Cmt	13.89	Acc	38.89	Cmt
A. dorsalis	16.67	Acc	5.56	Vac	11.11	Acc	19.44	Acc
A. detritus	19.44	Acc	27.78	Cmt	2.78	Vac	8.33	Vac

The ecological indices of structure

The comparison between the ecological indices (diversity, equitability, H max and H´) of the *Aedes* group in the three sites of Biskra reveals that the most favorable season for the reproduction of these species was the autumn season and during this period, the population of *Aedes* has a high equitability values. This statement does not in agreement with the finding shown in Fig. 09.

The physicochemical components of water can play an essential role not only in the biology of a species, but also in the structure and dynamics of the entire biocenosis (Berchi 2000). Of the physicochemical components conductivity, pH, salinity, and temperature rate appear as important parameters, which could explain the absence of larvae in certain lodgings (Bendali *et al*. 2014).

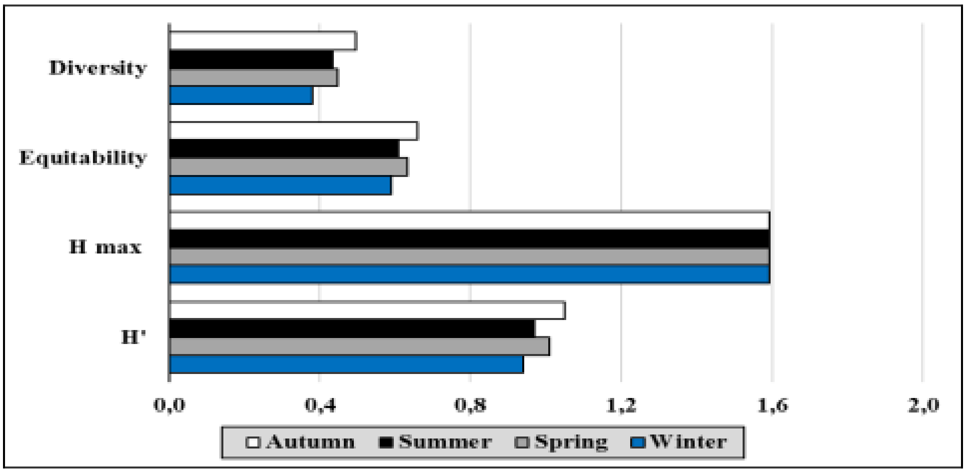

Fig. 9. The ecological structure indices of the *Aedes* group in the three sites of Biskra.

It appeared from our results that the *Aedes* group mosquitoes populate in the alkaline environment the pH of which varies from 8.07 to 8.75 and its salinity was high from 16.3 to 46 g/l. This has been confirmed under laboratory conditions, where the larvae tolerate pH values ranging from 4 to 11 (Clarke *et al.* 2002). Indeed, Zalizniaki *et al.* (2006) showed that alkalinity influences the development of certain species of aquatic invertebrates, particularly in saltwater. Our results are in agreement with Bouattour (1995) who collected pre-imaginal forms of *Aedes detritus* in bed waters with a salinity of around 50 g/l in Tunisia.

The results found indicate that the species *Ae. caspius* grows during all periods either dry or temperate, unlike the species *Ae. dorsalis* and *Ae. detritus*, which respectively prefers the temperate period and the dry period respectively for their development.

The seasonal dynamics of a mosquito species is closely linked to climatic factors. The triggering of physiological processes, such as diapause is one of the consequences of the effect of temperature and day length on mosquito metabolism (Lacour *et al.* 2015).

Carron (2007) indicated that the emergence of adults was massive and linked to seasonal meteorological characteristics, the most important being observed after the rains of the vernal and autumnal equinoxes.

We found in the present study that the number of larvae of *Ae. caspius* decreased especially during the summer season, for the larvae of *Ae. dorsalis* were present better during the fall; while *Ae. detritus* was found during winter and spring.

Handaq (1997) showed that *Ae. caspius* disappeared in winter and gives way to *Ae. detritus*, which colonizes the same breeding sites, the species reappeared in spring with the lifting of hibernation, which lasts more than three months. Merabti *et al.* (2020) reported the presence of *Ae. caspius* from the months from February to June, while *Ae. dorsalis* was only present in May and June. *Ae. dorsalis* is generally identified from February to November (El Ouali Lalami 2010), while Messai *et al.* (2016) could detected it in February, March, April, September, and October; this species has a discontinuous development in spring, autumn and winter, and a break in summer. According to Himmi *et al.* (1998) this species has a continuous winter-autumn development.

In addition, Carron (2007) proved that the seasonal dynamics of *Aedes* was characterized by the presence of adults from March to November with two peaks, one vernal and one autumnal, and by a passage from winter to the egg stage. However, if the species belonging to the same class, have the same type of biological cycle and are present in the same biotopes, they are not necessarily present at the same time and may never cohabit, there is a chronology (Merabti 2010).

In turn, the biotic and abiotic conditions prevailing in the terrestrial compartment directly influence the survival and reproduction of adults and indirectly the presence and abundance of immature in the aquatic compartment (Talaga 2016).

Global warming causes many changes in abiotic factors, including temperature, precipitation and humidity and would have a significant impact on mosquitoes and the diseases they transmit. Indeed, this climate change affects the distribution, abundance, behavior, and population dynamics of disease vector mosquitoes (Mourot 2020).

The study of *Aedes* populations in the two regions of El Hajeb and Ouled Djellal in the region of Biskra shows that the mosquitos populations consisted of three species, viz. *Ae*. *caspius*, *Ae*. *dorsalis* and *Ae*. *detritus*. The results revealed that *Ae*. *caspius* has ability to adapt itself to the environmental conditions throughout the year in the Biskra region. We noted that *Ae*. *detritus* was more abundant (higher frequency) than *Ae. dorsalis* in the cold months, but *Ae. dorsalis* showed heigher numbers than *Ae. dertitus* in the rest of the seasonal months. The frequency of those species in the dry season and the rainy season does not affect the *Ae*. *caspius* species, but it has an influence on the frequency of *Ae*. *dorsalis* and *Ae*. *detritus*. The results of this study showed that the rainy season was suitable for the development of *Ae*. *dorsalis* species. However, the dry season was suitable for *Ae*. *detritus* species in the region of Biskra.

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