Volume 5(2). Published January, 15, 2018
www.jnsciences.org
E-ISSN 2286-5314

The genus *Orius* Wolf (Insecta; Heteroptera; Anthocoridae) in the Tunisian coastal region: biodiversity and distribution

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Abstract – Anthocoridae are polyphagous predators of soft-bodied insects. Among Anthocoridae, the genera *Orius* and *Anthocoris* are of great importance in Biological Control programs. In this context, a study on the biodiversity of the *Orius* species was undertaken in 7 sites in the governorates of Sousse and Monastir in the region of the Tunisian Coastal during 2010 and 2011. Samples consisting of 100 flowers of *Chrysanthemum coronarium* L. from each site were collected monthly from February to June in each year. Three species were identified on *C. coronarium*: *Orius leavigatus, O. albedipenis* and *O. majusculus.* The predatory bug *O. leavigatus* seems to be the most abundant and the most distributed species in all the studied sites. *O. albedipenis* was the second most abundant species, but not constant in all localities. *O. majusculus* was rare and present only in the sites near the sebkhas. Concerning biodiversity indices, the highest values were recorded in the site of Moknine with a Shannon index of 0.75 and Simpson index of 0.49, certifying the effect of the diversity of the landscape on the biodiversity of entomofauna. On the other hand, the dominance index clearly showed the dominance of *O. leavigatus*, confirming its ubiquitous character. Besides, biodiversity indices indicated that encountered species were not equitably distributed and that the different visited sites had a disturbed environment.

Keywords: *Orius.sp, C. coronarium, O. leavigatus, biodiversity, Shannon index, Simpson index.*

1. Introduction

The order Heteroptera forms an important section of entomofauna. It contains many phytophagous and zoophagous insects. Zoophagous species are of great interest in biological control (Fauvel 1999). The Anthocoridae Fieber family contains between 400 and 600 worldwide species (Péricart 1996). Among the famous species that belong to this family, the genus *Orius* Wolff, 1811 (Heteroptera; Anthocoridae), which includes many species, is known to be an effective predator of thrips or other small sized insects such as mites, aphids and psyllids (Ferragut and Gonzalez-Zamora 1994; Fauvel 1999). Most species of Anthocoridae are predaceous as nymphs and adults (Péricart 1972; Lattin and Stanton 1992). Many Anthocorids and Mirids are employed in the development of Integrated Pest Management (*IPM*) strategy and represent an interesting alternative to replace chemical control (Fauvel 1999).

Regarding the Anthocoridae family, it is divided into two subfamilies: Anthocorinae and Lyctocorinae (Péricart 1972). The first sub-family includes the Oriini tribe with the *Orius* genus, which are of importance in agro-ecosystems because of their role in predation (Veres et al. 2012). *Orius* species in the Palearctic region are estimated at twenty and are predators and occasionally phytophagous on trees and herbaceous plants (Péricart 1972). Species of this genus such as *O. laevigatus* Fieber (1860), *O. albidipennis* (Reuter) 1884, *O. tristicolor* (White) 1879, *O. insidiosus* (Say) 1832 and *O. majusculus* (Reuter) 1879 are known as effective agents employed in biological control against many thrips species such as *Frankliniella occidentalis* Pergande, 1895 and *Thrips tabaci* Lindemann, 1888 (Loomans and van Lenteren 1995; Parker et al. 1995). According to Sanchez and Lacasa (2002), Tommasini (2004), Sanchez and Lacasa (2006) and Bosco and Tavella (2008), those species are naturally present on different host plants and weeds growing in protected cultures when pesticides are minimized. Ben Moussa (2004) indicated that *Chrysanthemum coronarium* Linneaus is the host plant on which different species of the genus *Orius* were encountered in Tunisian vineyards.

It is in this context that this work was initiated, aiming to evaluate the biodiversity on the one hand and the monitoring of different *Orius* species on *C. coronarium* in different localities of the Coastal region of Tunisia in the other hand.

2. Material and methods

2.1. Experimental sites

The different experimental sites that were used for this study are placed in seven different localities belonging to the Coastal region of Tunisia in the governorate of Sousse and the governorate of Monastir (Central Eastern Coast) (Figure 1). Those experimental sites are uncultivated fields where *C. coronarium* grew abundantly. Geo-climatic characteristics of the different localities are summarized in Table 1.

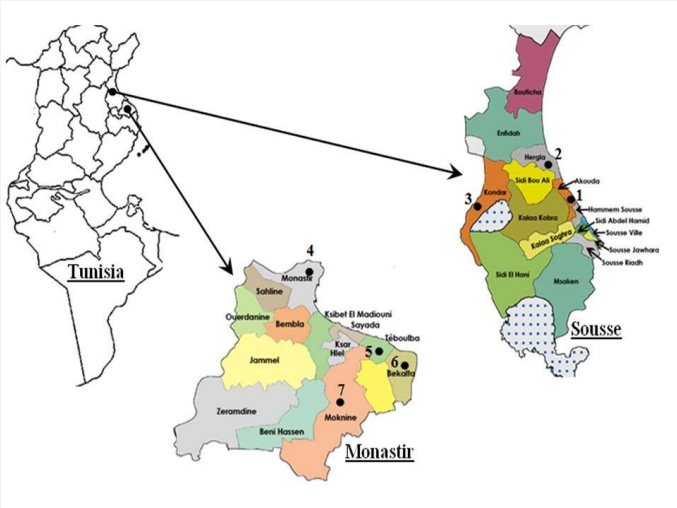

Figure 1. Geographical localization of the different experimental sites in the governorates of Sousse and Monastir and in Tunisia. 1, Chott-Mériem; 2, Hergla; 3, Kondar; 4, Monastir; 5, Teboulba; 6, Bekalta; 7, Moknine.

Table 1. Geo-climatic characteristics of the different experimental sites. (+) presence of marshes or sebkha, (-) absence of marshes or sebkha.

Number	Experimental site	Governorate	Geographic localization	Area (m²)	Distance to the sea (km)	Altitude (m)	Near Sebkha*
1	**Chott-Mériem**	Sousse	35°54'39.69''N 10°33'24.42''E	7 176	2.08	46	-
2	**Hergla**	Sousse	36°01'00.95''N 10°28'07.22''E	897	3.88	9	+
3	**Kondar**	Sousse	35°55'03.11''N 10°17'10.59''E	11 088	23.38	21	+
4	**Monastir**	Monastir	35°45'04.03''N 10°49'22.80''E	1 722	0.46	7	-
5	**Teboulba**	Monastir	35°38'18.34''N 10°57'17.20''E	728	2.02	23	-
6	**Bekalta**	Monastir	35°37'52.20''N 10°58'55.31''E	1 768	1.71	16	-
7	**Moknine**	Monastir	35°37'48.66''N 10°56'06.68''E	2 457	6.66	1	+

2.2. Sampling

According to Ben Moussa (2004), species of the genus *Orius* are frequent in the flowers of *C. coronarium*. During this study, 100 flowers from each site were sampled monthly from February to June during 2010 and 2011. The sampling period is consistent with the period of flowering of *C. coronarium* in Tunisia which extends from February and March till June (Carem 1990).

2.3. *Orius* diversity in the Tunisian Coastal region

According to Roger (1977), indices of the diversity of a population represent the amount of information represented by a given sample on how individuals are distributed among various species. In this way, changes in diversity indices of samples from the same population spread over time give an idea about the changing structure of the population and monitoring its evolution.
Among the studied parameters to get an idea about the diversity of a population, we find species richness which is the number of recorded species in a habitat. The index of Shannon or Shannon-Weaver is used to evaluate the spatial and temporal diversity in a habitat or set of habitat (Roger 1977) stands. This index is calculated using the following formula:

$$H' = -\sum_{i=1}^{S} pi \log 2\ pi$$

where *H'* is the Shannon biodiversity index, *i* is the species of the studied site, *Pi* is the proportion of species *i* relative to the total number of species (S) in the study areas, knowing that *Pi = ni / N* where *ni* is the number of individuals of species *I,* and *N* is the total number of all species. It should be noted that this parameter, in nature, is located generally between 0.5, which indicates a very low diversity, and 4.5.

The Shannon index is usually associated with the Simpson index, which is a formula to calculate that two individuals chosen at random and in a given habitat belong to the same species. The formula for this index is:

$$S = \sum Ni\ (Ni-1)/N\ (N-1)$$

Where *S* is the Simpson index, *Ni* is the number of individuals of a given species and *N* is the total number of individuals. This index is between 0 and 1. The closer it is to 0, the higher the chance of having individuals of different species.
The other parameters that have been measured are dominance and equitability. The first is expressed by:

$$D = n\ x\ 100\ /\ N$$

Where *D* is the dominance, *n* is the number of individuals belonging to the species best represented and *N* is the total number of individuals in a given sample.
Concerning equitability, it is the ratio of the actual diversity observed at the theoretical maximum diversity. Similarly, equitability clarifies the structure of the ecosystem. It is expressed by the following formula:

$$E = H'/Ln\ N$$

This parameter varies between 0 and 1; it tends to 0 when almost all the encountered individuals are concentrated on a single species and therefore it is the most dominant, and tends to 1 when all species have the same abundance and in this case they are equitably distributed and the population is homogeneous across all species. In addition, a number of less than 0.6 fairness characterizes a turbulent environment (Roger 1977; Graham et al. 2009).
All these parameters were measured using the software PAST® (Paleontological Statistics).

2.4. Identification of the specimens

The identification of the encountered species was done using the identification keys of Péricart (1972), and based on the analysis of male genitaliae and female copulatory tubes.

3. Results and Discussion

The obtained results during the years 2010 and 2011 showed the existence of three species of the genera *Orius* on the flowers of *C. coronarium;* they were distributed in all the studied localities of the Tunisian Coastal. The identification of the individuals was based on the analysis of the shape of the parameter in the male and the shape, the size and the orientation of the copulatory tube in the female. This work leads to the identification of three species: *O. laevigatus*, *O. albidipennis* and *O. majusculus*.

The study of the geographical distribution and the abundance of these three species on flowers of *C. coronarium* in the Tunisian Coastal showed several interspecific differences. Indeed, it proved that the most distributed and the most abundant bug is *O. laevigatus.* In the region of Monastir (Figure 2)**,** this species presents high cumulated percentages of occupation going from 59.48 to 77.14% respectively in Moknine and Teboulba and reaching 81.10% in Bekalta. Moreover, in Monastir, *O. laevigatus* was the only species of Anthocoridae present with a cumulated percentage of 100% in2010 and 2011. As in the governorate of Monastir, *O. laevigatus* was the most abundant species in the governorate of Sousse (Figure 3). The cumulated percentages were 67.44, 89.48 and 100% respectively in the localities of Kondar, Hergla and Chott-Mériem.

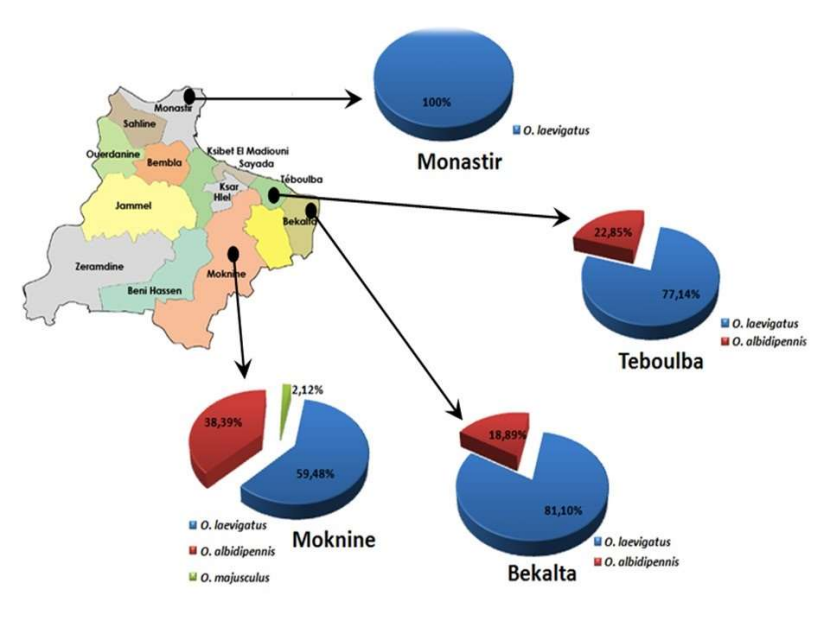

Figure 2. Percentages of the *Orius* species collected on *C. coronarium* flowers in the study sites of the Governorate of Monastir

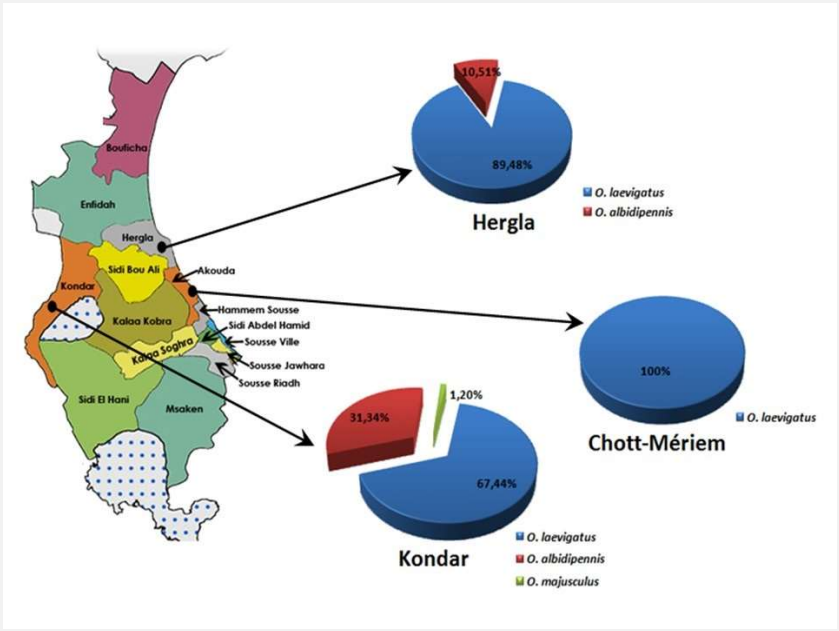

Figure 3. Percentages of the *Orius* species collected on *C. coronarium* flowers in the study sites of the Governorate of Sousse.

The second most abundant species is *O. albidipennis* with cumulated percentages of 18.89, 22.85 and 38.39% respectively in the localities of Bekalta, Teboulba and Moknine of the governorate of Monastir (Figure 2). This species was completely absent in the locality of Monastir. Concerning the governorate of Sousse (Figure 3), the cumulated percentages of this species was 10.51% and 31.34% respectively in the localities of Hergla and Kondar, it is and absent in the locality of Chott-Mériem. Regarding *O. majusculus,* it was rare and its presence was limited to the localities of Moknine in the governorate of Monastir with a cumulated percentage of 2.12% (Figure 2), and Kondar of the governorate of Sousse with 1.2% (Figure 3).

In addition, the evaluation of the indices of the diversity in the various biotopes of study (Table 2) showed that the highest Shannon index was recorded in the locality of Moknine with 0.75 bits, followed by that of Kondar with 0.68 bits. These results show that in these two localities, the diversity of *Orius* species is the highest. In the other localities, the Shannon index was lower or equal to 0.5, testifying a very weak biodiversity with one or two species of *Orius.*

Table 2. *Orius* biodiversity indices in the different experimental sites.

Governorate	Locality	Species number	Total number	Shannon index	Simpson index	Dominance	Equitability
Monastir	**Monastir**	1	474	0	0	1	0
	Teboulba	2	560	0,53	0,35	0,64	0,77
	Bekalta	2	942	0,48	0,3	0,69	0,69
	Moknine	3	659	0,75	0,49	0,5	0,69
Sousse	**Chott-Mériem**	1	899	0	0	1	0
	Hergla	2	371	0,33	0,18	0,81	0,48
	Kondar	3	1579	0,68	0,44	0,55	0,62

Concerning the Simpson index, it was the highest in the localities of Moknine and Kondar with respectively 0.49 and 0.44 bits. In the other localities, the index was lower with 0.18, 0.30 and 0.35 respectively in Hergla, Bekalta and Teboulba. In Monastir and Chott-Meriem, this index was zero. As for Simpson index, the equitability in Monastir and Chott-Mériem was zero, proving that the totality of the individuals collected belongs to only one species. The study of the specific richness in the Tunisian Coastal shows that the cumulated number of individuals of *O. laevigatus* collected during the two years of sampling were the most significant,with 4358 individuals representing 79.46% of the total individuals of *Orius* collected. *O. albidipennis* is the second species in numerical importance with a cumulated number of individuals of 1093 and a percentage of 19.93%. Finally, *O. majuculus* comes in third and last position, with 33 individuals and a percentage of 0.6% compared to the total number of *Orius* individuals found (Figure 4) (Table 3).

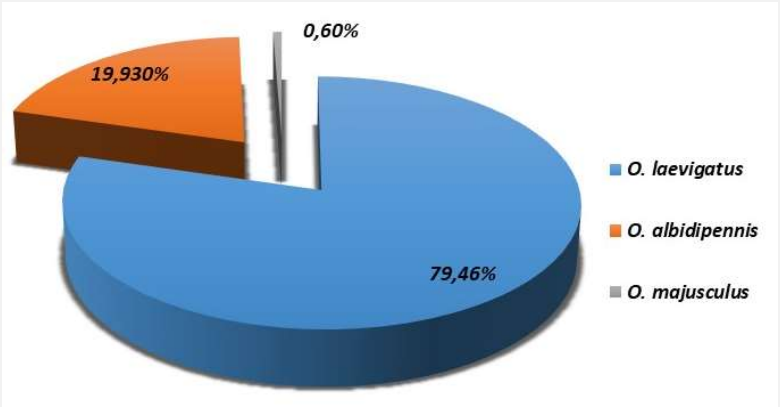

Figure 4. Percentages of *Orius* species collected on *C. coronarium* flowers in the region of Coastal.

Tableau 3. Total number of each *Orius* species collected on *C. coronarium* flowers in the region of Coastal.

	O. laevigatus	*O. albidipennis*	*O. majusculus*	Total
Monastir	474	-	-	474
Teboulba	432	128	-	560
Bekalta	764	178	-	942
Moknine	392	253	14	659
Chott-Mériem	899	-	-	899
Hergla	332	39	-	371
Kondar	1065	495	19	1579
Total	4358	1093	33	5484

In addition, the evaluation of the various parameters of the diversity of *Orius* on *C. coronarium* in the Tunisian Coastal reveals a poor biodiversity illustrated by a Shannon index of 0.53 and a Simpson index of 0.32. In the same way, the equitability recorded is 0.48, which means that the near total of the populations of *Orius* counted is formed by only one species. Moreover, the equitability of the species of *Orius* in the Tunisian Coastal is lower than 0.6 (Table 4), which indicates that the environment is disturbed (Roger 1977).

Tableau 4. *Orius* biodiversity indices in the region of Coastal.

Species number	3
Total number	5484
Shannon index	0,53
Simpson index	0.32
Dominance	0,67
Equitability	0,48

These results show that the species found in the various prospected localities are not equitably distributed on the one hand, while on the other hand, they demonstrate the existence of a dominant species because of its best adaptation to the conditions of the explored sites (Roger 1977). *O. laevigatus* seems to be the most adapted species to the geo-climatic conditions of the area of the Tunisian Coastal as testified by the importance of its number of individuals and its presence in all the visited biotopes. Ben Moussa (2004) reports, in an inventory of the species of *Orius* populating the vineyards in Tunisia, that *O. laevigatus* was the most dominant and the most abundant, whereas *O. albidipennis* was more distributed geographically. These results are similar with our data except that *O. laevigatusis* is at the same time the most significant and the most distributed in the different prospected localities. Moreover, the work of Tommasini (2004) showed that *O. laevigatus* is the most frequent species in the various territories of Italy, from the North to the South, with a total cumulated percentage of 57.58% compared to the other species. The same author adds that the number of individuals of this species was more significant in the central and south areas of Italy. Moreover, Vacante and Tropea Garzia (1993) and Vacante (2011) indicate that *O. laevigatus* is the most abundant species of Anthocorride in Italy on various crops.

In Spain, Lacasa and Llorens (1996) mentioned that *O. laevigatus* is widely distributed in all the Iberian peninsula including Spain and Portugal. Moreover, Péricart (1972) confirmed that this species is very widespread in the Mediterranean region up to the North of France and the British Isles. In addition, Mohamed (2009) indicates that the area of the Tunisian Coastal is subjected to a littoral Mediterranean climate characterized by hot and dry summers and soft and wet winters, of transition between the arid to South-west and semi-arid bioclimatic stages on the coastal zone to the East. The coastal zone can be shared between a semi-arid superior bioclimate (Governorate of Sousse) and semi-arid inferior (Governorate of Monastir). These data explain the abundance of *O. laevigatus* in the area of the Tunisian Coastal where it was found to be the most adapted to the local climatic conditions according to the diversity indices obtained. Furthermore, Tommasini (2004) underlines in its work the prevalence of this

species in the coastal areas of Italy. Moreover, Péricart (1972) confirmed that this species is acharacteristic element of the west Palearctic areas under maritime influence, which confirms our results. In addition, Alauzet et al. (1994) and Tommasini et al. (2004) showed that *O. laevigatus* is adapted to relatively high thermal conditions and that its biotic performances are limited toan interval of temperatures ranging between 20 and 30°C with an optimum average temperature of 26°C. Consequently, Tommasini (2004) speaks about a probable predominance of the species of *O. laevigatus* in the Mediterranean basin, which was the case during this study in the Tunisian Coastal, where this species crossed a cumulated percentage in 2010 and 2011of about 79.46% compared to the other species collected.

The second numerically significant species is *O. albidipenni.* It was present in all the biotopes prospected except for the localities of the littoral of Chott-Meriem and Monastir. The highest percentages of abundance were recorded in the biotopes located in the internal areas of the Tunisian Coastal and the most farthest from the sea which are Moknine and Kondar. Péricart (1972) indicates that this species, originating in the Canary islands, presents a surface distribution limited to the southern coast of the Mediterranean sea from the Iberian peninsula passing by the North of Africa up to the near East including the North African deserts, Western Sahara, and the Arabic peninsula. In Spain, this species is present only in the South and in the littoral areas of the Mediterranean Sea (Ferragut and Gonzalez-Zamora 1994; Lacasa and Lorens 1996). In the same context, Tommasini (2004) quoted that this species was not met in Italy except for the South in Sicily where some individuals were counted. Concerning Tunisia, Ben Moussa (2004) indicated that *Orius* is not the most abundant species, but the most widespread. On the other hand, Riudavets and Castane (1994) observed in the area of Murcie (South of Spain), that *O. albidipennis* is the most abundant species of the genera. Péricart (1972) also mentions that it is very common in the Maghreb and in Egypt.

Concerning *O. majusculus,* Tommasini (2004) and Bosco and Tavella (2008) mentioned that it is more abundant in the areas of the North of Italy. However, its abundance decreases from the North to the South of the peninsula, to become zero in Sicily (Tommasini 2004). As in Italy, Lacasa and Llorens (1996) indicated that this species is present in Spain only in the Northern half of the Iberian Peninsula. According to Péricart (1972), *O. majusculus* is widespread and very common in all of central Europe, from Poland to France, as in parts of the British Isles and South Scandinavia. It is known also in Asia Minor, but it is probably missing in North Africa, which explains the very low number of individuals detected and its very limited distribution area in the Tunisian Coastal. Tommasini (2004) indicates that *O. majusculus* disappears with latitudes lower than 38°. However, the biotopes prospected in this study are located at a latitude of 35° except for that of the locality of Hergla which is 36°. In spite of these data, *O. majusculus* was already present with a very low number of individuals and a limited distribution. Furthermore, Péricart (1972) observed that this species was occasionally phytophagous in the Netherlands and that it was regarded as harmful to chrysanthemums. At the same time, *O. majusculus* prefers areas at the edge of water (Péricart 1972). However, in the Tunisian Coastal, the species was found only in the internal localities and thus distant from the edge of the sea. On the other hand, Péricart (1972) also states that this species develops especially near the marshes where it is found on the vegetation. Indeed, the two localities where *O. majusculus* was found are located near marsh land or Sebkha: Sebkha of Moknine in Moknine and Sebkha of Kelbia in Kondar. This can explain its presence in spite of the non-favorable latitude. However, it should be noted that in the locality of Hergla which borders a Sebkha, *O. majusculus* was not found. Indeed, this biotope showed the lowest number of individuals that could be allotted to the characteristics of the diversity of the population and those of the locality where the equitability was about 0.48, thus characterizing this biotope as a disturbed environment (Roger 1977).

4. Conclusion

The knowledge of different insect predators and their density in different locations and moments of their development and population's increase is very important because of their effect on different crops' pests. During this work, three different predators' species belonging to the genus *Orius* were encountered in many studied locations of the coastal region in Tunisia. *Orius laevigatus*, which is known as an efficient predator of many pests, was the most abundant and the most frequent in different visited sites. It was followed by *O. albidipennis* which was not present in all locations. The third species is *O. majusculs* which was not found in all studied regions but only in sites near sebkhas. On the other hand, evaluation of the biodiversity indices showed the existence of a dominant species because of its best adaptation to

the conditions of the explored sites. Moreover, species found in different localities were not equitably distributed. These results indicated that the environment of different prospected sites is disturbed.

Acknowledgements
All authors are thankful to the SPDD laboratory of the High School of Agriculture of Mograne and the laboratory of Entomology in the General Directorate of Agricultural Protection of the Ministry of Agriculture of Water Resources and Fisheries.

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