

Diversity of beetles associated with watermelon crops *Citrullus lanatus* (Thunb.) Mats. in the region of Ouargla (southern Algeria)

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Abstract

Diversity of beetles in watermelon crops Citrullus lanatus (Thunb.) Mats. in the region of Ouargla (southern Algeria). We studied the diversity of beetle families in watermelon fields in the palm grove of Zaatote at Ouargla (34° 54' N, 5° 20' E). The sampling method used was Barber pots as they allowed the largest number of captures of insects, regarding both individuals and species. Over the three years of the study (2016, 2017 and 2018), we identified 787 individuals from 12 taxonomic families. Throughout the sampling period, the Coccinellidae family was clearly dominant, with an Fc = 35.02% in 2016, 36.2% in 2017 and 34.34% in 2018. The second most dominant family was Tenebrionidae with an Fc = 26.35% in 2016, 30.04% in 2017, and 33.33% in 2018. Other families were poorly represented. In 2016, regarding their trophism, 18 species of beetles (30.91%) were phytophagous and feed on the watermelon crop, while 26 species were predatory and decomposing auxiliaries.

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Key words: Inventory, Diversity, Watermelon, Beetle, Barber pot, Ouargla

Resumen

Diversidad de coleópteros asociados a cultivos de sandía Citrullus lanatus (Thunb.) Mats. en la región de Ouargla (sur de Argelia). Se estudió la diversidad de familias de coleópteros en campos de cultivo de sandía situados en el palmeral de Zaatote (Ouargla) (34° 54' N, 5° 20' E). El método de muestreo utilizado fueron botes de Barber, que permitieron el mayor número de capturas de insectos, tanto por lo que respecta a individuos como a especies. Durante los tres años del estudio (2016, 2017 y 2018) se identificaron 787 individuos pertenecientes a 12 familias taxonómicas. En todo el periodo de muestreo, la familia Coccinellidae fue claramente dominante con Fc = 35,02% en 2016, 36,2% en 2017 y 34,34% en 2018, seguida de la familia Tenebrionidae con Fc = 26,35% en 2016, 30,04% en 2017 y 33,33% en 2018. Las demás familias estaban muy poco representadas. En 2016, según su trofismo, 18 especies de coleópteros (30,91%) eran fitófagas y se alimentaban de los cultivos de sandía, mientras que 26 especies eran depredadoras y descomponedoras auxiliares.

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Palabras clave: Inventario, Diversidad, Sandía, Coleóptero, Trampa de Barber, Ouargla

Resum

Diversitat de coleòpters associats a cultius de síndria Citrullus lanatus (Thunb.) Mats. a la regió de Ouargla (sud d'Algèria). S'ha estudiat la diversitat de famílies de coleòpters en camps de síndria al palmeral de Zaatote a Ouargla (34° 54' N, 5° 20' E). El mètode de mostreig aplicat va ser amb pots de Barber que van permetre el major nombre de captures d'insectes, tant en individus com en espècies. Durant els tres anys d'estudi (2016, 2017 i 2018), es van identificar 787 individus pertanyents a 12 famílies taxonòmiques. Durant tot el període de mostreig, la família Coccinellidae va ser clarament dominant amb Fc = 35,02% el 2016, 36,2% el 2017 i 34,34% el 2018. En segona posició, la família Tenebrionidae amb el Fc = 26,35% el 2016, el 30,04% el 2017 i 33,33% el 2018. La resta de famílies estaven molt poc representades. En 2016, en funció del seu trofisme, 18 espècies de coleòpters (30,91%) eren fitòfagues i s'alimentaven dels cultius de síndria, mentre que 26 espècies eren depredadores i descomponedores auxiliars.

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Paraules clau: Inventari, Diversitat, Síndria, Coleòpter, Barber pot, Ouargla

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Introduction

Watermelon *Citrullus lanatus* (Thunb.) Mats. is an annual plant belonging to the family of Cucurbitaceae, native to tropical Africa (Paris, 2015). The ripe fruit has a high nutritional value, being rich in vitamins B1, B2, A, C, and mineral salts, particularly magnesium (van Der Vossen et al., 2004). In Algeria, especially in the province of Ouargla, watermelon is perceived as a promising sector. According to the Directorate of Agricultural Services (DSA, 2020), the area of watermelon in crops in green houses in the 2019/2020 season was estimated to be 1,957.5 ha with a production of 1,082,500 qx/ha. The area of crops in the open field is estimated at 274 ha with a production of 31,792 qx. The harvest generally lasts from April until mid-June. Watermelon in Ouargla are now cultivated in several new agricultural areas, such as Khechem–Errih, Hassi Benandalleh, Hassi Messaoud and Taibet (DSA, 2020). Considering the rapid maturation of this crop, farmers in these regions are interested in growing this product to benefit from the high prices at the start of the marketing campaign, despite lower yields. Market gardening has become one of the main income-generating activities in the area (Toni et al., 2020). However, the crops face several phytosanitary problems, such as pest arthropods that can severely damage the output (Diatte et al., 2016). Unfortunately, the list of vegetable crop pests in general is not well established in the region of Ouargla. To our knowledge, the diversity or abundance of insects associated with watermelon production in this region has not been studied to date. The first step to protect this crop is therefore to determine which pest and which non-pest arthropods are associated with this plant. The

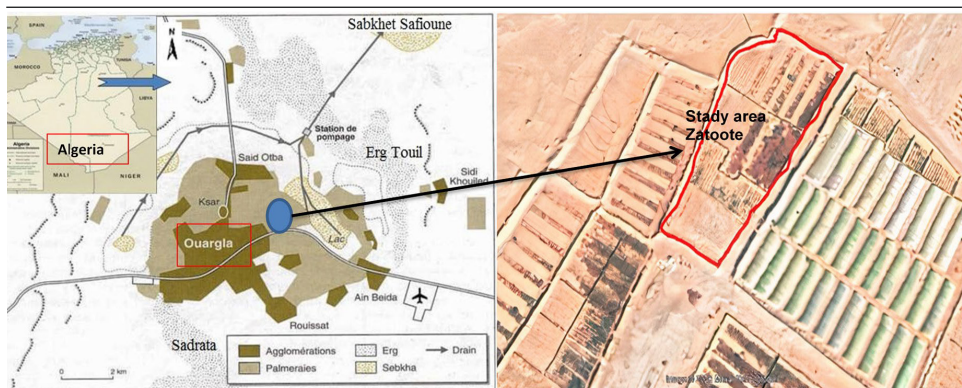


Fig. 1. Geographical position of the palm grove of Zaatote, and the location of the study area (Kahf Soltan) (Google Earth, 2020).

Fig. 1. Situación geográfica del palmeral de Zaatote y localización del área de estudio (Kahf Soltan) (Google Earth, 2020).

present study was conducted to identify and create an inventory of the different families of beetles living in watermelon fields in order to establish sustainable phytosanitary protection of the crop. We aimed to establish a basic repository in order to draw up an inventory of the main pests and evaluate the natural control agents.

Material and methods

Study area

The present experiment was carried out in the palm grove of Zaatote at Ouargla. Plots were chosen in cultivated watermelon fields. This palm grove is located on the road between the region of Ouargla and that of El-Goléa (10 km south-east of Ouargla) (fig. 1). The region of Ouargla is located in the Saharan bioclimatic zone. It has clay-sandy soils. The winter is temperate and summers are hot and dry.

Collection and conservation of specimens' techniques

Sampling was carried out in three plots, each of 500 m², using Barber pots from December (transplanting) until June (fruiting and ripening of the first fruits). The pots used were cylindrical cans, 15 cm in diameter and 18 cm in height (Benkheil, 1991). They were buried vertically so that the opening was at ground level to avoid the barrier effect for small species. We installed 10 traps 5 meters apart per row in each field so that there was no interaction between them. The traps were filled with water to one-third and a few drops of detergent were added to prevent insects from climbing up the walls. The pots were placed on the ground and collected after 24 hours. The contents of each pot were filtered separately on to petri dishes, labelled with number, date and place of capture, and stored in alcohol (70%), for subsequent faunal determinations in the laboratory. The watermelon plots where traps were installed watermelon underwent phytosanitary treatment at various stages crop growth.

Identification of collected insects

Insects were identified by Professor Faiza Marniche at the Zoology Laboratory at the National Veterinary School of El Alia, and confirmed in the Arthropod section of the Museu de Ciències Naturals de Barcelona by Amador Viñolas.

The identified species were classified according to the trophism of images and grouped into four functional groups: pests, predators, scavengers and miscellaneous in order to determine the role played by each species.

Data analysis

Recorded data based on identified beetle catches were analysed using software PASTsoftware (PA-leontologicalStatistics) Version 2.17 (Hammer et al., 2001). The following numerical indices were used:

- The centesimal frequency (Fc) is the percentage of individuals of a species in relation to the total number of individuals, all species combined

$$Fc = n_i * 100/N$$

where n_i is the number of individuals of a concrete species, and N the total of individuals (Dajoz, 1971).

- The Shannon Diversity Index (H') is calculated from the formula:

$$H' = - \sum P_i \log_2 P_i$$

expressed in bits (Ramade, 1984); where P_i is the probability of encountering species and it is calculated by the formula: $P_i = n_i/N$ where n_i is the number of species' individuals i ; and N is the total number of individuals.

- The Pielou equity index (E) corresponds to the ratio of the observed diversity H' to the maximum diversity H'_{max} :

$$E = H'/H'_{max}$$

It is expressed in bits (Ramade, 1984) and H'_{max} is calculated using the formula $H'_{max} = \log_2 S$ (Blondel, 1979).

Results

Sampling using Barber pots over the three study years (2016, 2017 and 2018) allowed us to draw up the list of beetles found on watermelon crops in the region of Ouargla. We collected a total of 787 individuals of beetles: 277 individuals in 2015 (Fc = 35.21%), 213 in 2016 (Fc = 27.06%), and 297 in 2017 (Fc = 37.73%). Twelve families were identified (fig. 2). The family Tenebrionidae was the most represented with a predominance of the species *Mesostena longicollis* (Lucas, 1858). The families Coccinellidae, Scarabaeidae and Curculionidae were represented by five species, followed by the Carabidae with four species. The families Anticidae and Staphylinidae were each represented by three species (table 1). We also identified two species for each of the families Chrysomelidae, Elateridae and Dermestidae. The Nitidulidae and the Cryptophagidae families were represented by only one species each.

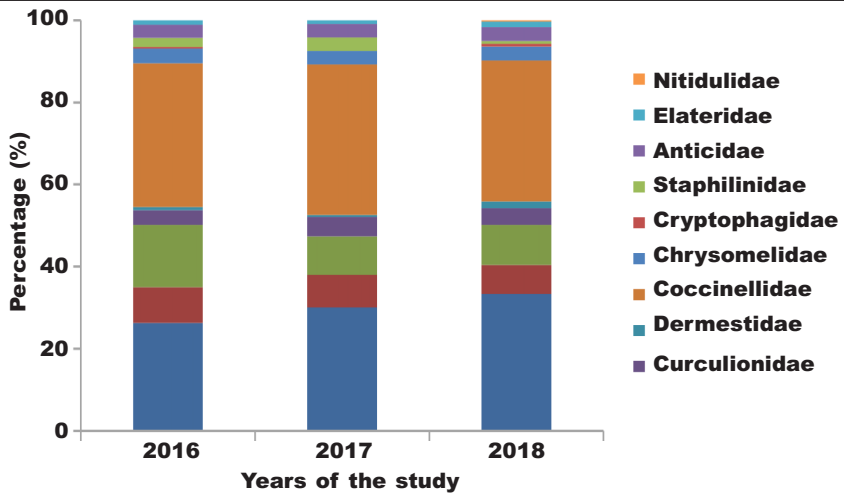


Fig. 2. Distribution of the main beetle families collected from watermelon fields over the three years of the study.

Fig. 2. Distribución de las principales familias de coleópteros recolectadas en los campos de cultivo de sandía durante los tres años de estudio.

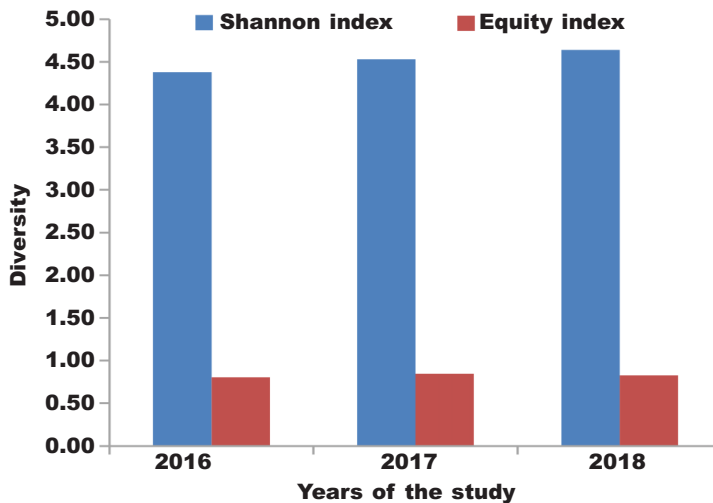


Fig. 3. Diversity index of identified beetle families on watermelon crops according to the year of collection.

Fig. 3. Índice de diversidad de las familias de coleópteros identificadas en los campos de cultivo de sandía según el año de captura.

Table 1. Centesimal frequencies of beetle species collected over the three years (2016, 2017 and 2018) in watermelon fields in the region of Ouargla: Ni, abundance; F(%), frequency.

Tabla 1. Frecuencias centesimales de las especies de coleópteros recolectadas en los tres años de estudio (2016, 2017 y 2018) en los campos de cultivo de sandía de la región de Ouargla: Ni, abundancia; F(%), frecuencia.

Species	2016		2017		2018	
	Ni	Fc%	Ni	Fc%	Ni	Fc%
Family Tenebrionidae						
<i>Mesostena longicollis</i> (Lucas, 1858)	13	17.80	12	18.75	16	16.16
<i>Alphitobius diaperinus</i> (Panzer, 1796)	0	0	0	0	1	1.01
<i>Pimelia angulata</i> ssp.	8	10.95	5	7.81	3	3.03
<i>Pimelia angulata expiata</i> (Peyerimhoff, 1923)	7	9.58	9	14.06	11	11.01
<i>Pimelia</i> sp.	0	0	0	0	1	1.01
<i>Pimelia (Chaetotoma) cephalotes</i> (Pallas, 1781)	5	6.84	2	3.12	1	1.01
<i>Trachyderma (Atrachyderma) hispida</i> (Forsk., 1775)	8	10.95	5	7.81	9	9.09
<i>Cheirodes sardous</i> (Gené, 1839)	0	0	0	0	8	8.08
<i>Gonocephalum rusticum</i> (Olivier, 1811)	6	8.21	3	4.68	1	1.01
<i>Gonocephalum</i> sp.	5	6.84	2	3.12	9	9.09
<i>Blaps</i> sp. 1	3	4.10	2	3.12	5	5.05
<i>Blaps</i> sp. 2	1	1.36	5	7.81	3	3.03
<i>Imatismus villosus</i> (Haag–Rutenberg, 1870)	1	1.36	2	3.12	4	4.04
<i>Lagria villosa</i> (DeGeer, 1775)	3	4.10	2	3.12	5	5.05
<i>Tribolium confusum</i> (Hertst., 1797)	4	5.47	2	3.12	3	3.03
<i>Zophosis letheirryi</i> (Deyrolle, 1867)	1	1.36	2	23.12	5	5.05
<i>Heliotaurus</i> sp.	7	9.58	11	17.18	9	9.09
<i>Corticeus unicolor</i> (Piller and Millerpacher, 1783)	1	1.36	0	0	5	5.05
Family Carabidae						
<i>Pheropsophus (Pheropsophus) africanus</i> (Dejean, 1825)	14	58.3	11	64.6	7	33.33
<i>Carabus (Macrothorax) morbillosus</i> spp.	4	16.6	2	11.77	3	14.28
<i>Calisoma (Campalita) algiricum</i> (Géhin, 1885)	2	8.8	2	11.77	5	23.80
<i>Pterostichus (Pseudomaseus) nigrita</i> (Paykull, 1790)	4	16.6	2	11.77	6	28.57
Family Scarabaeidae						
<i>Hybosorus illigeri</i> (Reiche, 1853)	0	0	1	5.00	3	10.34
<i>Phyllognathus exavatus</i> (Forester, 1771)	11	26.19	8	40	6	20.68
Scarabaeidae indeterminé	0	0	0	0	2	6.89
<i>Oxythyrea feunesta</i> (Poda, 1761)	17	40.47	5	25.00	7	24.13
<i>Tropinota squalida</i> (Scopoli, 1763)	14	33.34	6	30	11	37.93
Family Curculionidae						
<i>Lixus</i> sp. 1	1	10	1	10	1	8.33
<i>Lixus</i> sp. 2	1	10	3	30	5	41.67
<i>Bradybatus</i> sp.	1	10	3	30	4	33.34
<i>Lixus algirus</i> (Fabricius, 1801)	7	70	3	30	1	8.33
Curculionidae indeterminé	0	0	0	0	1	8.33
Family Dermestidae						
<i>Attagenus heydeni</i> (Reitter, 1881)	1	50	1	100	3	60
<i>Attagenus eremivagus</i> (Peyerimhoff, 1943)	1	50	0	0	2	40
Family Coccinellidae						
<i>Scymnus</i> sp. 1	9	9.27	11	14.10	8	7.84
<i>Coccinella septempunctata</i> (Linnaeus, 1758)	3	3.09	7	8.97	5	4.9
<i>Coccinella quinquepunctata</i> (Linnaeus, 1758)	1	1.03	1	1.28	3	2.94
<i>Hippodamia variegata</i> (Goeze, 1777)	78	80.41	51	65.38	83	81.37
<i>Coccinella algerica</i> (Kovar, 1977)	6	6.18	8	10.25	3	2.94
Family Chrysomelidae						
<i>Altica</i> sp.	4	40	5	71.42	3	30
<i>Podagrica fuscicornis</i> (Linnaeus, 1767)	6	60	2	28.58	7	70
Family Cryptophagidae						
<i>Cryptophagus</i> sp.	1	100	0	0	2	100
Family Staphylinidae						
<i>Aleochara</i> sp.	1	16.66	6	85.71	2	100
<i>Eusphalerum signatum</i> (Märkel, 1857)	3	50	1	14.29	0	0
<i>Lathrobium fulvipenne</i> (Gravenhorst, 1806)	2	33.34	0	0	0	0
Family Anticidae						
Anticidae indeterminé sp. 1	1	11.11	1	14.28	3	30
Anticidae indeterminé sp. 2	1	11.11	2	28.57	4	40
<i>Anthicus floralis</i> (Linnaeus, 1758)	7	77.78	4	57.15	3	30
Family Elateridae						
<i>Agriotes</i> sp.	2	66.66	1	50	2	50
<i>Aeoloderma crucifer</i> (P. Rossi, 1790)	1	33.34	1	50	2	50
Family Nitidulidae						
<i>Omosita depressa</i> (Linnaeus, 1758)	0	0	0	0	1	100

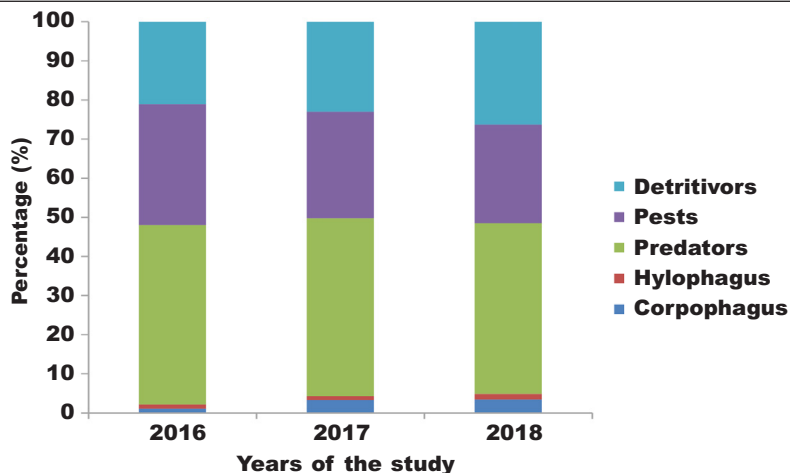


Fig. 4. Diversity and abundance of functional groups of beetles collected over the three years of the study.

Fig. 4. Diversidad y abundancia de los grupos funcionales de escarabajos recolectados según el año de estudio.

Concerning the Shannon diversity index (H') for collected beetle families in watermelon fields according to the years of collection, 2018 was the most diverse ($H' = 4.63$ bits), followed by 2016 ($H' = 4.37$ bits) (fig. 3). These high values reflect the importance of the richness and diversity of the selected environments. The Pielou equity index (E) was substantially similar over the three years of study.

The diet of the harvested species was divided into five trophic categories. Figure 4 shows the predominance of predatory beetles, with a rate of 45.81% in 2016, 45.53% in 2017, and 43.59% in 2018. Most of these predators were Carabids and Coccinellidae. Pests were most numerous in 2016 (30.91%). The proportion of scavenging insects, however, was almost identical over the three years of sampling.

Discussion

The aim of this study was to determine which beetle species were associated with the watermelon crop in the region of Ouargla. This would be the first step towards developing methods to control plant pests and to preserve auxiliaries in the environment. The beetles we identified belonged to 12 families, the most common being Tenebrionidae, Coccinellidae, Carabidae, Scarabeidae, and Curculionidae.

The Shannon Index of the beetle family showed that watermelon fields were colonized by approximately the same number of insect families over the three years of the study. Furthermore, the equity index was close to unity, indicating a relatively similar abundance among the families with similar diversity over the years of the study. This is most likely explained by the cultural practices being similar throughout the study.

Coleoptera are the richest group of insect species in the world. Their widely diverse way of life (as phytophages, decomposers, auxiliary, predators, etc) allows them to play an ecological role in agro ecosystems (Kromp, 1999).

Eighteen species of beetles were identified as pests. The most harmful species (*Oxythera feunesta*, *Phyllognathus exavatus*, *Tropinota squalida*, *Anthicus floralis*, *Heliotaurus* sp.) were observed in watermelon plots in the region of Ouargla. These results were similar to those found by Tendeng et al. (2017) who demonstrated that the culture of Cucurbitaceae harbors a multitude of insects from many orders. Same authors have reported that pests of Cucurbitaceae: *Bactrocera cucurbitae*, *Leptoglossus australis* and *Diaphania indica* have also caused problems in the production watermelon, and also cucumber, in the region of Basse Casamance (Senegal). The low production of watermelon and cucumber in Lower Casamance was explained by the fact that many producers were discouraged by the significant damage caused, in the main, by *B. cucurbitae* (Tendeng et al., 2017). In contrast, in a study on the auxiliaries of vegetable crops on Reunion Island (Vayssières et al., 2000) showed that the main pests identified in the Cucurbitaceae family were: *Bactrocera cucurbitae* (Coq.), *Dacus ciliatus* Loew, *Dacus demmerezi* (Bezzi) (all three being Diptera, Tephritidae) and *Aphis gossypii* Glover (Hemiptera, Aphididae). The results also demonstrated that alongside pests, many useful beetles (predators and decomposers) coexist in watermelon crops. Zappalà et al. (2013) indicated that the presence of auxiliaries (predators and parasitoids) contributes significantly to the decrease in the numbers of pest populations, thus reducing the need to intervene to control their development. According to Son et al. (2018) the presence of natural enemies is partially linked to that of pests. According to Vayssières et al. (2000) Coccinellidae beetles are polyphagous predators not only of Aphididae but also Aleyrodidae, Margarodidae and Coccidae, especially in the larval state but also in adults. *Scymnus constrictus* Mulsant has been observed as an essential predator of *A. gossypii* on Cucurbitaceae in all coastal areas and at medium altitude.

Conclusion

The present study allowed us to determine the biodiversity of insects associated with the watermelon crop in the region of Ouargla, Algeria. This is the first step towards setting up a database that could provide useful information before establishing a pest control strategy. After identification, 50 species of beetles belonging to 12 families were listed (see table 2), essentially belonging to the families of Tenebrionidae, Scarabaeidae, Coccinellidae, Carabidae, Curculionidae, among which, 14 genera and species of insects are recognized as pests.

Besides the coexistence of pests and useful insects we identified 12 species of predators and 14 species of decomposers. This inventory represents a first approach and constitutes a working tool for the implementation of integrated pest management actions.

Table 2. Trophic characterization of captured entomofauna in watermelon fields in the region of Ouargla: D, detritivores; PE, pests; PR, predators; H, hylophagus; C, coprophagus.

Tabla 2. Caracterización trófica de la entomofauna capturada en los campos de cultivo de sandía de la región de Ouargla: D, detritívoros; PE, plagas; PR, predadores; H, hilófagos; C, coprófagos.

Species	Trophism
Family Tenebrionidae	
<i>Mesostena longicollis</i> (Lucas, 1858)	D
<i>Alphitobius diaperinus</i> (Panzer, 1796)	C
<i>Pimelia angulata</i> ssp.	D
<i>Pimelia angulata expiata</i> (Peyerimhoff, 1923)	D
<i>Pimelia</i> sp.	D
<i>Pimelia (Chaetotoma) cephalotes</i> (Pallas, 1781)	D
<i>Trachyderma (Atrachyderma) hispida</i> (Forskl, 1775)	D
<i>Cheirodes sardous</i> (Gené, 1839)	D
<i>Gonocephalum rusticum</i> (Olivier, 1811)	D
<i>Gonocephalum</i> sp.	D
<i>Blaps</i> sp. 1	D
<i>Blaps</i> sp. 2	D
<i>Imatismus villosus</i> (Haag–Rutenberg, 1870)	D
<i>Lagria villosa</i> (DeGeer, 1775)	R
<i>Tribolium confusum</i> (Hertst, 1797)	R
<i>Zophosis letheirryi</i> (Deyrolle, 1867)	D
<i>Heliotaurus</i> sp.	PE
<i>Corticeus unicolor</i> (Piller and Millerpacher, 1783)	PE
Family Carabidae	
<i>Pheropsophus (Pheropsophus) africanus</i> (Dejean, 825)	PR
<i>Carabus (Macrothorax) morbillosus</i> spp.	PR
<i>Calisoma (Campalita) algiricum</i> (Géhin, 1885)	PR
<i>Pterostichus (Pseudomaseus) nigrita</i> (Paykull, 1790)	PR
Family Scarabaeidae	
<i>Hybosorus illigeri</i> (Reiche, 1853)	PR
<i>Phyllognathus exavatus</i> (Forester, 1771)	PE
Scarabaeidae indeterminé	C
<i>Oxythyrea feunesta</i> (Poda, 1761)	PE
Family Curculionidae	
<i>Lixus</i> sp. 1	PE
<i>Lixus</i> sp. 2	PE
<i>Bradybatus</i> sp.	PE
<i>Lixus algirus</i> (Fabricius, 1801)	PE
Curculionidae indeterminé	PE
Family Dermestidae	
<i>Attagenus heydeni</i> (Reitter, 1881)	C
<i>Attagenus eremivagus</i> (Peyerimhoff, 1943)	C
Family Coccinellidae	
<i>Scymnus</i> sp. 1	PR
<i>Coccinella septempunctata</i> (Linnaeus, 1758)	PR
<i>Coccinella quinquepunctata</i> (Linnaeus, 1758)	PR
<i>Hippodamia variegata</i> (Goeze, 1777)	PR
<i>Coccinella algerica</i> (Kovar, 1977)	PR
Family Chrysomelidae	
<i>Altica</i> sp.	PE
<i>Podagrica fuscicornis</i> (Linnaeus, 1767)	PE
Family Cryptophagidae	
<i>Cryptophagus</i> sp.	D
Family Staphylinidae	
<i>Aleochara</i> sp.	C
<i>Eusphalerum signatum</i> (Märkel, 1857)	PR
<i>Lathrobium fulvipenne</i> (Gravenhorst, 1806)	PR
Family Anticidae	
Anticidae indeterminé sp. 1	PE
Anticidae indeterminé sp. 2	PE
<i>Anthicus floralis</i> (Linnaeus, 1758)	PE
Family Elateridae	
<i>Agriotes</i> sp.	H
<i>Aeoloderma crucifer</i> (P. Rossi, 1790)	H
Family Nitidulidae	
<i>Omosita depressa</i> (Linnaeus, 1758)	C

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