

Diet Selection of *Heteracris littoralis* in a Cultivated Environment, Mzab Valley, Septentrional Sahara, Algeria

Youcef Zergoun, Laboratoire des Bio-ressources Sahariennes: Préservation et Valorisation, Département des Sciences Agronomiques, Faculté des Sciences de la Nature et de la Vie et Sciences de la Terre. Université Kasdi Merbah, 30000 Ouargla, Algeria / Département des Sciences Agronomiques, Faculté des Sciences de la Nature et de la Vie et Sciences de la Terre, Université de Ghardaïa, 47000 Ghardaïa, Algeria, **Omar Guezoul**, **Makhlouf Sekour**, Laboratoire des Bio-ressources Sahariennes: Préservation et Valorisation, Département des Sciences Agronomiques, Faculté des Sciences de la Nature et de la Vie et Sciences de la Terre, Université Kasdi Merbah, 30000 Ouargla, Algeria, **Noureddine Bouras**, Département de Biologie, Faculté des Sciences de la Nature et de la Vie et Sciences de la Terre, Université de Ghardaïa, 47000 Ghardaïa, Algeria, **and Michael D. Holtz**, Field Crop Development Centre, Alberta Agriculture and Forestry, Alberta T4L1W8, Canada (Algeria/Canada)

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ABSTRACT

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This paper presents the results of a study on the diet of *Heteracris littoralis* in an agro-ecosystem at Mzab valley, Ghardaïa Province, Northern Sahara, Algeria. The diet was determined by the analysis of plant fragments in the feces of *H. littoralis* sampled in the field. The studied grasshopper consumed 12 of the 30 plant species found in the cultivated environment. The results showed that the locust predominantly fed on a few plants, such as *Lagenaria siceraria* and *Solanum lycopersicum*, although their diet includes over 12 plant species. Its food niche breadth was narrow (0.51), with a selectivity index of 0.61 for females, 0.52 for males and 0.42 for larvae. The plants consumed by the two sexes and larvae were not significantly different. This study suggests that Eypreocnemidinae is a polyphagous grasshopper species, in spite of pronounced preference towards Cucurbitaceae and Solanaceae. This property results in a low Berger-Parker index value (0.24). Results are of great significance, increasing the understanding of insect herbivore feeding behavior and how to control the damage caused by this Orthoptera.

Keywords: Algeria, food selection, *Heteracris littoralis*, Mzab valley, niche breadth, Septentrional Sahara

Corresponding author: Noureddine Bouras
Email: noureddine_bouras@yahoo.fr

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There are more than 500 species of acridids (Orthoptera: Acridoidea) that can cause damage to pastures and crops (Duranton et al. 1982), and about 50 are considered major pests. Although locust outbreaks

are now better controlled and invasions are often shorter and reduced in extent, large outbreaks of both locusts and grasshoppers continue to occur in many parts of the world (Zhang et al. 2019). In Algeria, there are many locust and grasshopper species, which periodically cause significant damage on crops (Doumandji and Doumandji-Mitiche 1994). Among them, *Heteracris littoralis* (Rambur, 1838) occurs mainly in area of the Mزاب valley, Northern Sahara, Algeria where it constitutes a major problem to several cultivated plants. Although many common species have been studied exhaustively due to their significance as agricultural pests, information on Acridid species showing a high degree of feeding specialization remains sparse. However, quantitative data on the feeding and the amount consumed by *H. littoralis* in Algeria and the Sahara are practically absent because the only species that are well-studied are the gregarious and economically important species such as the migratory locust *Locusta migratoria*, the desert locust *Schistocerca gregaria*, and the Moroccan locust *Dociostaurus maroccanus*. The geographic distribution of *H. littoralis* is around the Mediterranean (southern Spain, Turkey); North Africa (Libya, Egypt, Saharan oases); Sahel (from Mauritania to Sudan); Middle East (Iraq and Iran); Arabian Peninsula; Afghanistan; Pakistan; South West Asia; India; Kazakhstan; Turkmenistan (Louveau et al. 2020). *H. littoralis* is an important pest of crops in East Africa and feeds on many different plants, causes moderate to severe damage to sorghum, rice, cotton and vegetable crops (Duranton et al. 1982). This Eyprepocnemidinae is considered one of the most harmful pests of different cultivated crops in

Egypt. Its economic importance comes from attacking many cultivated crops, vegetables and even trees, and the resulting great losses in quantity and quality of the attacked crop. In some cases, thousands of cultivated hectares may be attacked by grasshopper swarms leaving it as a desolate desert (Sharaby et al. 2010; Sharaby et al. 2012; Sharaby et al. 2013; Sabbour 2014).

This study was undertaken following field observations of an apparent preference by the grasshopper *H. littoralis* as indicated by the considerable damage on Cucurbitaceae and Solanaceae. Interest in the importance of Cucurbitaceae and Solanaceae in the valley agriculture and the special relationship of these crops and *H. littoralis* led to a field study of this Eyprepocnemidinae diet in this agrosystem in the Northern Algerian Sahara. Therefore, this investigation was conducted aiming: (i) to estimate the diet composition of *H. littoralis* using the fecal analysis technique, (ii) to analyze on grasshoppers' food selectivity and trophic niche breadth, and (iii) to characterize the damage caused by this Orthoptera.

MATERIALS AND METHODS

Study area.

The study was conducted between June and September of 2019 at a cultivated environment in the Mزاب valley (Ghardaïa), Northern Sahara, Algeria (Fig. 1). The region is situated at 32°26'-32°30'N in latitude and 3°36'-3°43' E in longitude and at an elevation of 558 m. Vegetative biomass at this site was dominated by the date palm (*Phoenix dactylifera*), citrus (*Citrus sinensis*), olive trees (*Olea europaea*), vegetable crops such as *Lagenaria siceraria*, *Cucurbita maxima*, *Cucumis melo*, *Capsicum*

annuum, *Solanum melongena* and *Solanum lycopersicum*, while common grasses included *Cynodon dactylon*, *Setaria verticillata* and *Polypogon monspeliensis* (Zergoun et al. 2018a, 2019). Climatically, the area is characterized by low rainfall (Zergoun

et al. 2018b). Average annual precipitation is about 65 mm, and the annual average temperature 22.3 °C. Air temperatures can fall as low as 4 °C in December and reaches 42 °C in July (ONM 2019). Soil type is Sandy-loamy soil.

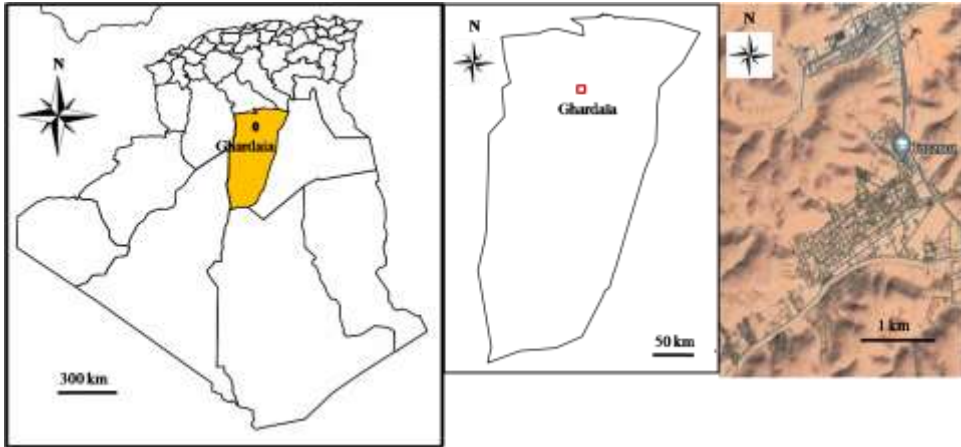


Fig. 1. Geographic location of the studied sites in the Mزاب Valley (Ghardaïa), Septentrional Sahara (Algeria).

Vegetation sampling.

We delimited a 500 m² (10 m × 50 m) sampling surface, in which we recorded the percentage cover of each plant species and was estimated following the methods described by Duranton et al. (1982). The plant species were determined by using the flora of Quezel and Santa (1962-1963).

Diet sampling.

For 4 months, 75 individuals of *H. littoralis* (25 males, 25 females and 25 larvae) were collected biweekly, in the morning after 9 a.m, and their feces were preserved for diet analysis. Feces were stored in plastic tubes, one tube per grasshopper. Age and sex of each grasshopper was noted on each sample. Analysis of the diet was performed by

feces content analysis, which is based on the recognition of epidermal fragments of the consumed plants contained in the feces, using a light microscope (Launois-Luong 1976). The determination is made by comparing to reference epidermises, prepared from fresh plants collected from the study site.

Data analysis.

Frequency of occurrence was calculated for each food item present based on the number of fields containing a particular food item. Frequency was converted to relative frequency. The Diet Selectivity Index (SI) for field collected *H. littoralis* was determined according to the formula: $SI = D/P$, where D = percentage of a plant

species consumed and P = percentage of biomass of the same species in the environment (Wang 2001). A SI of 1 indicates that the plant species was consumed in the same ratio as its availability (i.e., no preference). A SI > 1 indicates that a greater proportion of that plant species was eaten than was available, and thus was a preferred food for the herbivore. A SI < 1 indicates that the herbivore ate a smaller proportion of that species, than was presented, and thus that plant was less preferred by the herbivore. Sampling adequacy was determined using Lehner's formula (Lehner 1996): $Q = 1 - N_1/I$, ranging from 0 to 1, where N_1 is the number of the food components occurring only once, and I is the total number of the food components.

To determine the consumption rate (T %) of *H. littoralis*, the method proposed by Doumandji et al. (1993) has been used to estimate the surfaces of the fragments contained in the feces. $T = S / \sum S * 100$. T: the consumption rate of a given plant species is the percentage of leaf area of this species ingested by *H. littoralis*, by comparison to the total leaf area ingested. S: the average area of a plant species consumed by N individuals.

Population-level diet breadths were quantified using the Levins (1968) measure that is estimated by measuring the uniformity of distribution of individuals among the resource states. He suggested one way to measure this was: $B = 1 / \sum p_j^2$, where: B = Levins' measure of niche breadth, p_j = fraction of items in the diet that are of food category j. Hurlbert (1978) suggested the following measure for standardized niche breadth: $BA = B - 1/n - 1$, where BA = Levins' standardized niche breadth, B = Levins' measure of niche breadth, n = Number of possible

resource states. The second, the Shannon-Weaver information-theoretic index (Pielou 1969), was used: $H' = - \sum_{i=1}^s P_i * \ln P_i$, where P_i represents the proportion in which each resource state is used by the species. H' weights the relative abundance of different resources utilized by the grasshopper species as a whole (Otte and Joern 1977). To determine the level of food specialization of males, females and larvae, the Berger-Parker dominance index (d) was calculated by the following formula (Magurran 1988): $d = N_i \max / N$, where N is the number of all recorded food components (taxa), and $N_i \max$ is the number of specimens from taxon i (the most numerous taxon in the diet). The Berger-Parker index (d) varies between 1/N and 1. A value closer to 1 indicates higher specialization in the choice of food, while a value closer to 1/N is typical of species that are general feeders (polyphagous) (Capello et al. 2012). We used Kruskal-Wallis non-parametric one-way analysis of variance to test for differences of plant fragments frequency found in the feces of males, females and larvae. P values of 0.05 or smaller were interpreted as significant. All statistics were performed using statistical package Past 3.4 (Hammer et al. 2014). All data transformations were done in Excel.

RESULTS

Thirty plant species belonging to 15 families occurred in the cultivated environment. The most frequent family was represented by the Poaceae with 11 species (36.7% of the total number of plant species). The Cucurbitaceae and the Solanaceae (10% each) followed the Poaceae in importance. The Asteraceae was represented by two species (6.7%). The 11 remaining families were

represented by a single species (3.3% each). The plant cover of this site was above average (63.89%). This indicates the greater probability of finding considerable number of Orthoptera within the habitat. Analysis of feces from 75 individuals of *H. littoralis* shows the diet was 83.3% Dicotyledons and only 16.7% Monocotyledons. Among thirty species found in the habitat, only twelve have been identified at least once in feces as indicated in Table 1.

L. siceraria made up 23.96% in the feces of the grasshoppers but constituted 4.02% of the percentage cover in the habitat. *S. lycopersicum* accounted for 20.14% in the feces of the acridid and only 4.95% of the percentage cover. *C. maxima* made up 14.58% in the feces of the insects but constituted 3.77% of the percentage cover in the site. The results of the diet selectivity index revealed that, this Orthoptera has a definite selectivity for seven cultivated plants; this marked selectivity for food crops could be attributed to the ability of these plants to strongly support the growth and development of *H. littoralis*.

Quantitatively, *L. siceraria* is well consumed, characterized by a consumption rate of 19.78%, followed by *S. lycopersicum* (18.27%), *C. maxima* (14.31%), *C. melo* (12.21%), and *S. melongena* (11.36%); however, other plant species are less consumed.

The percentages cover of food plants in the environment does not appear to affect the relative frequency of plant fragments found in the feces. However, a comparison of relative frequency of plant fragments found in

the feces with the percentage cover of food plants in the habitat using the non-parametric Kruskal-Wallis test did not reveal any significant differences (Kruskal-Wallis test, $\chi^2 = 0.85$, P -value = 0.3556). The same was true for a comparison of the diet selectivity index with the percentage cover of food plants in a cultivated environment (Kruskal-Wallis test, $\chi^2 = 1.47$, P -value = 0.2253).

In terms of a composite diet for *H. littoralis*, cultivated plants constituted 92.36%, forbs constituted 3.82% of the diet, and grasses contributed by 3.82% of the diet. Fecal pellet analysis of this Acrididae showed that 2.67% of both larvae and adults had eaten only one plant, 54.67% had eaten 2 plants, and 42.67% ate 3 plants. The analysis of fecal pellets demonstrated that over 97% of the individual of this Eyprepocnemidinae, had diversified their diet, eating 2 to 3 plants species, while the rest of the grasshoppers had eaten only one plant species. The adults ate 12 plant species each; on the other hand, only 7 plants species were selected by larvae of *H. littoralis* in the following order of preference: *S. lycopersicum*, *L. siceraria*, *C. maxima*, *S. melongena*, *Mentha pulegium*, *C. melo* and *C. annuum* (Fig. 2).

The sampling adequacy is considered sufficient (0.97). The trophic niche breadth of females has the highest value (0.61), followed by males (0.52) and larvae showed the lowest value (0.42) (Table 2). This is confirmed by the values of the Shannon-Wiener Measure: female (2.20), males (2.10) and larvae (1.50).

Table 1. Plant species found in the diet of *Heteracris littoralis*, in a cultivated environment, Mzab valley (Septentrional Sahara, Algeria)

Families	Vegetable species	C (%)	F (%)	SI	T (%)
Arecaceae	<i>Phoenix dactylifera</i>	8.48	-	-	-
Rutaceae	<i>Citrus sinensis</i>	3.77	-	-	-
Oleaceae	<i>Olea europaea</i>	2.83	-	-	-
Vitaceae	<i>Vitis vinifera</i>	2.12	-	-	-
Cucurbitaceae	<i>Lagenaria siceraria</i>	4.02	23.96	5.96	19.78
	<i>Cucurbita maxima</i>	3.77	14.58	3.87	14.31
	<i>Cucumis melo</i>	2.51	11.81	4.70	12.21
Solanaceae	<i>Capsicum annum</i>	2.54	6.94	2.73	8.50
	<i>Solanum melongena</i>	2.54	9.03	3.55	11.36
	<i>Solanum lycopersicum</i>	4.95	20.14	4.07	18.27
Lamiaceae	<i>Mentha pulegium</i>	3.14	5.90	1.88	6.57
Poaceae	<i>Cynodon dactylon</i>	7.85	2.08	0.27	2.86
	<i>Setaria verticillata</i>	4.91	1.74	0.35	2.69
	<i>Polypogon monspeliensis</i>	0.49	-	-	-
	<i>Digitaria commutata</i>	0.39	-	-	-
	<i>Dactyloctenium aegyptium</i>	0.34	-	-	-
	<i>Anisantha sterilis</i>	0.25	-	-	-
	<i>Lolium multiflorum</i>	0.29	-	-	-
	<i>Hordeum murinum</i>	0.25	-	-	-
	<i>Agrostis stolonifera</i>	0.39	-	-	-
	<i>Stipagrostis plumosa</i>	0.34	-	-	-
<i>Phragmites australis</i>	0.57	-	-	-	
Cyperaceae	<i>Cyperus rotundus</i>	0.39	-	-	-
Asteraceae	<i>Sonchus oleraceus</i>	0.44	-	-	-
	<i>Crepis capillaris</i>	1.23	1.04	0.59	0.93
Convolvulaceae	<i>Convolvulus arvensis</i>	0.29	-	-	-
Amaranthaceae	<i>Amaranthus hybridus</i>	0.35	-	-	-
Zygophyllaceae	<i>Tribulus terrestris</i>	2.94	1.74	0.88	1.18
Polygonaceae	<i>Rumex vesicarius</i>	0.32	-	-	-
Malvaceae	<i>Malva parviflora</i>	1.18	1.04	0.85	1.35
Total / Rate	30	63.89	100	-	100

C (%): Percentage cover, F (%): Relative frequency of plant fragments found in the feces, SI: The diet selectivity index, T (%): consumption rate, (-): Absent species.

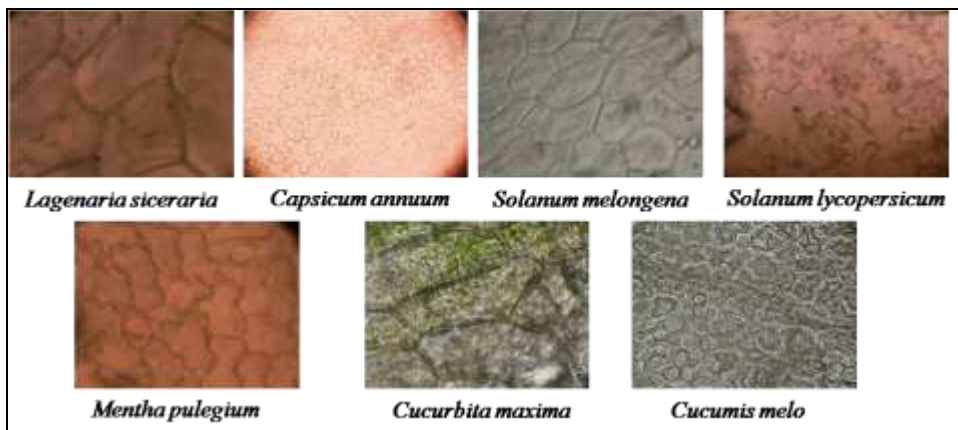


Fig. 2. Epidermis of the main cultivated plants found in the feces of *Heteracris littoralis* (magnification: $\times 40$).

Table 2. Different ecological indices applied to diet of *Heteracris littoralis* in agriculture ecosystem in Mزاب valley (Septentrional Sahara, Algeria)

Index	Males(M)	Females (F)	Larvae(L)	All individuals (M + F + L)
Number of specimens	25	25	25	75
Number of plants consumed	12	12	7	12
Diet breadths (B_A)	0.52	0.61	0.42	0.51
Diversity index (H')	2.1	2.2	1.5	2.08
Berger-Parker index (d)	0.24	0.2	0.41	0.24

The Berger-Parker index of larvae showed a value of 0.41 (Table 2); because the majority of the diet consists of *S. lycopersicum* (41%) and *L. siceraria* (32%) and only 27% of the diet consists of the remaining five plants, thus showing plant specificity. The Berger-Parker index of males and female showed considerably low values (0.24 and 0.20) (Table 2), because most of the diet distributed over four plant species were: *L. siceraria* (24-20%), *C. maxima* (17-16%), *S. lycopersicum* (15% each), *C. melo* (14% each), thus showing a low specificity.

DISCUSSION

In our study, *H. littoralis* consumed 12 plant species and mainly selected Cucurbitaceae and Solanaceae, such as *L. siceraria*, *C. maxima*, *S. lycopersicum* and *S. melongena*. This preference may in part be due to the behavioral characteristics of the grasshopper in its particular habitat. Field observations have indicated that this Caelifera is primarily vegetation dwelling, feeding and roosting on vegetation at all times. Only 7 plant species were selected by larvae of this grasshopper. This may be due to the larvae having a more limited range of

movement, due to a lack of fully formed wings, which could restrict their diet. The present study showed that plants of the Cucurbitaceae and Solanaceae were the preferred food source. *H. littoralis* may act as a pest of some of the economically important plant species of those families in the study area. Since there has been no previous study of this nature involving phytophagous Acridids of the Mزاب valley, the present finding brings to light some observations that may have major agro-economic importance. At Beni Abbes oasis, South-West of Algeria, the analysis of the feeding diet of *H. annulosa* shows that it consumes only six Poaceae (Ould Elhadj 1999). In East Africa, *H. littoralis* causes moderate to severe damage to sorghum, rice, cotton and vegetable crops (Duranton et al. 1982). Previous research in Egypt has shown that *H. littoralis* is more common in cultivated crops, vegetables and even trees, feeding on those and causing great losses in quantity and quality of the attacked crop (Sharaby et al. 2013; Sabbour 2014). A diet selectivity index value greater than 1.0 indicates that the plant species is preferred by the grasshopper (Huang et al. 2016). Indeed, we found seven crops with a food selectivity index higher than 1.0. This Eyprepocnemidinae always selected high quantities of Cucurbitaceae and Solanaceae, suggesting, perhaps, that they contained some essential nutrient, lacking in the other host plants. According to Yousaf et al. (2018), plant species belonging to the Cucurbitaceae family contain several naturally related triterpenes, collectively known as cucurbitacins. These are constitutive or insect-induced allelochemicals and have been shown to have acute and sublethal toxicity, as well as deterrent effects for feeding and

oviposition in insects (Agrawal et al. 1999; Tallamy et al. 1997). On the other hand, for many luperines (Coleoptera: Chrysomelidae: Galerucinae), cucurbitacins act as potent phagostimulants (Tallamy and Krischik 1989). As *H. littoralis* subsists almost entirely on plants in the Cucurbitaceae, which generally contain cucurbitacins, this suggests that cucurbitacins play a phagostimulant role in the diet of this Acridid. The following crops have been observed to suffer from *H. littoralis* during the study period: bottle gourd, pumpkin, tomato and melon. The feeding behavior of these insects through consumption rates can lead to increased damage to crop plants.

The niche breadth is the sum of different plant resources used by a species in an ecosystem (Zhang 2004). Generally, when food is abundant, herbivores tend to utilize the most available and suitable food resources which narrow their niche. In comparison, when food is lacking, herbivores will expand the range of plant species they consume, which widens their niche (Wang et al. 1996). According Capello et al. (2011), the diet breadth of grasshoppers varies from strict monophagy to extreme polyphagy. Between these extremes there are species exhibiting varying degrees of food selectivity. The food selection of *H. littoralis* in a cultivated environment in the Mزاب valley was studied and the results showed that the locust used 40% of the trophic resources of the habitat and the diet selectivity index showed that our insect presents preferences for some plants and caused severe damage to seven cultivated dicotyledonous plants. According Le Gall and Gillon (1989), in well-established assemblages of grasshoppers, outside forests, one can find almost half graminivorous species

and half for bivorous species. Moreover, Le Gall et al. (1998) noted that grasshoppers are not only graminivorous insects and they are not opportunistic feeders. Even if they potentially feed on a large number of plant species, they are highly selective among them. The selection of the Cucurbitaceae and Solanaceae by this Acrididae may be due to the water content of the plants. In fact, Latchininsky (2010) noted among the factors separating unpalatable from palatable food, the water content of the food plays a significant role. Specifically, based on our observation, we can say that Eypreocnemidinae would be associated with areas that had a greater percentage of forbs and in particular the Cucurbitaceae and Solanaceae. Oviposition sites are another cue to the feeding behavior of newly hatched stages and reproductive adults (Le Gall et al. 1998). At Mzab valley, *S. lycopersicum* patches are good places for oviposition sites and can modify feeding behavior. In fact, during the study period, the larvae of *H. littoralis* are very abundant in tomato plots. In order to control these pests, it is essential to be able to predict their spatial distribution and to understand the factors that lead to outbreaks (Huang et al. 2015). Diet influences locust population dynamics (Ibanez et al. 2013), and the plant availability and

feeding preferences are two major determinants of both locust diets and spatial distribution (Singer and Stireman 2001). Studies of grasshopper feeding habits and their interaction within plant communities are important for grasshopper control and protection of plant resources (Raymond et al. 2004; Lu et al. 2005). Our observations clearly showed that the Cucurbitaceae and Solanaceae influences the local presence and abundance of *H. littoralis*. This is undoubtedly due, in part, to the strong feeding preferences exhibited by this insect toward these two botanical families.

The present study showed that plants of the Cucurbitaceae and Solanaceae were most preferred. *H. littoralis* may act as a pest of some of the economically important plant species of those families in the study area. Since there has been no previous study of this nature involving phytophagous Acridid of Mzab valley, the present finding brings to light some observations, which may have major agro-economic importance. Future studies of the *H. littoralis* life cycle related to the plants on which it feeds under field conditions should be conducted to evaluate long-term responses that determine individual fitness, such as survival, development time, and fecundity.

RESUME

Zergoun Y., Guezoul O., Sekour M., Bouras N. et Holtz M.D. 2020. Sélection du régime alimentaire d'*Heteracris littoralis* dans un environnement cultivé, vallée du Mzab, Sahara septentrional, Algérie. Tunisian Journal of Plant Protection 15 (2): 69-80.

Cet article présente les résultats d'une étude sur le régime alimentaire d'*Heteracris littoralis* dans un agro-écosystème de la vallée du Mzab, Gouvernorat de Ghardaïa, Sahara septentrional, Algérie. Le régime alimentaire a été déterminé par l'analyse de fragments de plantes dans les fèces d'*H. littoralis* prélevés sur le terrain. Les individus analysés ont consommé 12 des 30 espèces végétales

trouvées dans le milieu cultivé. Les résultats ont montré que ce criquet se nourrissait principalement de quelques plantes, telles que *Lagenaria siceraria* et *Solanum lycopersicum*, bien que leur régime alimentaire comprenne plus de 12 espèces végétales. La largeur de sa niche alimentaire était étroite (0,51), avec un indice de sélectivité de 0,61 pour les femelles, 0,52 pour les mâles et 0,42 pour les larves. Les plantes consommées par les deux sexes et les larves n'étaient pas significativement différentes. Cette étude suggère que cet Eyprepocnemidinae est une espèce de criquet polyphage, malgré une préférence prononcée pour les Cucurbitacées et les Solanacées. Il en résulte une faible valeur de l'indice de Berger-Parker (0,24). Ces résultats sont d'une grande importance, augmentant la compréhension du comportement alimentaire des insectes herbivores et aide à contrôler les dommages causés par ces orthoptères.

Mots clés: Algérie, *Heteracris littoralis*, largeur de la niche, Sahara septentrional, sélection des aliments, vallée du Mzab

ملخص

زرقون، يوسف وعمر قزول ومخولوف سكور ونورالدين بوراس ومايكل هولتز. 2020. اختيار النظام الغذائي عند نوع الجراد *Heteracris littoralis*، في بيئة مزروعة، وادي مزاب، شمال الصحراء، الجزائر.

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يقدّم هذا البحث نتائج دراسة عن غذاء نوع الجراد *Heteracris littoralis* في نظام بيئي زراعي في وادي مزاب، ولاية غرداية، شمال الصحراء، الجزائر. تم تحديد النظام الغذائي من خلال تحليل أجزاء النبات في براز *H. littoralis* التي تم أخذ عينات منها في الحقل. استهلك هذا النوع من الجراد الذي أجريت عليه الدراسة 12 نوعاً من أصل 30 نوعاً نباتياً موجودة في البيئة المزروعة. أظهرت النتائج أن هذه الجرادات تتغذى في الغالب على عدد قليل من النباتات، مثل *Lagenaria siceraria* و *Solanum lycopersicum*، على الرغم من أن النظام الغذائي يشمل أكثر من 12 نوعاً من النباتات. كان مجال مكان الغذاء ضيق (0,51)، بمؤشر اختيار 0,61 للإناث و 0,52 للذكور و 0,42 لليرقات. لم تكن النباتات التي استهلكها كلا الجنسين واليرقات مختلفة معنوياً. تشير الدراسة إلى أن هذه الجرادات التي تنتمي إلى تحت-فصيلة Eyprepocnemidinae هي نوع من الجراد متعدد العوائل، على الرغم من التفضيل الواضح تجاه القرعيات والبانجانجيات. ينتج عن ذلك قيمة منخفضة لمؤشر Berger-Parker (0,24). إن لهذه النتائج أهمية كبيرة، حيث زادت من فهم سلوك تغذية الحشرات العاشبة وتساعد على السيطرة على الأضرار الناجمة عن مستقيمات الأجنحة.

كلمات مفتاحية: اختيار الغذاء، الجزائر، شمال الصحراء، مجال مكان الغذاء، وادي مزاب، *Heteracris littoralis*

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