FOOD CONSUMPTION AND UTILISATION OF THE GRASSHOPPER *CHROTOGONUS LUGUBRIS* BLANCHARD (ORTHOPTERA, ACRIDOIDEA, PYRGOMORPHIDAE) AND ITS EFFECT ON THE EGG DEPOSITION

ABDEL RAHMAN, K. M.

ABSTRACT

The grasshopper is found all the year round. It is considered as a pest for seedlings. The consumption index differed significantly between groups fed on different diets. Mated females consume more food than virgin females or virgin males. The highest values were recorded for the bean seedlings fed groups indicating some inadequacy in the nutritional value of bean. The growth rate was the highest in clover fed groups. Insects were able to digest bean and clover more efficiently than either wheat seedlings or cotton leaves. The growth rate was accompanied with a higher C.I. in bean, wheat, and cotton indicating that most of these food was excreted. The ECD and ECI were significantly higher in clover fed groups. This indicated that clover was utilised efficiently than the other groups. The different food stuff affected the egg production which could be attributed to the nutritional efficiencies of these diets. The preovipositional period and number of egg-pods were also affected. The number of abnormal egg-pods was the highest in the bean seedlings fed groups.

KEY WORDS: Acrididae, locust, diet, growth rate, egg production

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ABSTRAKT

Spotreba a využitie potravy boli študované u imág. Určená dávka čerstvej potravy bola poskytnutá hmyzu každý ráno a kontrola z rovnakej potravy bola uchovaná v rovnakých podmienkach za účelom zistenia množstva vody stratenej vyparovaním z poskytnutej potravy. Zvyšok neskonzumovanej potravy bol separovaný od trusu hmyzu a odvážený. Hmotnosť neskonzumovanej potravy boli spolu s počiatočnou a finálnou hmotnostou kontroly používané na odhadnutie množstva skonzumovanej potravy hmyzom. Potom hmotnosť sušiny skonzumovanej potravy bola vypočítaná a zaznamenaná podľa nasledujucího vzorca: Hmotnosť sušiny skonzumovanej potravy = (1-A/2) x (W – L (1 + B)), kde W = Hmotnosť čerstvej poskytnutej potravy, L = Hmotnosť sušiny neskonzumovanej potravy, A = Počiatočná hmotnosť kontroly, B = Finálna hmotnosť kontroly. Vyhodnotené indexy boli: index spotreby, rýchlosť rastu, approximacia trávenia, účinnosť premeny zožratej potravy na telovú hmotu a účinnosť premeny stráviteľnej potravy na telovú hmotu.

Index spotreby (C.I.) (tabuľka 2) indikuje, že oplodnené samičky skonzumujú viac potravy ako neoplodnené samičky (P<0.05). Najvyššia hodnota C.I. bola zistená pri oplodnených skupinách, ktoré sa kŕmili bôbom môže to byť vzhľadom na nutričnú neadekvátnosť bôbu. Hmyz v tomto prípade je donútený prijať viac potravy aby dostal dostatočne množstvo nutričnej hmoty. Pri neoplodnených samčekoch živených pšenicou a bôbom hodnoty indikovali že tieto druhy potravy môžu byť viac výživné ako ďatelina alebo bavlna. Rovnaké výsledky boli dosiahnuté mnohými autormi [4, 14, 15].

Rýchlosť rastu G.R. bola najvyššia pri skupine, ktorej sa živila ďatelinou (P<0.05). Najnižšia rýchlosť rastu bola pri skupine, ktorej sa živila bôbom, bavlnou a pšenicou bola sprevádzaná vyšším C.I. Toto indikuje, že väčšina tých potráv bola vylúčená. Vyššia rýchlosť rastu, účinnosť premeny zožratej a stráviteľnej potravy na telovú hmotu boli pri skupinách živiacich sa na ďateline ako tých ktorých sa živili na bôbe, bavlne a pšenici dokazujú, že ďatelina bola využiteľnejšia ako ostatne plodiny. Podobne výsledky boli urobené na Locusta migratoria [5], Schistocerca gregaria a Locusta migratoria [15], a Heteracris littoralis [4] podporujú naše zistenia. Vplyv rôznych potráv na vajcového vačku je znázornene v tabuľke 2. Oplodnené samičky produkovali viac vajcových vačkov ako neoplodnené samičky pri rovnakej potrave (P<0.05). Oplodnené samičky živiacich sa na bôbe produkovali najvyšší počet vajcových vačkov, z ktorých 15% boli normálne (P<0.05). Interval pred kladením vajíčok boli preukazný rozdielny medzi oplodnenými a neoplodnenými samičkami živiacich sa rovnakou potravou. Vplyv rôznych potráv na produkciu vajíčok môže byt spôsobený rozdielnymi nutričnými účinnosťami tých potráv. Podobne výsledky dosiahli mnohí autori [1], [2] [7], [13] a [14]. Rôzne potravy ovplyvnili interval pred kladením vajíčok rovnako ako pri iných druhoch hmyzu [11, 12]. Bolo tiež známe, že rôzne druhy potráv ovplyvňujú počet vajicových vačkov na jednu samičku.

INTRODUCTION

Grasshoppers represent a major group of insect pests in Egypt. The moderate weather conditions enable many pest species to exist all the year round. Of these insects is the grasshopper *Chrotogonus lugubris* which was recorded to be a seedling pest in Egypt [7]. *C. lugubris* is an indigenous geophilus and widely distributed in Egypt and can be seen jumping close to the fields and never get into the vegetation when the plants are fully grown. Of these plants that are very important in Egypt are clover, cotton, wheat and bean.

Scanning the available literature about this grasshopper, revealed a little work done by Ibrahim [6, 7, 8] on the ecology and biology of this grasshopper.

The present work thus was carried on to add to our knowledge some information about the consumption of different food stuff and its effect on the egg production.

MATERIAL AND METHODS

Adults and nymphs were collected from ”Abou-katata” and ”El-Mansouria” areas in Giza Governorate, near Cairo, Egypt. They were reared in electrically-heated breeding cages at constant temperature of 35 ± 1°C and photoperiod of 14 : 10 LD. The stock was maintained on clover (*Trifolium alexandrinum*) from November to June, and then on garden purslain (*Portulaca oleracea*) [7]. Cages were provided daily with suitable ovipositional containers filled with sieved washed and sterilised sand, which were always kept moist.

To study the food consumption and utilisation in the adult stage of *C. lugubris*, the insects were divided into three groups. The first group consisted of mated insects and included 10 replicates of a male and a female in each. The second group consisted of virgin females and included five replicates, five females in each. Likewise the third group consisted of virgin males and included five replicates of five males in each. Each group was reared in a suitable glass jar provided with an ovipositional pot. Experiments were carried out, starting from newly emerged adults till about the time the females laid their last egg-pod.

Every morning, definite quantities of fresh washed leaves were provided to the insects, and aliquots of the same food were kept in the same conditions to calibrate the water lost from the food provided. The food chosen was clover, *Trifolium alexandrinum,* cotton leaves, *Gossypium barbadense,* bean seedlings, *Vicia faba,* and wheat seedlings, *Triticum vulgare.* Uneaten food was separated from the faeces and weighed. This weight was used together with the initial and final weights of the aliquots to calibrate the approximate food consumed by insects. Then the dry weight of the food consumed was calculated and recorded according to the following equation developed by Waldbauer (1968):

Dry weight of food consumed:

$$(1 - A/2)\cdot(W - L(1 + B))$$

where: W - fresh weight of food provided, L - dry weight of uneaten food, A - initial weight of the aliquot, B - final weight of the aliquot

The differences between the weight of food consumed by mated pairs and that consumed by isolated males would give an estimation of the weight of food consumed by mated females. The weight of the faeces produced by mated females was estimated in the same manner. Faeces were dried at 100°C and their dry weight was recorded.

The insects were weighed every morning, and the weight gained or lost (due to egg-deposition) was recorded. Dry weights of insects were compared with those groups of insects reared in the same feeding conditions. At certain physiological periods, the fresh weight of 5 insects from each feeding group was recorded. Then they were killed immediately and air dried at 100°C, and their dry weight was recorded. The physiological periods chosen were the newly emerged adults, before and after oviposition. The dry and fresh weights of these insects were used to calibrate the dry weight of the tested insects at the same physiological period. The following equation was used:

$$D_1W_1 = \frac{(DW/FW)}{F_1W_1}$$

where: FW and DW are the fresh and dry weight of the insect used in calibration, F_1W_1 and D_1W_1 are the fresh and dry weight of the tested insect, respectively.

The dry weight of the eggs deposited was calculated by drying the whole egg-pod at 100°C, then its dry weight was recorded. Thereafter, the pod was heated to 250°C for 3 hrs., so that the sand particles become loosened; then the burnt biomass, i.e., the eggs and the foamy secretion could be easily removed and sand particles were then weighed; the difference between the dry weight of the whole egg-pod and sand particles was considered as the dry weight of the biomass. Abnormal egg-pods (that were not laid in the oviposition pot) were removed from the rearing jars and were air dried and weighed.

The indices calculated were:

1. The Consumption Index:

$$C.I. = F/TA$$

where F is dry weight of food ingested, T - Duration of feeding period (in days), A - mean dry weight of the insect

According to Waldbauer (1968), the mean dry weight "A" of the insect during the experiment was calculated from the area under its growth curve (Figures 1-12).

2. The Growth Rate:

$$G.R = WT/TA$$

where WT = dry weight gained

3. Approximate Digestibility:

$$A.D. = ((F - Fe)/F) \cdot 100$$

where Fe = dry weight of faeces

4. Efficiency of conversion of ingested food to body substance E.C.I.

$$E.C.I. = (WT/F) \cdot 100$$

5. Efficiency with which digested food is converted into body substance E. C. D.

$$E.C.D = (WT/(F - Fe)) \cdot 100$$

RESULTS AND DISCUSSION

The amount of food consumed, the weight of faeces excreted and changes of the weight of the insect for each diet are represented in Figures 1 – 12. Table 1. shows the different consumption indices.

The consumption index (C.I.) indicates that mated females consumed more food than the virgin females

Table 1: Consumption indices in insects fed on different diets

Diet		C. I.		G. R.		A. D.		E. C. I.		E. C. D.	
		$X \pm S$ ($x\,10^{-2}$)	Range ($x10^{-2}$)	$X \pm S$ ($x\,10^{-4}$)	Range ($x10^{-4}$)	$X \pm S$	Range	$X \pm S$	Range	$X \pm S$	Range
Bean seedlings	FM	36.07 ± 3.12	31.1 – 46.8	35.4 ± 9.67	20 - 70	40.42 ± 2.41	37.15 – 44.80	0.93 ± 0.51	0.35 – 1.92	3.19 ± 1.22	0.173 – 6.24
	F	23.33 ± 1.34	21.9 – 24.8	41 ± 0.41	40 – 42	46.76 ± 2.03	44.30 – 48.94	1.75 ± 0.04	1.70 - 1.82	3.75 ± 0.12	3.50 – 4.11
	M	11.26 ± 0.26	11.1 – 11.54	18 ± 0.87	17 – 19	26.75 ± 2.05	23.73 – 28.21	0.26 ± 0.02	0.192 – 0.282	1.02 ± 0.01	0.921 – 1.025
Clover	FM	26.68 ± 2.41	18.4 – 29.96	67 ± 18.5	22 – 171	40.01 ± 5.69	28.37 – 48.63	2.55 ± 0.11	1.96 – 2.784	6.60 ± 1.25	3.84 – 8.73
	F	24.67 ± 3.62	17.04 – 32.4	74 ± 18.4	33 – 135	46.59 ± 8.92	27.70 – 56.91	3.03 ± 0.82	1.026 – 4.68	6.49 ± 1.17	3.704 – 9.83
	M	21.98 ± 3.31	16.6 – 25.6	34 ± 6.7	10 – 50	55.63 ± 4.23	44.41 – 63.10	1.69 ± 0.46	1.037 – 2.598	2.95 ± 1.9	1.063 – 4.618
Cotton leaves	FM	21.25 ± 4.66	11.65 – 28.4	22 ± 4.9	15 – 61	28.01 ± 6.11	20.52 – 34.24	0.55 ± 0.41	0.027 – 2.35	4.10 ± 1.56	1.45 – 8.26
	F	21.99 ± 3.91	14.2 – 30.3	50 ± 5.32	26 – 68	23.98 ± 5.54	13.29 – 36.95	2.39 ± 0.82	1.345 – 4.602	10.44 ± 3.41	4.40 – 18.37
	M	18.29 ± 1.03	16.76 – 19.7	8 ± 3.12	4 – 16	30.73 ± 4.33	21.03 – 36.03	0.94 ± 0.21	0.403 – 1.30	1.48 ± 2.2	0.16 – 5.41
Wheat seedlings	FM	17.76 ± 5.84	10.7 – 24	36 ± 9.42	21 – 130	16.56 ± 5.39	6.47 – 26.60	1.44 ± 0.22	0.49 – 2.92	7.29 ± 0.82	5.02 – 9.21
	F	15.12 ± 1.05	13.5 – 16.66	45 ± 4.62	36 – 53	18.12 ± 1.22	16.12 – 21.91	2.97 ± 0.15	2.70 – 3.16	12.70 ± 1.31	8.70 – 16.40
	M	11.12 ± 0.09	10.6 – 11.2	14.7 ± 0.32	14 - 15	19.25 ± 1.01	17.20 – 20.03	1.32 ± 0.08	1.288 – 1.43	6.43 ± 0.92	6.00 – 8.31

FM, F, M, mated females, virgin females, and mated males; X ± S, mean and the standard deviation, C. I., consumption index, G. R., growth rate, A. D., approximate digestibility, E. C. I., efficiency of conversion of ingested food into body substance, E. C. D., efficiency with which the digested food is converted into body substance.

(P<0.05). The C.I. was the greatest in bean seedling-fed mated females. There was no significant differences between the clover-, cotton-, or wheat seedlings-fed groups (P>0.05). in virgin females, the C.I. of wheat seedlings-fed group was significantly lower than those of the other groups (P<.05). In virgin males, the clover and the cotton fed groups had a significantly higher C.I. than those fed on bean or wheat.

The highest value of the C.I. for mated groups fed on bean might probably be due to nutritional inadequacy of bean. The insect might then be forced to devour more food to drive sufficient nutrients. In virgin females, the different values of the C.I. were not significant. In virgin males, values for wheat and bean indicated that these foods might be more nutritive than either clover or cotton. Such results were also obtained on *Schistocerca gregaria* and *Locusta migratoria* [15], *Zonocerus variegatus* [14], and *Heteracris littoralis* [4].

The growth rate G.R. was the highest in clover fed groups (P<0.05). The lower the growth rate in bean, cotton, and wheat was coupled with a higher C.I. This indicated that most of these food were excreted. The higher growth rate, the efficiency of conversion of ingested and digested food into body substance for groups fed on clover than those fed on bean, cotton and wheat suggested that clover might be utilised efficiently than the other groups. These results might be supported by the findings of Hoekestra and Beenakkers (1976) in *Locusta migratoria,* Mehrotra *et al.,* (1978), in *Schistocerca gregaria* and *Locusta migratoria,* and El-Shazly (1991) in *Heteracris littoralis.*

Insects were able to digest bean and clover more efficiently than cotton and wheat (P<0.05). The approximate digestibility was significantly higher in bean and clover-fed groups. This indicated that our insect digested bean and clover more efficiently than cotton or wheat (P<0.05). It is known that the approximate digestibility depended on the diet [5].

There was no significant differences between the mated or virgin females fed on clover, wheat or bean in the E.C.I. values (P>0.05). This value was significantly different between virgin and mated cotton-fed groups (P<0.05). The E.C.D. was higher in wheat and clover-fed mated females than cotton and bean-fed groups (P<0.05). Also, in virgin females, the E.C.D., was higher in wheat and cotton-fed groups than clover and bean-fed groups (P<0.05). The differences between E.C.D. values of mated and virgin groups fed on the same diet were not significant (P>0.05). This might be attributed to the fact that virgin females laid significantly fewer egg-pods than mated females. This might mean that mated females utilised food in energy for egg-production and deposition [18].

The influence of different diets on egg-pod is shown in Table 2. Egg-pods laid in sand were considered as "normal" egg-pods. Mated females produced more egg-pods than virgin females fed on the same diet (P<0.05). mated females fed on bean produced the highest number of egg-pods, from which, 15% were normal (P<0.05). The preoviposition period differed significantly between mated and virgin females fed on the same food. In mated females, the preoviposition period was more or less the same in clover and bean-fed groups and was significantly different from wheat and cotton groups (P<0.05). The difference between wheat and cotton fed groups was also significant (P<0.05).

Table 2: Egg-pod production of mated and virgin females fed on different diets and the percentage of normal egg-pods

Food	Bean seedlings*		Clover*		Cotton leaves		Wheat seedlings	
	FM	F	FM	F	FM	F	FM	F
X ± S	11.71±1.4	3.55±0.8	7.00±0.9	3.5 ±	3.57±0.2	1.87±0.1	3.71±1.	1.83 ±
Rang	1*	5	2*	0.11	6	3	01	0.15
e	9 – 14	2 – 5	5 – 9	2 – 5	3 – 5	1 – 3	2 – 5	1 – 3
% PN	15	10	65	40	95	0	100	8

X ± S, mean ± standard deviation, % PN; percent of normal egg-pods produced; FM, mated females; F, virgin females; * differences are significant at P<0.05

The influence of different diets on egg-production might be attributed to the different nutritional efficiencies of these diets. Similar results were reached many authors [1], [7], [2], [13], and [14].

The different diets also affected on the preovipositional period similar to the case in *Schistocerca gregaria* [12], and in *Camnula pellucida* [11].

Concerning the number of egg-pods per female, the *Pyrgomorpha conica* when fed on bean produced 8 pods/female and *C. lugubris* when fed on cotton produced 9 pods/female [6, 8]. These insects produced the lowest number of egg-pods when fed on cotton and wheat, respectively. El-Shazly (1991) reported that *Heteracris littoralis* fed on bean produced 11.8 pods/female, whereas females fed on corn produced 1.7 pods/female.

It is known that the survival, growth, and egg production are often responsive to variation in diet quality [10]. This fact is also confirmed by Milbrath et al., (1998) on five grasshoppers belonging to the genus *Melanoplus* fed on no-choice diets of some legumes. Field pea (*Pisum sativum* L.) and lentil (*Lens culinaris* Medikus) were the least suitable legumes when considering the combination of grasshopper survival, development, and reproduction. The effect was most pronounced for *M. sanguinipes* (F.) and *M. femurrubrum* (De Geer). These grasshoppers displayed poor survival and delayed development when fed field pea or lentil compared with other legumes or a control. More evidences supporting this fact could be obtained from many authors [3] and [17].

Adult fecundity and fertility of eggs also were adversely affected when no-choice diets of field pea or lentil were offered. For *M. packardii*, a nymphal diet of field pea resulted in the poorest development; grasshoppers fed an adult diet of field pea did not reproduce. *M. bivittatus* and *M. differentialis* experienced limited mortality when fed field pea or lentil. Nevertheless, development was substantially delayed and reproduction inhibited to varying degrees [16]. The same result was also obtained on *Zonocerus variegatus* [17]. The ovaries did not develop as the grasshopper fed on *C. odorata* and *P. pinnata*. In late vitellogenesis, the largest ovarioles, containing the most reserves, were found in adult females fed on *M. esculenta*, and the smallest on *S. nodiflora*. On *A. wilkesiana* and the mixture, these were intermediate. Most eggs were produced on *M. esculenta,* but egg-pod length was constant irrespective of food plant. It was concluded that a mixed diet, even of relatively poor plants, is generally more beneficial than single food plants.

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Khaled Mohamed Abdel Rahman, rahman@sai.uniag.sk
Permanent address: Entomol., Dep., Fac. Sci., Cairo Univ., Egypt,
Present address: Dept of Plant Protection, The Slovak Agricultural University in Nitra,
A. Hlinku 2, 949 76 Nitra, Slovakia