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Effect of certain food plants on key demographic parameters of *Chrotogonus trachypterus* Blanchard (Orthoptera: Acrididae)

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Abstract
Grasshoppers are mainly polyphagous, but showed definite preferences and some degree of selectivity for certain categories of plants. There is complex interaction between properties of the food, feeding behavior, digestion and assimilation, physiology, metabolism and specific nutritional requirements of the insect. A laboratory study was conducted on effect of some selected food plants on key demographic parameters of *Chrotogonus trachypterus* Blanchard. Survival and longevity of nymphs as well as the reproductive performance of *C. trachypterus* Blanchard was greater and better, fed on cauliflower as compared to those fed only on spinach, tomato, cabbage, bajara and gram. As revealed by growth index, highest growth occurred on cauliflower (1.83 and 1.64) followed by spinach (1.31, 1.43) > tomato (1.38, 1.26) > cabbage (1.53, 1.15) > bajara (1.30, 1.27) > gram (1.26, 1.09) > wheat (1.18, 1.09) > grass (1.09, 1.02) > brinjal (0.72, 0.68) and groundnut (0.67, 0.61) in decreasing order.

Keywords: Chrotogonus trachypterus Blanchard, growth index, key demographic parameters

Introduction

Chrotogonus trachypterus Blanchard is also known as surface grasshopper, is extremely polyphagous but shows definite preferences and some degree of selectivity for certain categories of plants. Feeding selection of acridids related to specific aspects concerning short term behavioral aspects pertaining to quantitative food intake and utilization and long term physiological effects involving growth and reproduction on diverse host plants. *C. trachypterus* has been found a serious pest of young seedling plants and because of greater abundance of this grasshopper in semi arid area, a laboratory study was conducted on effect of some selected food plants on its growth and development. There is complex interaction between properties of the food, feeding behavior, digestion and assimilation, physiology, metabolism and specific nutritional requirements of the insect.

Key demographic parameters such as survival, fecundity, developmental rate and growth, significantly respond to changes in plant quality. Poor-quality food results in poor demographic performance and vice versa [1]. Total food availability directly affects these factors [2]. Egg production makes significant demands on the grasshopper's nutritional economy and depends significantly on protein and energy obtained from the diet. Such results become important for understanding grasshopper population dynamics, as reproductive changes can drive population change.

A polyphagous pest does not damage all the host plants with equal severity. There is considerable speculation for such selection by insects. For a better understanding of the nature of food material, it is obligatory to collect information on the rate of feeding and its effect on growth and development, the amount of food digested and the quantity of food converted into body mass [3]. The suitability of the host plant greatly depended upon the physical and chemical factors [4, 5, 6]. Few host plants provide a completely balanced diet for most grasshopper species and that grasshoppers can adjust behaviorally to optimize diets [7]. If we can learn what is required for balanced diets by economically important grasshopper species and remove that balance, then we may be able to manipulate plant communities to decrease grasshopper populations. A number of wild plants have a detrimental effect on the insect life. Such plants have great promise in crop rotation in the integrated pest management (IPM). Thus food preference studies will be of immense importance from this point of view.

The purpose of this study was to determine the impact of the different food plants associated with the population of *C. trachypterus* in the Entomology Laboratory, Department of Zoology, University of Rajasthan, Jaipur on its growth, development and fecundity.

Materials and methods

Nymphs and adults of *C. trachypterus* were collected from fields nearby Jaipur city and culture maintained on ten selected food plants in the laboratory at 32±2°C and 60 ± 5% R.H for one year. Selected food plants included *Brassica oleracea* var. *capitata* (cabbage), *Brassica oleracea* var. *botrytis* (cauliflower), *Lycopersicon esculentum* (tomato), *Solenum melongena* (brinjal), *Arachis hypogea (*groundnut), *Triticum aestivum (*wheat), *Cicer arietinum (* gram), *Spinacia oleracea* (spinach), *Cynodon dactylon* (doob/grass) and *Pennisetum typhoides* (bajra) for observation of key demographic parameters, such as developmental rate, nymphal period, cumulative survival percentage, survival, fecundity and growth index. Insects were starved for 24 h before being fed their various diet regimens. Fresh food was provided to the developing nymphs daily in adequate quantity of standard food plants. For the study of pre-oviposition, oviposition, post-oviposition period and longevity on different food plants adult male and female were paired in glass jars (6 X 10 cm) with the different tags bearing the name of the respective food plants and allowed them to mate. Total number of egg pods, number of total eggs laid per female, incubation period, hatching percent were observed. After hatching the developing nymphs were maintained in sterilized rearing jars at room temperature viz. 32±2 °C and 60±5% R.H. which were cleaned every day to avoid contamination and checking of exuviae, which were removed to prevent their being eaten. The ecdysis was criterion to fix the nymphal instars to the developing insect. The development period of nymphs in days were monitored from hatching to fledging. Upon fledging, adult insects from different jars/tubes were marked with indelible ink for easy identification.

Results

Results revealed that pre- oviposition period ranged from 8.03±1.20 to 22.4±3.97 days. Maximum pre-oviposition period was found on brinjal (22.4±3.97 days) and minimum on cauliflower (8.03±1.20 days). All the females with the exception of those fed on brinjal and groundnut, readily oviposited and oviposition period varied from 18.86±1.60 and 51.8±1.77 days after feeding on different food plants. Average post- oviposition period ranged from 5.9±1.93 to 33.33±4.04 days, fed on spinach and brinjal, respectively (Table- 1).

The female laid on an average 7.5±0.38 (groundnut) to 12.6±1.21 (spinach) egg pods on different food plants. Average number of eggs per pod ranged from 10.4±0.87 to (20.4±0.61) on grass and cauliflower, respectively. Fecundity was highest on spinach (220.3±2.60 eggs per female). Hatching percent was observed maximum on cauliflower (92.26±0.93) which was closely followed by spinach (90.63±1.75) and tomato (89.4±3.61) and minimum on groundnut (60.6±5.66). Incubation period was also affected by various plant species Average incubation period observed to be 18.63±0.33 to 25.33±1.64 days on cauliflower and groundnut, respectively (Table- 2).

Longevity of male and female varied from 37.36±9.18 to 61.43±2.35 and 51.16±3.79 to 66.26±4.13 days, respectively. Male longevity was highest on tomato (61.43±2.35) and minimum on brinjal (37.36±9.18) days. Female longevity also showed non-significant difference on different diets whereas significant differences were found when fed on brinjal (61.43±2.35 days) (Table-18). In all overall cumulative survival percentage of *C. trachypterus* fed on cauliflower was very high compared to those fed on spinach wheat > grass > cabbage > bajara > gram > tomato > brinjal and groundnut for male and female, respectively (Table-3).

The duration of nymphal development of *C. trachypterus* fed on the different food plants ranged between 48.33±1.79 to 72.26±2.60 days. Insects fed on grass and brinjal required significantly longer period to develop to adults than insects fed on cauliflower, cabbage, tomato, spinach bajara, gram, wheat and groundnut. As revealed by growth index highest growth occurred on cauliflower (1.83 and 1.64) followed by spinach (1.31, 1.43) > tomato (1.38, 1.26) > cabbage (1.53, 1.15) > bajara (1.30, 1.27) > gram (1.26, 1.09) > wheat (1.18, 1.09) > grass (1.09, 1.02) > brinjal (0.72, 0.68) and groundnut (0.67, 0.61) in decreasing order. Figures in parantheses indicate value for male and female, respectively (Table-3).

Table 1: Effect of various food plants on pre oviposition, oviposition, post oviposition period and longevity of *Chrotogonus trachypterus* Blanchard at 32±2˚C and 60±5% R.H.

Food plants	Pre-oviposition period (days)	Oviposition period (days)	Post-oviposition period (days)	Longevity (days)	
				Female	**Male**
Brassica oleracea var. *botrytis* (Cauliflower)	8.03±1.20	51.8±1.77	8.7±0.36	64.16±6.55	59.2±2.10
Lycopersicon esculentum (Tomato)	10.7±2.55	49.3±3.62	12.2±3.52	55.2±1.16	61.43±2.35
Brassica oleracea var. *capitata* (Cabbage)	18.26±1.13	46.36±3.82	18.36±2.43	63.3±3.41	55.53±2.80
Solanum melongena (Brinjal)	22.4±3.97	18.86±1.60	33.33±4.04	58.43±3.53	37.36±9.18
Arachis hypogea (Groundnut)	20.43±3.22	29.67±1.95	10.4±1.13	51.16±3.79	42.26±4.79
Triticum aestivum (Wheat)	18.37±1.62	30.63±2.00	15.53±2.87	60.53±5.59	49.2±2.63
Spinacea oleracea (Spinach)	8.7±0.22	49.33±1.65	5.9±1.93	61.93±2.88	52.26±4.19
Pennisetum typhoideum (Bajara)	11.8±1.11	42.5±2.10	8.03±1.80	56.16±3.60	51.2±5.26
Cicer arietinum (Gram)	11.3±0.49	33.2±2.10	15.36±2.03	61.3±4.52	48.06±2.86
Cynodon dactylon (Grass)	13.3±1.28	28.2±3.62	22.4±3.61	66.26±4.13	58.63±3.62
F- value	76.359**	380.378**	200.884**	222.216**	151.690
S-Em±	2.0253	2.5652	2.734	4.2925	8.3802
C.D. at 5% level	5.9745	7.5673	8.0651	12.6627	24.7213
CV	25.9	11.7	31.52	13.19	28.79

**= F- test significant

Table 2: Effect of various food plants on fecundity, incubation period and hatching % of *Chrotogonus trachypterus* Blanchard at 32±2˚C and 60±5% R.H.

Food plants	Total no. of egg pods	Total no. of eggs per pod	Fecundity	Incubation period (days)	Hatching %
Brassica oleracea var. *botrytis* (Cauliflower)	10.5±1.29	20.4±0.61	215.66± 3.53	18.63±0.33	92.26±0.93
Lycopersicon esculentum (Tomato)	10.1±1.57	18.5±1.20	178.3±7.80	19.33±0.63	89.4±3.61
Brassica oleracea var. *capitata* (Cabbage)	8.3±0.61	18.2±0.47	150.66±2.61	19.23±0.58	85.43±3.49
Solanum melongena (Brinjal)	6.1±0.78	12.4±1.93	75.6±1	24.53±0.82	65.26±4.22
Arachis hypogea (Groundnu)	7.5±0.38	15.6±1.09	114.67±2.40	25.33±1.64	60.6±5.66
(*Triticum aestivum* (Wheat)	8.4±1.73	13.1±1.06	108.33±1.20	23.63±1.73	71.73±1.42
Spinacea oleracea (Spinach)	12.6±1.21	18.5±0.82	220.3±2.60	18.7±1.50	90.63±1.75
Pennisetum typhoideum (Bajara)	9.3±1.39	15.4±0.67	141±5.69	20.4±1.22	82.43±1.65
Cicer arietinum (Gram)	8.8±1.01	11.1±0.89	105.3±4.07	21.4±1.18	80.6±2.11
Cynodon dactylon (Grass)	8.1±1.34	10.4±0.87	87.36±2.97	22.26±1.07	69.4±1.19
F- value			7383.929**	18.6364**	382.052**
S-Em±			4.1271	1.1629	2.9915
C.D. at 5% level			12.175	3.4307	8.8247
CV			5.06	9.44	6.58

**= F- test significant

Table 3: Effect of various food plants on nymphal duration, survival percent and growth index of *Chrotogonus trachypterus* Blanchard

Food plants	Sex	No. of instars observed	Cumulative survival percent of instars (n)	Nymphal duration (days) (av)	Growth index =n/av
Brassica oleracea var. *botrytis* (Cauliflower)	Male	50	88.26±2.23	48.33±1.79	1.83
	Female	50	91.43±3.18	55.86±2.57	1.64
Pennisetum typhoideum (Bajara	Male	50	72.2±4.65	55.33±3.36	1.3
	Female	50	76.66±3.87	60.33±2.37	1.27
Brassica oleracea var. *capitata* (Cabbage)	Male	50	76.1±2.96	49.66±0.96	1.53
	Female	50	75.6±3.54	65.96±0.92	1.15
Solanum melongena (Brinjal)	Male	50	52.3±4.11	72.26±2.60	0.72
	Female	50	61.16±3.44	89.26±2.84	0.68
Arachis hypogea (Groundnut)	Male	50	46.2±3.08	68.13±2.57	0.67
	Female	50	48.33±3.32	79.5±2.86	0.61
Triticum aestivum (Wheat)	Male	50	81.13±2.34	68.33±4.13	1.18
	Female	50	82.3±2.95	75.33±3.44	1.09
Lycopersicon esculentum (Tomato)	Male	50	69.26±3.62	50.3±2.43	1.38
	Female	50	72.6±4.37	57.46±2.28	1.26
Spinacea oleracea (Spinach)	Male	50	70.86±2.35	54.23±2.56	1.31
	Female	50	90.2±1.36	62.9±2.63	1.43
Cicer arietinum (Gram)	Male	50	72.3±2.28	57.33±5.31	1.26
	Female	50	69.53±4.66	63.4±2.91	1.09
Cynodon dactylon (Grass)	Male	50	72.43±6.01	71.66±2.27	1.01
	Female	50	80.6±1.43	78.3±5.23	1.02
F- value			463.939** (male)	273.121** (male)	
			507.153** (female)	368.565**(female)	
S-Em±			3.564 (male	3.0253 (male)	
			3.3718 (female)	2.9836 (female)	
C.D. at 5% level			10.5156 (male)	8.9247 (male)	
			9.9467 (female)	8.8016 (female)	
CV			8.81	8.8	
			7.8	7.51	

**= F- test significant

Discussion

The purpose of this study is to find out relationship between growth of insects and verity of food plants. The present study revealed that highest growth of *C. trachypterus* occurred on cauliflower followed by spinach, tomato, cabbage, bajara, gram, wheat, grass, brinjal and groundnut. Feeding on cauliflower resulted shortest nymphal period for male and female. Contrary to this, grass and brinjal led to the prolonged nymphal duration. Thus, variable duration of developmental period could occur in nature, depending upon preponderance of particular food plants in various localities [8] and food quantity exert influenced the rate of development of insects [9]. This also agrees with the findings of McCaffery [10] who reported that both the food quality and quantity influenced the egg production of *Locusta migratoria migratoriodes*.

It was confirmed that brinjal was consistently and significantly inferior to cauliflower of larval length and weight of *Diacrisia oblique* [11]. Developmental period of *S. gregaria* was shortest when hoppers were fed on *Tribulus terrestris* (kanti) and longest on *Zea mays* (maize) [12] whereas *Gastrimargus transversus* Thunb. and *Oxya velox* exhibited high preference to a variety of grasses only [13].

The developmental responses i.e. longevity, fecundity, fertilization and growth index of acridid grasshoppers were markedly influenced by food plants [14, 15, 16, 17]. Finding of Singh and Srivastava [18] was also similar to present one where growth index of *Atractomorpha crenulata* Fab. was highest on cauliflower and lowest on brinjal. Nymphal duration was minimum on cauliflower which was closely followed by cabbage on brinjal it was prolonged. Longevity of females was invariably higher as compared to males at all food plants.

Development of the nymphs of *Oedaleus nigeriensis* was shortest when reared on a mixed diet, in comparison to a single host plant [8]. According to Sultana and Wagan [19] feeding adaptability of *H. nigrorepletus* on *Oryza sativa*, *Zea mays* and mixed diet lead to the faster development of nymphs as compared to those fed on *Saccharum officinarum* and *Desmostachya bipinnata*. Therefore, it could be revealed that life cycle is influenced by complex interaction between properties of the food, digestion, assimilation and specific nutritional requirements of the insect. Level of sucrose, glucose and fructose commonly found in plants are normally sufficient to stimulate feeding. Various phagostimulatory components (sugar, amino acids, phospholipids) tend to be additive in their effect on *Locusta migratoria* [20]. Amino acids are involved in enabling the insect to select foods of different quanlities [21].

Cumulative survival percentage of *C. trachypterus* was observed maximum on cauliflower followed by spinach> wheat > grass > cabbage > bajara > gram > tomato > brinjal > groundnut in descending order. It was reported that mixed diet of plants was superior for *Melanoplus bivittatus* (Say) by promoting higher survival, larger adults and higher growth indices than single plant diet [22]. *Oxya nitidula* (Walker), the shortest nymphal period was obtained when reared on *Panicum maximum* [23]. It was also demonstrated that survivability and longevity of nymphs as well as the reproductive performance of adult *Zonocerus variegatus* (L) was greater and better when fed on *Manihot esculenta* (cassava) and mixed diet [24].

All the females of *C. trachypterus* with the exception of those fed on brinjal and groundnut, readily oviposited on different food plants. Longevity was highest on tomato followed by cauliflower and grass. Whereas, fecundity was highest on spinach and minimum on grass and brinjal. various food diets exerted influence on the fecundity of *C. trachypterus* as maximum and minimum number of eggs were laid by a female when fed on *Brassica oleracea* var. *botrytis* and *Calotropis procera*, respectively. No egg laying took place on *Solanum melongena* and *Ricinus communis* [16]. *Atractomorpha crenulata* showed 100% mortality in the first instar of *A. crenulata* when reared on *O. sativa*. The highest number of egg pods was laid when fed on *R. communis* and *A. hypogea*. Similarly hatching percent was higher on *R. communis* and *A. hypogea*, whereas, it was lower on *P. maximum* [6]. It was evaluated that duration of post-embryonic development of both sexes of *Oxya nitidul* were least on *P. maximum* while the consumption index and growth rate were highest when fed on *P. maximum* [23]. Many workers have also revealed that food plants exert influence on development, fecundity, hatchability and longevity [25, 26, 27].

It was revealed that family Poaceae was most preferred by *Acrida exaltata* while, *Atractomorpha crenulata* preferred *Daucus carota, Adiantum caudatum* and *Hemartheria compressa* the most amongst 13 plant species [28, 29]. females of *Poecilocerus bmtonius* were shorter on *Calotropis procera* than those fed on other host foliages. Fecundity and fertility of females fed on *C. procera* were significantly higher as compared with those reared on *Zygophylum simplex* and *Pulicaria cispa* [30].

According to Sultana and Wagan [19] adults of *H. nigrorepletus* laid more number of egg-pods on *O. sativa*. Prolonged oviposition period was reported on *O. sativa* followed by *Z. mays* and mixed diet while it was significantly reduced on *S. officinarum* and *D. bipinnata*. Total egg production per female during entire life was more in the adults fed on *O. sativa* and mixed diet than fed on *Z. mays*, *S. officinarum* and *D. bipinnata*.

Thus it could be concluded that correct nutrient level of foods play a vital role which triggers the activity in endocrine system for oocyte development. It is generally supposed that the activity within the endocrine system is generated by the stimulation of foregut stretch receptors during increased feeding [31]. During somatic growth fairly large amount of food is ingested so that fat may develop to a point at which vitellogenic protein synthesis can begin [32], therefore the optimal amount and quality of food are essential pre-requisites for the development and production of eggs. The suitability of the host plant greatly depended upon the physical and chemical factors [4, 6, 33]. Biochemical analysis of food plants for acridids for their total protein, carbohydrate, phenols, free amino acids, water and nitrogen content revealed significant correlation with regard to their host preferences. Thus, selection of foods by insects has been correlated with their faster development and growth.

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