Indian Journal of Applied Entomology **24**(2) : 131-135 (2010)

INFLUENCE OF FOOD PLANTS ON THE GROWTH AND DEVELOPMENT OF THE GRASSHOPPER, *HIEROGLYPHUS NIGROREPLETUS* BOLIVAR

PRADEEP SINGH RATHORE AND R. SWAMINATHAN

Department of Entomology,
Rajasthan College of Agriculture, MPUAT, Udaipur, INDIA

ABSTRACT

Investigations on the effect of different food plants on growth and development of the common grasshopper, *Hieroglyphus nigrorepletus* Bolivar were carried out in the Department of Entomology, Rajasthan College of Agriculture, Udaipur over two *kharif* (monsoon) crop seasons (2007 and 2008). Growth and development was best on maize followed by sorghum; resultantly, the development period manifested by hopper duration was the lowest on these two host plants (21.5 to 22.0 days on maize; 22.75 to 23.5 days on sorghum); the survival ranged from 97.50 to 100 per cent; and the growth index was the highest during both years on maize (4.54 and 4.65), followed by that on sorghum (4.26 and 4.40). Plants of Graminae (Poaceae) were more preferred than dicots; however, mixed food indicated a moderate preference. The food utilization indices, efficiency of conversion of ingested food (ECI) and the approximate digestibility (AD) were the highest when the grasshopper (*H. nigrorepletus*) was fed on maize, though the efficiency of conversion of digested food into body substances (ECD) was the maximum for sorghum and *Cynodon dactylon*.

Key words : *Hieroglyphus nigrorepletus* Bolivar, food plants, growth and development, grasshopper

INTRODUCTION

The feeding ecology of polyphagous herbivores has been widely studied; however, little is known about the nutritional ecology of mixed feeding herbivores. Polyphagous herbivores feed on plants from a variety of plant families (Chapman, 1990), where most polyphagous species feed only on plants in dicotyledonous families and fewer feed only on monocotyledonous plants. In an even smaller subset of polyphagous species, both dicots (*i.e.*, forbs) and monocots (*i.e.*, grasses) are consumed in a mixed feeding strategy, presenting these herbivores with interesting problems because they must overcome the physical and chemical challenges unique to each plant group [grass *vs* forb] (Jonas and Joern, 2008). It is a well established fact that food plants are known to affect the biology and behaviour of insects including rate of growth and development, survival, fecundity and fertility (Pickford, 1962; Banjerjeet and Haque, 1985; Aslam and Whitworth, 1988). Extensive studies on food selection by grasshoppers have been adequately reviewed by Uvarov (1977) and Chapman (1990). In view of the fact that *H. nigrorepletus* has become increasingly pestiferous in maize/sorghum cultivated areas of Rajasthan, the present study on food preference was undertaken.

MATERIALS AND METHODS

Field-collected adults of the grasshopper, *Hieroglyphus nigrorepletus* Bolivar, were reared during 2006 (July through October) in the laboratory on fresh and untreated maize leaves as food and the live culture maintained in aluminum frame net cages kept on steel racks protected from ants. The adults were sexed and put into the cages (30 x 30 x 30 cm), wherein they were allowed to mate. Eggs liad were used for further studies in the two subsequent years 2007 and 2008. During each of these years, for host-plant studies, newly hatched-out hoppers were maintained on leaves of maize until they moulted thrice; thereafter, healthy IV instar hoppers were starved for 6 hours and transferred singly into individual wooden wire-gauge cages (15 x 7.5 x 7.5 cm) having the bottom with small dry twigs to facilitate moulting. Four replications of 10 hoppers each were maintained on fresh untreated leaves for each of the 10 different treatments, comprising 9 host plants, selecting 5 from cultivated crops and 4 from uncultivated pasture grasses and weeds, and mixed food forming the tenth treatment. Fresh food was provided twice daily. The host plants as treatments were maize, *Zea mays* L.; sugarcane, *Saccharum officinarum* L.; sorghum, *Sorghum bicolor* (L.) Moench.; soybean, *Glycine max*

(L.) Merr.; greengram, *Vigna radiata* (L.) Welczek; common weed, *Setaria glauca* (L.) Beauv.; napier grass, *Pennisetium purpureum* K. Schum.; Bermuda grass, *Cynodon dactylon* (L) Pers.; portulaca weed, *Trianthema monogyna* L.; and the mixed food (tender shoots and leaves from above plants).

Observations over the period taken to complete each subsequent hopper period were recorded (in days). The sixth instar hopper was weighed and per cent hopper survival on each host plant computed. The time required for adult development on each host plant was recorded and the survival of adults was also noted. To compare the relative growth of hoppers on different host plants a growth index was calculated using the following formula:

$$\text{Growth index} = \frac{\text{Percent hoppers attaining VI instar}}{\text{Duration of hoppers (in days)}}$$

Food utilization indices were calculated on a dry weight basis for the newly formed VI instar hoppers at ambient conditions of temperature and humidity in the laboratory. The hoppers reared on maize right from hatching, were starved overnight, and thereafter provided with the different host-plants until they developed as adults. Fresh, tender green parts of the different host plants were divided into two equal portions. One portion was weighed wet and fed to the newly formed and starved VI instar hoppers, while the other portion taken as aliquot. The aliquot food was weighed wet first, then dried at 80°C in an oven and dry weight was recorded. Left over food and faeces were removed every 24 h and dried to a constant weight at 80° C. At the end of the experiment the newly formed adults were starved to empty their guts of residual faecal material. Faeces for the period of starvation were also collected every 24 hours. After starvation, the newly formed adults were killed and dried to a constant weight at 80° C in an oven.

Calculation of food utilization indices: Having recorded the dry weight of left-over food and faeces, the quantity of ingested food was calculated by subtracting it from the weight of the food introduced. The approximate weight of digested food was calculated by subtracting the weight of faeces from the weight of the ingested food. From these values, on a dry weight basis, the utilization indices were computed (Waldbauer, 1968):

$$\text{Efficiency of conversion of ingested food [ECI]} = \frac{\text{Weight gained}}{\text{Weight of food ingested}}$$

$$\text{Approximate digestibility [AD]} = \frac{\text{Wt. of food ingested - Wt. of faeces}}{\text{Weight of food ingested}} \times 100$$

$$\text{Approximate digestibility [AD]} = \frac{\text{Wt. of food ingested - Wt. of faeces}}{\text{Weight of food ingested}}$$

$$\text{Efficiency of conversion of digested food into body substances [ECD]} = \frac{\text{Weight gained}}{\text{Wt. of food ingested - Wt. of faeces}} \times 100$$

RESULTS AND DISCUSSION

Among the food plants evaluated, the growth and development of *H. nigrorepletus* manifested by hopper duration was the lowest (22 days) on maize; the survival ranged from 97.50 to 100 per cent; and the growth index was the highest (4.54) during 2007 (Tables 1 & 2). Similarly, in the subsequent year too, hopper duration was the lowest on maize and the corresponding figures were 21.5 days (hopper duration), 100 per cent (survival), and 4.65 (growth index).

From Table 3, it becomes evident that when the grasshopper (*H. nigrorepletus*) was fed on maize the food utilization indices were the highest. The values for efficiency of conversion of ingested food (ECI) and the approximate digestibility (AD) were 44.28, 45.25 and 60.48, 61.80, for the respective years. The efficiency of conversion of digested food into body substances (ECD) was the maximum for *Sorghum bicolor* (76.68 & 73.13) and *Cynodon dactylon* (76.59 & 76.61) over the respective years.

Plants of Graminae (Poaceae) were more preferred as food plants having secured ranks from I to IV, VI and VII. The dicots were less preferred as food plants (ranking VIII to X) with *T. monogyna* (Portulacaceae) ranking tenth during both years of study. However, the mixed food ranked fifth (V) indicating a moderate preference. Riffat and Wagan (2007) observe that for a single host plant, feeding on

Table 1. Effect of Food Plants on the Development of *H. nigrorepletus* (2007)

Host Plants	Average Hopper Duration (days)				Hopper Survival (%)			Growth	Rank
	IV instar	V instar	VI instar	Total	IV instar	V instar	VI instar	Index	
Zea mays L.	6.00	6.50	9.500	22.00	97.50	100	100	4.54	I
Saccharum officinarum L.	6.75	7.75	10.75	25.25	100	100	97.50	3.86	III
Sorghum bicolor (L.) Moench.	6.50	6.75	10.25	23.50	100	100	100	4.26	II
Glycime max (L.) Merr.	8.50	9.50	13.50	31.50	92.50	82.50	87.50	2.77	VIII
Vigna radiata (L.) Welczek	8.75	9.75	13.75	32.25	80.00	77.50	77.50	2.40	IX
Setaria glauca (L.) Beauv.	7.00	8.00	12.00	27.00	97.50	97.50	100	3.70	IV
Pennisetium purpureum K. Schum.	8.00	8.75	13.00	29.75	92.50	92.50	90.00	3.03	VII
Cynodon dactylon (L.) Pers.	7.50	8.50	12.50	28.50	97.50	97.50	92.50	3.25	VI
Trianthema monogyna L.	9.50	10.50	14.75	34.75	65.00	67.50	70.00	2.01	X
Mixed food	7.75	8.50	12.75	29.00	97.50	100	97.50	3.36	V

Table 2. Effect of Food Plants on the Development of *H. nigrorepletus* (2008)

Host Plants	Average Hopper Duration (days)				Hopper Survival (%)			Growth	Rank
	IV instar	V instar	VI instar	Total	IV instar	V instar	VI instar	Index	
Zea mays L.	6.00	6.25	9.25	21.50	100	100	100	4.65	I
Saccharum officinarum L.	6.50	7.50	10.50	24.50	100	100	100	4.08	III
Sorghum bicolor (L.) Moench.	6.25	6.50	10.00	22.75	100	100	100	4.40	II
Glycime max (L.) Merr.	8.25	9.25	13.25	30.75	90.00	82.50	87.50	2.85	VIII
Vigna radiata (L.) Welczek	8.50	9.50	13.50	31.50	77.50	75.00	75.00	2.38	IX
Setaria glauca (L.) Beauv.	6.75	7.75	11.75	26.25	97.50	97.50	100	3.81	IV
Pennisetium purpureum K. Schum.	7.75	8.50	12.75	29.00	90.00	92.50	90.00	3.10	VII
Cynodon dactylon (L.) Pers.	7.25	8.25	12.25	27.75	97.50	95.00	92.50	3.33	VI
Trianthema monogyna L.	9.25	10.25	14.50	34.00	62.50	65.00	67.50	1.99	X
Mixed food	7.50	8.25	12.50	28.25	100	100	100	3.54	V

Oryza sativa resulted in the shortest development for the V-instar nymph, while feeding on *Zea mays* and mixed diet similarly gave the shortest nymphal development period for the first and third instar nymphs. In contrast to this, *Desmostachya bipinnata* led to prolonged nymphal development for the second, fifth and sixth instars. They concluded that in *H. nigrorepletus*, *Oryza sativa* and mixed diet are highly favoured for optimum nymphal development and higher fertility; certain single host plants could adequately promote adult maturation and egg-pod production. However, in nature, selection pressure may favour habitats with mixed host plants, since these will ensure adequate nutritional requirements for the development and survival of nymphs, a stage that is regarded as the most important with respect to population regulation among grasshoppers (Joern and Gaines, 1990; Lockwood, 1993). Variable developmental period for the grasshopper nymphs could occur in nature depending on the preponderance of particular host plants in various localities opined Nzekwu and Akingbohungbe (2002).

A comparison of the food utilization indices showed the efficiency of conversion of ingested food (ECI) and the approximate digestibility (AD) to be the highest when the grasshopper (*H. nigrorepletus*) was fed on maize, though the efficiency of conversion of digested food into body substances was the maximum for *S. bicolor* and *C. dactylon*. Therefore, it could be inferred that the acridid, *H. nigrorepletus* is typically a grass feeder, as is evinced by the first to fourth ranks occupied by plants of Poaceae and the tenth rank occupied by the dicot, *T. monogyna* (Portulacaceae), though it does feed on forbs. It might be deduced that the protein requirement for *H.*

Table 3. Effect of Food Plants on the Food Indices for *H. nigrorepletus*

Host Plants	2007			2008		
	ECI (%)	AD (%)	ECD (%)	ECI (%)	AD (%)	ECD (%)
Zea mays	44.28	60.48	73.28	45.25	61.80	73.22
	(41.72)	(51.05)	(58.88)	(42.28)	(51.83)	(58.84)
Setaria glauca	40.54	57.23	70.84	44.92	59.30	75.78
	(39.55)	(49.16)	(57.32)	(42.09)	(50.36)	(60.52)
S. officinarum	43.19	56.61	76.34	41.30	58.49	70.63
	(41.09)	(48.80)	(60.90)	(39.99)	(49.89)	(57.19)
Sorghum bicolor	38.85	50.66	76.68	40.03	54.75	73.13
	(38.56)	(45.38)	(61.13)	(39.25)	(47.73)	(58.78)
Cynodon dactylon	38.82	50.71	76.59	39.38	51.48	76.61
	(38.54)	(45.41)	(61.07)	(38.87)	(45.85)	(61.08)
Pennisetium purpureum	27.58	40.97	67.31	26.68	44.30	60.20
	(31.68)	(39.80)	(55.13)	(31.10)	(41.73)	(50.89)
Glycine max	21.19	30.75	69.27	21.69	35.63	60.89
	(27.41)	(33.68)	(56.34)	(27.76)	(36.65)	(51.29)
Vigna radiata	17.39	26.97	64.55	17.27	29.40	58.81
	(24.65)	(31.29)	(53.46)	(24.56)	(32.84)	(50.08)
Trianthema monogyna	11.39	25.42	44.87	11.23	25.59	43.85
	(19.73)	(30.28)	(42.06)	(19.58)	(30.39)	(41.47)
S. Em. ±	(0.323)	(0.272)	(0.850)	(0.355)	(0.35)	(0.625)
C.D. (5%)	(0.914)	(0.769)	(2.405)	(1.004)	(0.99)	(1.767)

Note: Figures in parentheses are arc sine values

nigrorepletus is relatively lower; hence, the grasshopper prefers grasses than forbs that have relatively more protein than in the grasses. Earlier reports indicate that mixed feeding by insect herbivores is relatively uncommon (Mulkern *et al*., 1969; Joern, 1983). Forbs usually make up the bulk of mixed feeder diets with grasses' contribution being variable, but often a minor component (Joern, 1983; Bernays and Bright, 1993). As seen in most polyphagous species, which perform best on diets containing plants from multiple families (Rapport, 1980; Hagele and Rowel-Rahier, 1999), mixed feeding herbivores also experience their greatest performance when both forbs and grasses are consumed (Bailey and Mukherji, 1976; McFarlane and Thorsteinson, 1980; Randolph *et al*., 1995; Hagele and Rowel-Rahier, 1999; Randolph and Cameron, 2001; Miura and Ohsaki, 2006).

ACKNOWLEDGEMENTS

We thank the National Coordinator, ICAR Network Project on Insect Biosystematics, New Delhi, for the financial help and the Director of Research, Maharana Pratap University of Agriculture and Technology, Udaipur for making available the necessary facilities to conduct the investigation.

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