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Host Plant Preferences in *Cyrtacanthacris ranacea* Stoll in some Malvaceous Hosts in Terms of Food Utilization

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Host preference studies of the cotton grasshopper, *Cyrtacanthacris ranacea* on different malvaceous host plants such as *Gossypium hirsutum*, *Abelmoschus esculentus*, *Abutilon indicum* and *Sida rhomboidea* in terms of the rate of post-embryonic development, growth rate and quantitative food utilization are discussed. Biochemical analysis of the host leaves indicated a preference for leaves with low water-nitrogen index.

Key Words: Host preference, *C. ranacea*, **Quantitative food utilization**, *Gossypium hirsutum*, *Abelmoschus esculentus*, *Abutilon indicum*, *Sida rhomboidea*

Introduction

Growth and reproductive success depend to a large extent on the insects' ability to ingest, digest and convert plant nutrients rapidly. The role of physicochemical factors in the host selection of grasshoppers has been recognised in recent years; the physical nature of the host leaves, as well as such chemical constituents as water, free amino-acids, sugars, nitrogen, phenols etc. being essential parameters (Mulkern 1967, Bernays & Chapman 1975). An understanding of the degree of damage in terms of the quantity of leaf consumed by the insect appears equally important; such a quantification pertaining to the food ingested/utilized presents a better evidence for the analysis of the food preference. Ananthakrishnan et al. (1985) reported significant differences in the quantitative food intake during post embryonic development in some pyrgomorphid species and also observed the impact of antennal and palp ablation on host selection. *Cyrtacanthacris ranacea*, the cotton grasshopper, is known to attack and feed voraciously on cotton plants causing considerable defoliation. In this study, the preferences of *C. ranacea* among the malvaceous host plants have been analysed quantitatively, in view of this species feeding on a number of other malvaceous plants like *Abutilon indicum* G.Don., *Abelmoschus esculentus* L., *Sida rhomboidea* Roxb., etc.

Material and Methods

Cyrtacanthacris ranacea were collected from cotton tracts and reared in the laboratory on cotton leaves in rearing cages measuring 25×25×30 cm. Newly hatched first

instar nymphs were segregated in groups and each group was fed with any one of the following malvaceous host plants: *Gossypium hirsutum*, *Abelmoschus esculentus*, *Abutilon indicum*, and *Sida rhomboidea*. Observations were made on the duration spent by each instar on the different host plants. To study the effect of host plants on the growth of the acridid, the nymphs were weighed immediately after each moult. The total nymphal duration on each test plant was taken as an index for a comparison of the rate of development on different host plants.

Quantitative Food Utilization

The gravimetric method was adopted for assessing the quantity of food utilized. Experimental insects were separated from the stock culture, confined individually and provided with water to clear off their guts for a period of 10 hrs. After measuring the initial weight, the grasshoppers were introduced one per cage and allowed to feed on weighed quantity of the malvaceous host leaves for a period of 24 hrs. At the end of the experiment the left over food and the excreta of the insects were reweighed. The difference in the weight of the leaves represents the quantity of the food ingested while the difference in the weight of the insect gives the weight gained during the period of study. Comparison of the various food utilization was carried out by studying the following parameters:

$$\textit{Consumption index } (CI) = \frac{\textit{Weight of the food eaten}}{\textit{Mean weight of the insect during feeding period} \times \textit{Duration of feeding period (Days)}}$$

$$\textit{Growth rate } (GR) = \frac{\textit{Weight gained by the insect}}{\textit{Duration of feeding period} \times \textit{mean weight of insect during feeding period}}$$

$$\textit{Approximate digestibility } (AD) = \frac{\textit{Weight of food ingested} - \textit{Wt of faeces}}{\textit{Weight of food ingested}} \times 100$$

$$\textit{Efficiency of conversion of digested food } (ECD) = \frac{\textit{Weight gained by the insect}}{\textit{Weight of food digested}} \times 100$$

$$\textit{Efficiency of conversion of ingested food } (ECI) = \frac{\textit{Weight gained by the insect}}{\textit{Weight of food ingested}} \times 100$$

The host leaves as well as the excreta obtained when fed on different host plants were subjected to biochemical estimation for their total proteins (Lowry et al. 1951). Carbohydrate (Dubois et al. 1956), nitrogen (Vogel 1963), and phenol (Hori 1974). The moisture content was estimated by weighing accurately 2 gm of the sample and incubating at 37°C till a constant weight was obtained. The difference in weight was calculated and the moisture content represented as percentage.

Observations

Rate of Development of C. ranacea *on Different Malvaceous Hosts*

Studies on the duration of post embryonic development when fed on different malvaceous host plants indicated the fastest rate of development on *G. hirsutum* (50±0.94 days) when compared to the other host plants. On *A. esculentus*, it took 53±0.82 days to develop into the adult and on *A. indicum* 62±1.66 days. On *S. rhomboidea*, the nymphs failed to develop beyond the third instar.

Growth Rate

The growth rate of *C. ranacea* on different host plants has been studied here in terms of the weight increase during successive moults. Figure 1 reveals the maximum growth rate for nymphs fed on *G. hirsutum* (1703 mg male; 1763 mg female) followed by those fed on *A. esculentus* (1303 mg male; 1585 mg female) and *A. indicum* (879 mg male; 904 mg female). Irrespective of the host plants on which they were fed, the nymphs showed a gradual increase in weight till the third instar stage. However, the weight

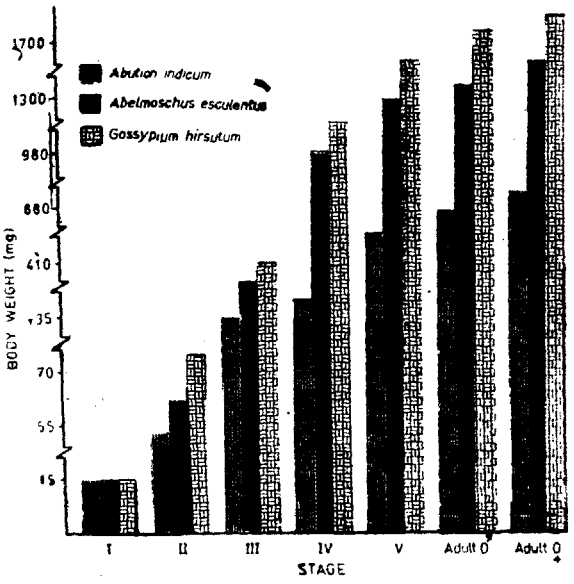

Figure 1 Growth rate of *C. ranacea* on different hosts

increased markedly from the fourth instar onwards.

Quantitative Food Intake

Figure 2 represents the food utilized per day and the resulting weight gain per day of *C. ranacea* on different host plants. The food utilized is computed here as the difference between the amount of food ingested per day and the weight of the excreta. It is evident from the figure that the consumption and utilization of the host leaves increase with age, although the maximum consumption occurred during the third instar stage, with significant differences observed among the host plants. *A. indicum* appears to be the least preferred host in comparison with *G. hirsutum* and *A. esculentus*. An increase in weight gain per day with increase in age is also evident on all the three host plants. However, the maximum weight gain resulted when fed on *G. hirsutum*.

The various growth parameters computed for *C. ranacea* in table 1, indicate greater growth on *G. hirsutum*, followed by *A. esculentus* and *A. indicum*. The rate of intake of food material is largely dependent on the functional responses during feeding. The rate of consumption decreased from the first to the last instar on all the three host plants. Also, the CI (consumption index) was the highest during the first instar stage, gradually decreasing with the growth of the nymphal stages, irrespective of the type of food provided. The second instar nymphs showed the greatest growth rate (GR) when fed on *G. hirsutum* and *A. esculentus*, but on the weed *A. indicum*, the GR was maximum only for the fifth instar nymphs. Data on the approximate digestibility (AD) indicates that on cotton during the first to third instar 90–94% of the food ingested was digested, while this value reduced to 74–88% in the fourth and fifth instars. An increased digestion capacity was observed for all the instars reared on *A. esculentus*, being so only for the first and second instars reared on *A. indicum*. The efficiency of conversion of ingested food (ECI) significantly varied with the host plants although the later instars showed greater efficiency of conversion of the ingested food into biomass irrespective of the host plants. On all the host plants the later larval stages were more efficient in the conversion of digested food (ECD). On cotton, the ECD value increased from the first to the second instar, but suddenly decreased in the third instar, a trend observed on *A. esculentus* as well. However, on *A. indicum*, the ECD values decreased in the second and third instars, but increased in the penultimate as well as the fifth instar.

Quantitative Intake of Proteins, Carbohydrates, and Phenols

Table 2 provides the amount of proteins, carbohydrates and phenols utilized per day by the different instars of *C. ranacea*. It is evident from the table that the third

Table 1 *Quantitative Food Utilization of* C. ranacea++

Host	Instar	Wt of food ingested	Wt of excreta*	Wt gain by insect*	CI	AD	GR	ECI	ECD
G. hirsutum	I	148.0	12.0	7.0	8.000	91.89	0.378	4.73	5.15
	II	392.0	23.0	81.0	3.824	94.13	0.790	20.66	21.96
	III	1375.5	129.0	104.0	4.663	90.62	0.353	7.56	8.34
	IV	475.0	52.0	190.0	0.516	88.62	0.214	41.57	46.91
	V	930.5	233.5	347.0	0.633	74.16	0.236	37.29	49.78
	Male	1002.5	254.0	385.5	0.588	74.66	0.226	38.45	51.50
	Female	1190.0	275.0	413.0	0.795	76.89	0.276	34.69	45.14
A. esculentus	I	173.0	34.0	5.0	9.867	93.44	0.286	0.97	3.59
	II	766.0	16.0	79.0	7.546	97.91	0.778	10.31	10.53
	III	1039.0	26.0	7.0	7.448	97.50	0.050	0.67	0.69
	IV	524.00	60.0	80.0	1.379	88.55	0.211	15.26	17.24
	V	789.0	61.0	190.0	0.809	92.36	0.193	23.81	26.10
	Male	1532.5	121.0	210.0	1.176	92.10	0.161	13.70	14.88
	Female	1893.0	147.5	245.5	1.194	92.21	0.155	12.97	14.06
A. indicum	I	116.0	4.15	4.0	5.967	97.42	0.191	3.19	3.58
	II	133.0	13.00	3.0	2.440	90.22	0.055	2.25	2.50
	III	108.0	17.8	2.0	1.714	83.52	0.032	1.85	2.22
	IV	113.0	21.0	15.0	1.404	81.42	0.186	13.27	16.30
	V	147.0	36.9	62.0	1.140	74.89	0.481	42.18	56.31
	Male	928.5	253.0	134.0	1.056	72.75	0.152	14.43	19.84
	Female	1184.0	338.0	163.0	0.301	71.45	0.041	13.77	19.27

++ Mean of 5 replicates
* mg/day/insect

instar stage consumed more of these nutrients as against the other instar stages. The amount of proteins utilized from *G. hirsutum* appeared significantly different from those utilized from *A. esculentus* and *A. indicum*. However, *C. ranacea* appeared to utilize more of carbohydrates from *A. esculentus* as against the other two host plants. Significant differences in the utilization of phenols from *A. indicum* was observed in comparison with *G. hirsutum* and *A. esculentus*. The differences in the coefficient of approximate digestibility of the nutrients are also evident. A high efficiency of digestibility of proteins, carbohydrates and phenols was observed for all the nymphal stages on the three host plants. However, the amount of phenols digested by the fifth instar nymphs was considerably low when fed on *A. indicum* and *G. hirsutum*.

Biochemical Estimation

In order to facilitate a better understanding of the food preferences as well as the impact of host plants on the developmental rate, biochemical estimations of the host plant leaves for total carbohydrates, proteins, phenols, nitrogen and water content were carried out (table 3). Proteins are generally known to be essential for the growth and development of the insect. A comparative assessment of the host plants for the total protein content indicated a very high level (97.5 mg/g) in *S. rhomboidea* where there is

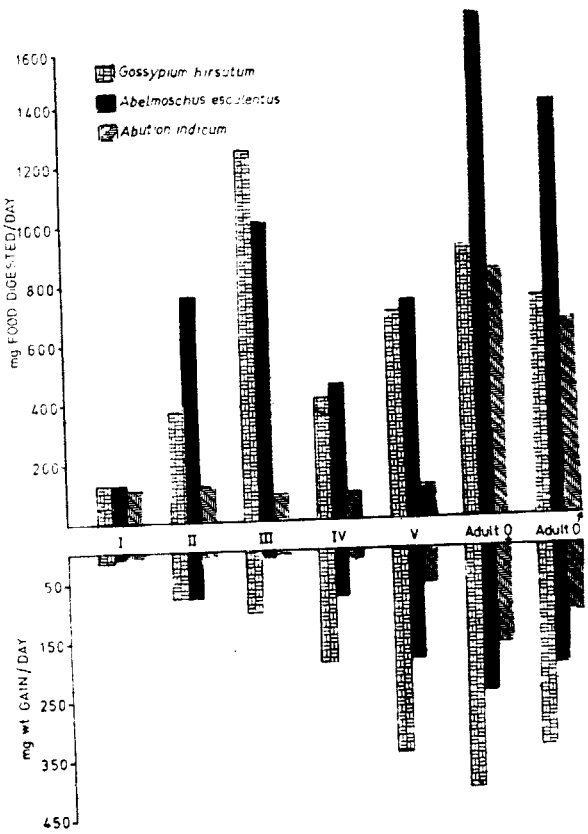

Figure 2 Comparison of food utilization by *C. ranacea* when fed on different malvaceous hosts

no complete development and a moderate level (55.0 mg/g) on the most preferred host, *G. hirsutum*. Optimal level of carbohydrates appears essential for the continued feeding by grasshoppers and the data on the total carbohydrates indicate a comparative low value (302.5 mg/g) for *S. rhomboidea*. No distinct differences were observed among the host plant with regard to their total phenol content. However, the nitrogen estimated showed a higher percentage in the most preferred host plant, *G. hirsutum*. Also the water-nitrogen index computed indicated a low ratio for *G. hirsutum*.

Discussion

Food preference in grasshoppers is known to be mostly influenced by physical, chemical and biotic factors resulting in considerable variations. The choice of the food plant is again intricately associated with the diverse aspects of the feeding behaviour, with considerable effect on the reproductive potential of the species. Earlier attempts to study the food preference in grasshoppers were mainly restricted to the quantification

Table 2 *Quantitative utilization of protein, carbohydrate and phenols per day by the various instars of* C. ranacea

Instar	Proteins (mg)			Carbohydrate (mg)			Phenols (mg)		
	GH	AE	AI	GH	AE	AI	GH	AE	AI
I	7.72 (94.84)	1.65 (76.30)	3.98 (98.03)	61.97 (95.16)	85.70 (96.19)	46.86 (99.13)	29.31 (85.18)	23.69 (55.89)	16.93 (89.81)
II	20.75 (96.29)	9.34 (96.55)	4.40 (94.52)	166.44 (96.50)	392.89 (99.59)	52.90 (97.61)	81.37 (89.28)	178.87 (95.31)	15.60 (72.18)
III	71.14 (94.04)	12.60 (97.02)	3.42 (90.48)	571.37 (94.41)	532.49 (99.52)	42.23 (95.96)	264.98 (82.86)	240.26 (94.38)	9.32 (53.11)
IV	23.32 (92.78)	5.65 (86.26)	3.54 (89.51)	187.43 (93.21)	263.86 (97.78)	43.95 (95.44)	84.15 (79.20)	95.38 (74.30)	8.65 (47.11)
V	43.01 (84.04)	9.06 (90.83)	4.41 (85.71)	348.13 (85.03)	404.87 (98.52)	56.21 (93.84)	117.10 (54.13)	161.96 (82.84)	6.82 (28.55)

GH—*Gossypium hirsutum*, AE—*Abelmoschus esculentus*, AI—*Abutilon indicum*
Values in parentheses represent CAD (Coefficient of approximate digestibility)

Table 3 *Biochemical analysis of the host plant leaves of* C. ranacea*

Host plants	Protein mg/gm	Carbohydrate mg/gm	Phenol mg/gm	Nitrogen %	Water %	Water/ Nitrogen
G. hirsutum	55.0	440.0	232.5	8.8	73.16	8.31
A. esculentus	12.5	515.0	245.0	5.6	80.49	14.37
S. rhomboidea	97.5	302.5	245.0	7.4	46.36	10.31
A. indicum	35.0	407.5	165.0	5.0	69.50	34.75

*Mean of 3 replicates

of such ethological parameters as palpation, nibbling, biting etc. In this study, the analysis of the host preference has been made based on the following: (1) Rate of development, (2) Growth rate and, (3) Quantitative food intake. Using these parameters, the preferential sequence computed for *Cyrtacanthacris ranacea* among the malvaceous host plants is *G. hirsutum*>*A. esculentus*>*A. indicum*>*S. rhomboidea*.

Faster post-embryonic development of *C. ranacea* when fed on *G. hirsutum* holds good with the observation of Pfadt (1949) where he mentioned that nymphs of *Aulocara elliotti* (Thos.) had the shortest duration in the most preferred host. This effect of food on the insect may be either due to the differences in the amount of food ingested or due to the chemical or physical differences in the food itself (Johansson 1964). The amount of food ingested by *C. ranacea* was significantly higher on *G. hirsutum* in comparison with the other hosts, facilitating faster rate of development on this host plant.

The relationship between live-weight changes during post-embryonic development has been an useful tool in growth studies, since the quality and quantity of food greatly influenced growth as well as the rate of development in grasshoppers. In the present study, a gradual increase in weight was observed up to the third instar beyond which the growth rate was markedly high in all the host plants. This feature may be correlated with the increased food intake during the third nymphal stage.

Irrespective of the host plants fed on, the maximum food consumption and utilization by *C. ranacea* was during the third instar stage. The approximate digestibility (AD) computed on the three host plants, indicate a high value during the early nymphal stages, that is first to third. Mehrotra et al. (1972) while comparing the food consumption by the third, fourth and fifth instars of *Schistocerca gregaria* Forskal and *Locusta migratoria* L. observed a maximum AD value for the third instar nymph. The differences in the AD, ECI and ECD values observed in the present study with different host plants is a feature also observed for *L. migratoria* by Bennakkers et al. (1971). The present study showed a positively low preference for *A. indicum* as against the other two hosts. Although the amount of food consumed was more on *A. esculentus*, in comparison to *G. hirsutum*, the net conversion of food into body substance, resulting in the weight gain of the insect was the maximum on *G. hirsutum*. This is further supported by the study on the nutrient utilization which showed a greater utilization of proteins and carbohydrates by the grasshopper fed on *G. hirsutum*. The greater consumption on the less preferred host plant may be explained as being due to the need for compensation for the low nutritive value of the host.

The post-ingestive growth performance is determined to a large extent by plant chemical quality and can be indexed by leaf water-nitrogen composition (Scriber 1984). *C. ranacea* appeared to show greater preference to host plants with low water-nitrogen index as evidenced by their greater consumption of *G. hirsutum* which has a comparative low index. Increased plant nitrogen increases insect damage, a feature also observed for *C. ranacea*. The inability for the nymphs to survive on *S. rhomboidea* beyond the third instar could be attributed to the comparative high concentration of proteins and very low concentration of carbohydrates in the leaves.

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