THE UTILIZATION OF FOOD BY BIGHEADED GRASSHOPPER, *AULOCARA ELLIOTTI* (THOMAS).

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Abstract. Aulocara elliotti nymphs were raised from the first nymphal stage to the final instar on the leaves of crested wheatgrass and western wheatgrass. The average efficiency of Conversion of Ingested Food to Body Substance (E.C.I.) of the male grasshoppers fed on crested wheatgrass was found to be 8.50 percent compared to 7.33% for those fed on western wheatgrass. The highest, 9.42 percent, occurred among the females fed on crested wheatgrass. During this period the Efficiency of Conversion of Digested Food to Body substance (E.C.D.) of the male grasshoppers was 22.52 percent on crested wheatgrass and 28.75 percent on western wheatgrass. The highest, 29.43 percent, occurred among the females fed on crested wheatgrass. In general the E.C.D. increased gradually during successive nymphal stages.

Introduction. The development of synthetic diets for several insect species has afforded considerable insight into the nutritional requirements of the class. It seems that insects are qualitatively vary uniform in their nutritional requirements (Dadd, 1960). The qualitative requirements of a number of insects, representing different taxa and feeding habits, have been tabulated by Albritton (1954), Altman and Dittmer (1964 and 1968), and House (1965).

Evidently, the qualitative nutritional requirements include about 25 substances (House 1969). These qualitative requirements offer few differences that distinguish one species from another, especially among phytophagous insects. House (1969) suggested that quantitative factors are more important. These depend on how much of each nutrient the digestion of food-stuff can provide for insect nutrition; and how well the amounts and proportions of the nutrient made available fit the quantitative nutritional requirements of insects.

Many vertebrate nutritionists have devised various indices of consumption, digestibility and efficiency of conversion (Crampton, 1959; Kleiber, 1961; Goldblith and Maynard, 1964; Tyler, 1964). The use of these indices in insect nutrition has been discussed by Trager (1953), Weldbauer (1962, 64, 68) and Gordon (1958). These indices were standardized by Waldbauer (1968) and successfully followed by others (Mordue and Hill, 1970) including this attempt.

Materials and methods. Grasshoppers were hatched from the eggs early in the month of June. Each newly hatched nymph was reared singly in cages on one of two food plants. The cages used for rearing were plastic containers. The dimensions of each

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container were top diameter 10 cm, bottom diameter 9.6 cm, depth 6.25 cm. The sides of the container had two cutout openings 2.5×5 cm each covered with saran screen. The containers were polystyrene plastic.

Agropyron smithii (Rybd) (western wheatgrass) and *Agropyron cristatum* (crested wheatgrass) were used as food plants. The food supply was replenished every day. The rearing was carried on in a controlled room at 85 ± 3 °F temperature and 30 ± 5 percent relative humidity. The room was continuously lighted by four 40 watt fluorescent tubes. The insects were reared till they reached the adult stage and data were summarized for each nymphal period. In all, forty grasshoppers were used in the experiment, each treatment receiving 20 nymphs.

Old food and faeces were removed every twenty four hours, and a known fresh weight of food was introduced at the same time. Food, faeces and insects were weighed on a Mettler balance. The fresh weight of each nymph was determined at the beginning of the experiment. An estimate of the dry weight of each nymph was calculated by using the mean percent dry weight of an aliquot of similar nymphs reared singly on each food, which had been killed by exposure in a freezer, weighed and then drived to a constant weight in an oven at 60 °C. Measurements of food utilization were made on a dry weight rather than fresh weight basis because leaves vary greatly in their content of dry matter. The estimated dry weight of each meal was calculated from the percent dry matter of an aliquot.

The efficiency of conversion of ingested food to body substance (E.C.I.) was calculated as:

$$\text{E.C.I.} = \frac{\text{Weight gain}}{\text{Weight of food ingested}} \times 100$$

and the efficiency with which digested food is converted to body substance (E.C.D.) was calculated as:

$$\text{E.C.D.} = \frac{\text{Weight gain}}{\text{Weight of food ingested-weight of faeces voided}} \times 100$$

The data were obtained on a physiologically defined period. Feeding was *ad libitum*. The "t" test was employed for comparison of the two foods.

Results and Discussions. The average E.C.I. of male grasshoppers fed on crested wheatgrass was 8.50 percent, compared to 7.33 percent for those fed on western wheatgrass (table 1). The lowest values were recorded during the first instar. The E.C.I. increased sharply in the 2nd instar and remained more or less constant during the third and fourth stages. The average E.C.I. of 9. 42 percent in females was highest among the grasshoppers fed on crested wheatgrass (table 2). With both grasses the E.C.I. increased substantially during the second stage and remained more or less same during the later stages. Statistical

analysis showed that male grasshoppers feeding on crested wheatgrass demonstrated better E.C.I. during the second stage, while female grasshoppers fed on crested wheatgrass achieved decidedly higher E.C.I. during all stages than those feeding on western wheatgrass.

The average E.C.D.s of crested wheatgrass and western wheatgrass were 22.52 and 82.75 percent for male grasshopper, respectively (table 3). The E.C.D. on crested wheatgrass increased from a low of 7.69 percent during the first instar to a high of 25.97 percent during the 4th instar. Grashopper fed on western wheatgrass attained an all time high of 3 .55 percent during the 4th stage. The E.C.D. was lowest during the first stage. Statistically these differences were non significant. In case of the female grasshopper, 29.43 percent was calculated for those fed on crested wheatgrass compared to 27.82 percent on western wheatgrass (table 4). Statistically these differences were found highly significant at 5 percent level using a "t" test.

From these observations it is clear that among the females there were considerable defferences in the efficiency with which both crested wheatgrass and western wheatgrass were utilized for growth. Differences in E.C.I. were greater than differences in E.C.D. Among the males the differences were found only during the first stage. The differences in E.C.D. were less than differences in E.C.I. This was not unexpected because the approximate digestibility (A.D.) has a considerable effect on the E.C.I. Besides this there are many other factors which affect both E.C.I. and E.C.D. A nutritional deficiency could cause the digested portion of the food to be poorly utilized. Hopkins (1912) observed that rats fed on a diet deficient in B vitamins wasted much of the food which they digested.

Both the E.C.D. and E.C.I. were higher during the later stages than the early stages. This was expected because the E.C.D. is affected by factors influencing the amount of energy devoted to physiological functions or support of activity. More food is devoted to energy production during the early stages of grasshoppers, while during the late stages the food is efficiently converted to body substances. In agreement with the work of Mordue and Hill (1970) our results show that both E.C.I. and E.C.D. were higher during overian than during somatic growth.

Table 1

E.C.I. † of Male grasshopper fed on crested wheatgrass and western wheatgrass.

Instar	Weight of food ingested (g)	Weight gain (g)	Food	E.C.I.	"t"
I	0.0278	0.0011	Crested wheatgrass	3.96	
	0.0337	0.0008	Western wheatgrass	2.37	1.3584
II	0.0491	0.0041	Crested wheatgrass	8.35	
	0.0555	0.0045	Western wheatgrass	8.11	0.8350
III	0.0884	0.0074	Crested wheatgrass	8.37	
	0.1144	0.0080	Western wheatgrass	6.99	0.9999
IV	0.1831	0.0167	Crested wheatgrass	9.12	
	0.2153	0.0174	Western wheatgrass	8.10	2.0302*

†average of 20 grasshoppers.
*Significant at 5% level.

Table 2

E.C.I.† of Female grasshopper fed on crested wheatgrass and western wheatgrass.

Instar	Weight of food ingested (g)	Weight gain (g)	Food	E.C.I.	"t"
I	0.0262	0.0010	Crested wheatgrass	3.82	
	0.0369	0.0007	Western wheatgrass	1.90	5.1505**
II	0.0407	0.0041	Crested wheatgrass	10.10	
	0.0577	0.0044	Western wheatgrass	7.63	2.5870**
III	0.0696	0.0059	Crested wheatgrass	8.48	
	0.1037	0.0060	Western wheatgrass	5.79	2.7216**
IV	0.1585	0.0176	Crested wheatgrass	11.10	
	0.1895	0.0168	Western wheagrass	8.87	1.3269
V	0.3534	0.0325	Crested wheatgrass	9.20	
	0.4118	0.0219	Western wheatgrass	5.33	6.025**

†average of 20 grasshoppers.
**Significant at 1% level.

Table 3

E.C.D.† of Male grasshopper fed on crested wheatgrass and western wheatgrass.

Instar	Weight of food ingested (g)	Weight of faeces voided. (g)	Weight gain (g)	Food	E.C.D.	"t"
I	0.0278	0.0135	0.0011	Crested wheatgrass	7.69	
	0.0337	0.0199	0.0008	Western wheatgrass	5.80	2.1313*
II	0.0491	0.0277	0.0041	Crested wheatgrass	19.16	
	0.0555	0.0370	0.0045	Western wheatgrass	24.32	2.7611**
III	0.0884	0.0547	0.0074	Crested wheatgrass	21.96	
	0.1144	0.0839	0.0080	Western wheatgrass	26.23	1.4363
IV	0.1831	0.1188	0.0167	Crested wheatgrass	25.97	
	0.2153	0.1713	0.0174	Western wheatgrass	39.55	4.0998**

†average of 20 grasshoppers.
*Significant at 5% level.
**Significant at 1% level.

Table 4

†*E.C.D. of Female grasshopper fed on crested wheatgrass and western wheatgrass.*

Instar	Weight of food ingested (g)	Weight of faeces voided (g)	Weight gain	Food	E.C.D.	"t"
I	0.0263	0.0124	0.0010	Crested wheatgrass	7.25	
	0.0369	0.0197	0.0007	Western wheatgrass	4.10	1.6151
II	0.0407	0.0223	0.0041	Crested wheatgrass	22.28	
	0.0577	0.0348	0.0044	Western wheatgrass	19.21	1.2259
III	0.0696	0.0443	0.0059	Crested wheatgrass	23.32	
	0.1037	0.0661	0.0090	Western wheatgrass	15.96	2.2488*
IV	0.1585	0.1075	0.0176	Crested wheatgrass	34.51	
	0.1895	0.1469	0.0168	Western wheatgrass	39.44	0.7172
V	0.3534	0.2543	0.0325	Crested wheatgrass	32.80	
	0.4118	0.3495	0.0219	Western wheatgrass	35.15	0.6726

†average of 20 grasshoppers.
*Significant at 5% level.

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