Proc. Indian Acad. Sci. (Anim. Sci.), Vol. 96, No. 3, May 1987, pp. 245–251.

Influence of nutrition on the reproductive biology of sugarcane pests and their natural enemies

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Abstract. The survival and fecundity of the scale insect, *Melanaspis glomerata* (Green) varies according to the sugarcane varieties on which they feed. When the sugarcane setts infested with scale insect crawlers were maintained on different nutritional bases, high survival and fecundity were observed in distilled water as the medium. The nutrition of immature stages and adults of the egg parasite, *Trichogramma* spp. was found to influence the longevity and reproduction. The eggs of *Corcyra* reared on groundnut kernels had appreciable quantities of growth promoting amino acids like glysine, analine and tyrosine and this influenced the size of the adult parasites. The higher fecundity of the parasites obtained from the eggs of *Corcyra* reared on greengram was attributed to the maximum level of nutrients. The individuals which emerged from superparasitized eggs showed reduction in mating and fecundity because of the sharing of the nutrients. The adult longevity and fecundity increased when fed with different sugars in the presence of host eggs. Increase in the protein content in adult diet decreased the fecundity.

In the larval parasite, *Sturmiopsis inferens* the qualitative variation in the nutrient contents due to interspecific variation and quantitative variation as influenced by the size of the host influenced the reproductive capacity of the parasite.

Keywords. Sugarcane pests; natural enemies; nutrition; fecundity.

1. Introduction

Though investigations on nutritional aspects have been done well in some phytophagous and parasitic insects, such basic information is scanty with regard to sugarcane pests and their insect natural enemies. The sugarcane entomologists in the past were more concerned with biology, ecology and control of sugarcane pests. But, it is well understood that basic nutritional information is necessary for species of economic importance, like various lepidopteran and hemipteran insects attacking sugarcane, which may demand studies involving the use of defined food, standardised culture or mass rearings. Attempts already made in this direction has resulted in the development of artificial diet for stalk borer, *Chilo auricilius* Ddgn (Varma *et al* 1975; Bhardwaj *et al* 1984; Jaipal *et al* 1986), internode borer, *Chilo sacchariphagus indicus* (Kapur) (Mehta and David 1978), pink borer, *Sesamia inferens* Wlk (Chatterji *et al* 1969; Qureshi *et al* 1975; Lingappa 1978; Easwaramoorthy *et al* 1986) and Sorghum borer, *Chilo partellus* Swinhoe (Dang *et al* 1970; Seshu Reddy and Davies 1978) infesting sugarcane. However, not much information has been generated on the impact of nutrition on reproductive biology of sugarcane pests and their natural enemies. The available information is summarised in this paper.

2. Sugarcane scale insect, *Melanaspis glomerata* (Green)

2.1 *Influence of sugarcane varieties*

The sugarcane varieties show quantitative variation in the chemical composition and there occurs significant variation in the reducing and non-reducing sugar content. This is found to influence the establishment, development and reproduction of scale insect, *M. glomerata*. Under laboratory conditions, the number of crawlers that successfully reached reproductive stage varied with the variety. While 72·4% of crawlers reached adult stage on variety Co 740, only 17·1% reached adult stage on CoC 671, probably due to the variation in the nutrient contents. On the other hand the females reared on Co 413 produced significantly more number of crawlers compared to females settled on varieties like Co 775, CoA 7602, CoC 671 and Co 975 (table 1).

2.2 *Influence of media*

The sugarcane setts after the establishment of crawlers, when planted on different media affected the development and fecundity of the scale insect. The proportion of crawlers reaching adult stage (table 2) was more when the medium used to support the sugarcane sett was distilled water, followed by mixed medium (silt, sand and farm yard manure in equal proportion) and White's medium (Thorpe 1981). The fecundity of females was more, when they were reared on cane setts planted in White's medium followed by those that developed on cane setts kept in distilled water. The increased fecundity may be attributed to increase in the size of the insect. This may be due to the availability of more amount of essential nutrients for the insects developing on cane setts planted in these media.

3. Egg parasite, *Trichogramma* spp.

Trichogramma spp. are the most important egg parasites of sugarcane borers in India. It is mass reared on the factitious host, *Corcyra cephalonica* St. The success of mass production in the laboratory and also performance in the field depends to a greater extent on the nutrition.

3.1 *Nutrition of immature stages*

Nutrition of the host insect significantly influences the reproductivity capacity of the

Table 1. Survival (%) and fecundity of scale insect on different sugarcane cultivars.

Variety[a]	Survival (%)	Mean fecundity
Co 413	61·4 (51·62)[b]	160·8
Co 740	72·1 (58·08)	125·7
Co 775	31·5 (34·05)	115·9
Co 975	61·4 (51·62)	102·9
Co 62175	44·5 (41·81)	147·1
CoA 7602	44·8 (42·03)	111·8
CoC 671	17·1 (24·44)	107·2
CoR 8001	36·6 (33·63)	159·5
CD at 5%	7·16[c]	9·59[c]

[a]Sugarcane setts planted on mixed medium
[b]Figures in parentheses are transformed values
[c]Significant at 1% level.

Table 2. Survival (%), weight, fecundity and sex ratio of scale insect on sugarcane setts kept in different media.

Medium	Survival(%)	Weight of 25 scale insects(mg)	Mean fecundity	Sex ratio (M:F)
Sand + White's medium	19·3	235·9	127·1	1:1·67
Mixed + White's medium	31·7	301·4	191·5	1:1·38
White's medium	55·4	281·1	225·9	1:0·77
Sand	21·2	223·9	99·7	1:0·81
Mixed medium	56·0	276·2	147·4	1:1·33
Distilled water	61·4	309·2	219·0	1:0·83
	7·3		30·57	

Table 3. Amino acid contents in the diets and eggs (μg/g)

Amino acid	Groundnut	Greengram	Sorghum
Total free (diet)	2160	5620	3200
Total bound (diet)	1,03,600	86,000	62,720
Total free (eggs)	31,800	29,600	27,400

Table 4. Effect of larval diets on the parasites, *T. chilonis* and *T. japonicum.*

	T. chilonis				*T. japonicum*			
	Size of female(μ)				*Size of female(μ)*			
Larval diet	Length	Breadth	Fecundity	Sex ratio	Length	Breadth	Fecundity	Sex ratio
Sorghum	409·2	171·6	14·5	1:1·20	457·6	158·4	13·5	1:2·78
Greengram	466·4	176·0	39·3	1:1·82	501·6	180·4	23·4	1:2·92
Groundnut	448·8	171·6	30·8	1:1·08	484·0	180·4	12·9	1:2·84

parasite (Navarajan Paul 1980). The effect of host nutrition on the longevity, fecundity and sex ratio of *T. chilonis* Ishii (= *T. australicum* Gir.) was studied by Katiyar (1962). He concluded that the parasite was most efficient when bred on eggs of *C. cephalonica* obtained from crushed sorghum mixed with 8% yeast. Later, Navarajan Paul *et al* (1975) made detailed studies on the effect of eggs of *C. cephalonica* bred on sorghum grains, greengram seeds and groundnut kernels on *T. chilonis* and *T. japonicum* Ashm. The size of the host eggs obtained from the different diets varied greatly. Eggs obtained from the adults of *C. cephalonica* reared on groundnut diet were comparatively larger than those from greengram and sorghum diets. It was noticed that the development of the parasites was influenced by the size and nutrient content of host eggs. Seshagiri Rao (1954) also observed a similar phenomenon in the pupae of *C. cephalonica* reared on different diets.

The eggs of *Corcyra* reared on groundnut kernels had appreciable quantities of growth promoting amino acids like glysine, alanine and tyrosine, when compared with the amino acid contents in the eggs of moths reared on other diets (table 3). This has influenced the size of the adult parasites. In both the species, the size of the adult parasites emerged from the eggs of *Corcyra* reared on groundnut kernels was the biggest (table 4).

The fecundity of the parasites obtained from the eggs of *Corcyra* bred on different diets showed remarkable differences. Highest fecundity of the parasites was noticed

Table 5. Nutrient contents in the eggs of *C. cephalonica*.

	Nutrient contents (%)					
Eggs obtained from	Calcium	Potassium	Phosphorus	Total nitrogen	Total soluble carbohydrates	Glycogen
Sorghum diet	1·40	0·90	0·312	2·80	26·67	12·50
Greengram diet	1·65	2·00	0·450	3·08	40·84	19·17
Groundnut diet	1·50	1·00	0·300	2·80	29·17	17·50

in both the species reared on the eggs of *Corcyra* bred on greengram diet (table 4). The higher rate of fecundity was attributed to the maximum level of nutrients viz calcium, phosphorus, total nitrogen, glycogen and total soluble carbohydrates present in the eggs of moths bred on greengram (table 5).

Even though the different larval diets of the host had influence on the size and nutrient content of the eggs of *Corcyra*, these had no effect on the sex ratio in both the species (table 4).

Another aspect of nutrition of immature stage is noticed when superparasitism occurs. As a result of superparasitism, though 1–3 adults of *T. chilonis* emerged from a single host egg (*Corcyra* egg), they were defective with poorly developed wings. Such individuals were inactive and only a few showed a tendency for mating with forms of about their own size. The fecundity of such females that emerged from superparasitized eggs was low (Chacko 1953; Narayanan and Chacko 1957). The reason for the improper development of the parasites and reduced fecundity is attributed to the sharing of the limited amount of food in the host eggs between the developing parasites.

3.2 *Nutrition of adult parasites*

The adults of *T. evanescens* West. fed on dilute honey lived significantly longer and produced more progeny than starved females (Lund 1938). Later, Narayanan and Mookherjee (1955) made detailed studies on adult nutrition. There was a significant increase in the longevity and fecundity of *T. chilonis* adults when fed with 10% solutions of glucose, fructose, maltose and sucrose compared to unfed females. Longevity and fecundity also increased to a certain extent with the addition of 10% solution of yeast extract, *Corcyra* eggs extract or centrifuged milk, to a 10% solution of glucose given as feed in equal proportions (table 6). There was a great increase in the longevity of the parasite, when fed merely on sugar than when fed with different proteins in combination with glucose. The fecundity of the parasite was highest when fed merely on sugar in the presence of host eggs and an addition of yeast extract, *Corcyra* egg extract or skimmed milk to the sugar solution lowered its fecundity. So, it is evident that host proteins are of more value than other proteins. The parasite, however, seems to need only a limited quantity of the host protein to lay its normal quota of eggs and any increase in the proportion of its protein beyond what the parasite normally imbibes from eggs at the time of oviposition has resulted in a lowering of its fecundity. It is, therefore, apparent that its protein requirements are normally derived from the host itself.

Ramachandra Rao (1955) also reported that the fecundity and longevity of

Table 6. Effect of adult nutrition on longevity and fecundity in *T. chilonis*.

	Longevity of males (days)			Longevity of females (days)			Fecundity of females*
Treatments	No mating Host eggs not provided	Mating Host eggs not provided	Mating Host eggs provided	No mating Host eggs not provided	Mating Host eggs provided	Mating in presence of host eggs and laying eggs	Number of *Corcyra* eggs parasitised
No food	0·99	1·15	1·06	1·49	1·21	1·80	46·05
Glucose	4·00	4·30	4·80	18·40	10·15	13·50	94·90
Maltose	3·95	3·65	4·75	9·20	7·35	11·45	94·40
Fructose	4·95	4·95	5·15	10·10	7·90	14·05	106·60
Sucrose	5·65	4·15	4·65	9·25	8·70	10·80	81·30
Skimmed milk and glucose	3·95	1·60	1·95	3·70	2·20	3·45	57·90
Yeast extract and glucose	3·30	2·75	2·55	5·70	4·00	5·55	69·45
Corcyra eggs extract and glucose	3·70	2·80	2·40	7·60	3·45	7·65	69·45
Tap water	2·25	1·27	1·23	2·57	1·14	1·76	35·1
Corcyra egg extract	1·67	—	—	1·27	—	—	—
CD at 5%	0·86	1·07	1·40	1·95	1·57	0·96	20·50

*Females mated and laid eggs in the presence of host eggs.

Table 7. Effect of different hosts on fecundity of *S. inferens*.

Host	Mean host pupal weight (mg)	Mean parasite puparial weight (mg)	Mean fecundity (number/female)
Chilo infuscatellus Snell.	72·7	34·0	196·4
Chilo partellus Swinhoe	79·4	40·8	252·6
Scirpophaga excerptalis Wlk.	96·0	39·3	270·0
Sesamia inferens Wlk.	123·3	48·5	322·0
Galleria mellonella (L.)	115·6	41·3	357·1
Corcyra cephalonica Stn.	23·6	21·2	No mating occurred

T. chilonis increased considerably when the parasites were fed on 10% solution of different sugars. Both virgin and mated females fed on honey-water solution lived upto 5 days and retained their eggs upto 72 h after emergence without any detrimental effect (Sharma 1968).

4. Larval parasite *Sturmiopsis inferens* Tns.

S. inferens is an endo-larval parasite of sugarcane shoot borer, pink borer, stalk borer and Gurdaspur borer, *Acigona steniellus* Hmpsn. Though the exact nutrient requirements of the parasite was not worked out, it was found that the size of the host is found to influence the size and fecundity of the parasite (table 7). A positive corr~lation was obtained between the weight of the host pupae and parasite puparia irrespective of the host. The weight of the puparia, in turn, influenced the fecundity of

Table 8. Influence of host sex on the pupal and adult weight.

	Weight (mg)					
	Male parasite	Female parasite	Mean	Male parasite	Female parasite	Mean
	Male host			Female host		
Host pupa	44·2	43·0	43·6	86·0	87·2	86·7
Parasite puparia	25·0	24·8	24·9	39·3	38·7	38·9
Parasite adult	18·1	17·1	17·8	23·8	23·9	23·8
	Host pupa		Parasite puparium		Parasite adult	
	SE	CD	SE	CD	SE	CD
Between host sex	2·44**	5·48	2·04**	4·58	1·02**	2·81
Between parasite sex	NS		NS		NS	

the adults (David *et al* 1980). So, the qualitative variation in the nutrient contents due to interspecific variation and quantitative variation as influenced by the size of the host affected the reproductive capacity of the parasite.

Even within a host, the quantitative variation in nutrition, as influenced by the size of the host had an effect on the parasite weight and fecundity. The data presented on the weight of shoot borer pupa, parasite puparia and adult in table 8 revealed that the puparia and adult parasite developed from female pupae of the host, *C. infuscatellus* were bigger irrespective of the sex, than that developed from male pupae. Again weight of the adult parasite had a positive association with fecundity ($r = 0{\cdot}3824^*$).

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