Proc. Indian Acad. Sci. (Anim. Sci.), Vol. 98, No. 6, November 1989, pp. 391–397.

Impact of age correlated biochemical changes of host plant on food consumption and utilization efficiency of *Aularches scabiosae* F (Orthoptera: Insecta)

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MS received 5 September 1989

Abstract. The impact of age correlated biochemical changes in *Tectona grandis* Linn f (Verbenaceae) leaves on the food consumption and utilization efficiency of *Aularches scabiosae* F is provided. The relative preference and maximum utilization of mature leaves when compared to young and senescent leaves are attributed to the changes in the chemical profile particularly protein, nitrogen, carbohydrates, phenols and free fatty acids.

Keywords. Food utilization; leaf age; nutritional changes; *Aularches scabiosa* F.; *Tectona grandis*.

1. Introduction

The significance of chemical composition of plants with regard to host selection between different plant species and its influence on all aspects of insect performance are well known (Chapman and Bernays 1977; Miller and Strickler 1984). The qualitative and quantitative aspects of feeding in acridids (Dadd 1963; Kayed 1983; Ananthakrishnan *et al* 1985) indicate that the biochemical components of the host plants besides the physical factors, decide host suitability. Variations in the nutritional quality between plant species or even within a plant can influence the food preference, growth rate, developmental time and hence the biotic potential of insects (Jermy 1976; Rees 1979; Slansky 1982). In this paper an attempt has been made to study the food consumption and utilization efficiency of *Aularches scabiosae* F in relation to the age correlated nutritional changes in *Tectona grandis* Linn f (Verbenaceae).

2. Materials and methods

Individuals of *A. scabiosae* were collected from the teak forests of western ghats and reared in the laboratory in wooden cages to observe the duration of each instar. Food consumption and utilisation were calculated according to gravimetric method of Waldbauer (1968). Nymphs were weighed after moulting into successive instar. Biochemical estimates of different aged leaves of *T. grandis* were done for total protein (Lowry *et al* 1951), carbohydrates (Dubois *et al* 1956), phenol (Bray and Thorpe 1954), free amino acids (Moore and Stain 1948), nitrogen (Vogel 1963) and lipids (Folch *et al* 1957). Qualitative fatty acids profile of the host leaves of different ages were analysed by Hewlett Packard HPLC system at 230 nm using an Hypersil ODS 5 μm column with water and acetonitrile as solvents at a flow rate of 0·45 ml according to the gradient programme as per Schuster (1985). The retention time and area percentage of free fatty acid methyl esters were recorded.

3. Results

A. scabiosae is a univoltine species feeding on teak leaves. The nymphs pass through 7 instars, each instar period lasting for 15–20 days. Food utilization by different instar stages shows the general trend of very high approximate digestability (AD) and low efficiency of conversion of digested food (ECD) during the early instars which gradually decrease and or increase towards the later instar stages (table 1). Figure 1 shows the biochemical components (%) of food consumed by *A. scabiosae* on different aged leaves of *T. grandis*. This indicates the relative preference of these acridids towards mature leaves with high protein (90 mg/g), lipid (59 mg/g), nitrogen (14·4%) and amino acid (15·79 mg/g) content (table 3). The carbohydrate content was comparatively less (440 mg/g) in mature leaves when compared with young leaf (460 mg/g). Maximum value for water/nitrogen ratio was recorded in mature leaves (6·17). The total phenolic content was the least in mature *T. grandis* leaves.

Table 1. Quantitative food utilization by *A. scabiosae* on *T. grandis*.

Instar	Consumption* (mg)	Excreta* (mg)	Wt. gain* (mg)	CI	GR	AD (%)	ECD (%)	ECI (%)
I	4·851 ± 1·75	2·715 ± 0·86	0·184 ± 0·014	7·081	0·268	44·03	8·614	3·79
II	11·863 ± 1·39	6·377 ± 1·30	0·541 ± 0·275	9·505	0·433	46·24	9·861	4·56
III	19·814 ± 4·44	17·610 ± 1·54	0·989 ± 0·700	4·628	0·231	11·12	44·872	4·99
IV	30·414 ± 3·33	27·535 ± 3·10	1·838 ± 1·217	4·442	0·268	09·46	63·841	6·04
V	58·894 ± 1·02	53·001 ± 0·86	4·560 ± 1·05	10·600	0·433	10·00	77·353	7·74
VI	142·586 ± 3·75	128·327 ± 1·02	9·651 ± 1·13	5·112	0·346	10·15	67·683	6·76
VII	240·278 ± 2·51	185·850 ± 1·60	14·453 ± 2·15	7·624	0·458	22·65	26·55	6·01

*Mean of 5 replicates mg dry wt/day/insect.

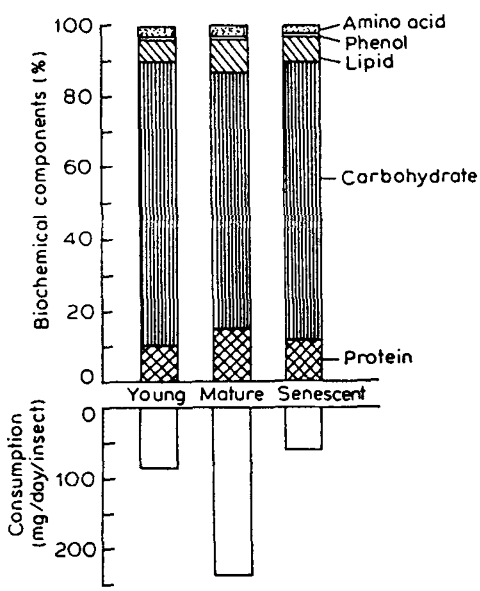

Figure 1. Biochemical components (%) of food consumed by *A. scabiosae* on different aged leaves of *T. grandis*.

Higher food intake in mature and young leaves was also observed (240·278 mg dry wt/day/insect and 81·688 mg dry wt/day/insect respectively). On the contrary, the consumption rate was much reduced in the senescent leaves (71·358 mg dry wt/day/insect) which contain higher proportions of phenols (table 2). Corresponding to feeding there was considerable variation in the weight gain and growth rate by insects when fed on different leaf stages. Individuals feeding on mature leaves showed a higher weight gain (14·45 mg dry wt/day/insect) than on young and senescent leaves. Figure 2 gives the relationship between the various biochemical parameters of different aged leaves and food consumption in *A. scabiosae*.

Age correlated changes in the fatty acid methyl ester of *T. grandis* leaves showed the presence of some early saturated fatty acids, lauric acid and linolenic acid in young and mature leaves. The percentage composition of linolenic acid was comparatively more than lauric acid in young leaves. However, in mature leaves the percentage composition of lauric acid increased to about cent per cent while linolenic acid decreased to only 12%. In senescent leaves lauric acid and linolenic acid were completely absent (figure 3, table 4).

Table 2. Food utilization of *A. scabiosae* (7th instar) on different aged leaves of *T. grandis*.

Leaf age	Consumption* (mg)	Excreta* (mg)	Wt. gain* (mg)	CI	GR	AD (%)	ECD (%)	ECI (%)
Young	81·688 ± 1·54	77·01 ± 1·8	3·57 ± 0·5	5·079	0·221	5·73	75·981	4·36
Mature	240·278 ± 2·51	185·85 ± 1·6	14·45 ± 2·1	7·624	0·458	22·65	26·554	60·15
Senescent	71·358 ± 1·61	67·10 ± 1·5	0·96 ± 0·1	3·217	0·043	6·10	22·010	1·34

*Mean of 5 replicates mg dry wt/day/insect.

Table 3. Chemical composition of *T. grandis* leaves.

Stage	Moisture (%)	Protein (mg/g)	Carbo-hydrates (mg/g)	Lipid (mg/g)	Phenols (mg/g)	Amino acid (mg/g)	Nitrogen (%)	Water/N ratio
Young leaf	59·00	60	460	36	2·83	9·50	9·6	6·14
Mature leaf	88·95	90	440	59	2·37	15·79	14·4	6·17
Senescent leaf	38·22	50	330	30	2·47	9·03	8·0	4·78

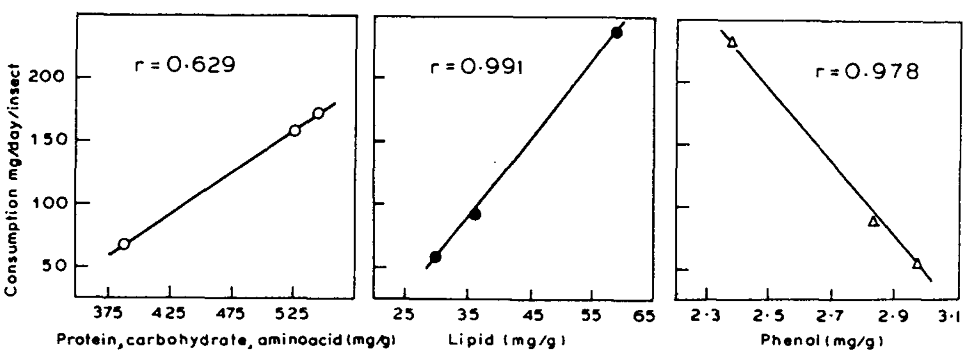

Figure 2. Relationship between various biochemical parameters of different aged leaves of *T. grandis* and food consumption in *A. scabiosae*.

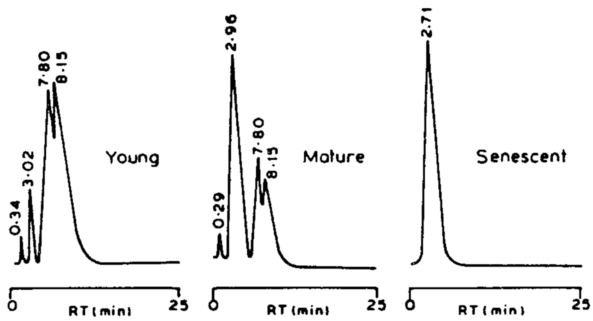

Figure 3. HPLC analysis of fatty acid methyl esters of different aged leaves of *T. grandis.*

Table 4. The retention time and area (%) of the free fatty acid methyl esters of *T. grandis.*

	Young		Mature		Senescent	
	Retention time	Area (%)	Retention time	Area (%)	Retention time	Area (%)
	0·34*	0·118*	0·29*	0·100*	2·71*	100·00*
	3·02*	17·116*	2·96*	77·769*		
Lauric acid	7·80	34·333	7·80	99·446		
Linolenic acid	8·15	48·443	8·15	12·685		

*Earlier fatty acids.

Food utilization efficiency in *A. scabiosae* shows variation in relation to changes in the nutrient contents of the leaves. The utilization efficiencies shows higher values in mature leaves. However, in senescent and young leaves the efficiencies were so adjusted by the insect to compensate for the reduced feeding (table 2).

4. Discussion

The seasonal variation in food quality found in many plants (McNeill and Southwood 1978; Prestidge and McNeill 1982) particularly the protein content is often limiting for insect development (Mattson 1980). The amount of food consumed and consequent growth occurring during the final instar comprise over 75% of the totals for the whole larval stage (Waldbauer 1968) and tend to be a representative of those calculated for the entire larval stage (Scriber and Slansky 1981). In the present study differences in the total quantity of ingested food by the 7th instar *A. scabiosae* from young, mature and senescent leaves of *T. grandis* might be attributed to the difference in the nutritive quality in relation to the age of the leaves, since the selection of food by acridids generally have a greater chemical basis (Bernays and Chapman 1970). In acridids water content of the leaves undoubtedly affect food consumption. The moisture content of *T. grandis* leaves declines from 88% in mature leaves to 38% in senescent leaves. It is known that acridids take larger meals on lush grass with high water content (Chapman and Bernays 1977). Similar to *A. scabiosae*, *Nomadacris* also exhibited a preference for grasses with high water content (Chapman 1957). However, Bernays and Chapman (1970) found no difference in the acceptability of grass with different moisture content to *Chorthippus parallelus*.

In addition to the reduction in water content there tends to be a reduction in the protein especially the nitrogen content and an increase in the secondary substances during senescing (Feeny 1976; Scriber and Slansky 1981). The final instar period which is a period of somatic growth is characterised by intense feeding activity. During this period considerably more protein is ingested. In desert locust omission of bran with high protein content slowed down the rate of somatic growth (Hill *et al* 1968). The consumption and the weight gain by *A. scabiosae* increased when fed with mature leaves, containing about 90 mg/g of protein and 14·4% of nitrogen. The growth rate of insects are generally more closely correlated with nitrogen in the leaves (Scriber and Feeny 1979). In this study, consumption and weight gain by *A. scabiosae* were significantly low in senescent leaves due to lesser concentrations of nitrogen and protein. Moreover the higher leaf water/nitrogen ratio in mature *T. grandis* leaves significantly increased the approximate digestability in *A. scabiosae* (Manuwota 1984; Slansky and Feeny 1977) (table 3). Higher growth rate and higher weight gain of *A. scabiosae* per day on mature leaves closely paralleled with the total leaf nitrogen, because of this strong correlation of approximate digestability with leaf nitrogen. Hence, the decline in the nitrogen and moisture content of senescent leaves are found to reduce the suitability of leaves as food for *A. scabiosae* and also the digestability.

Except for cholesterol and some amounts of fatty acids, acridids have no major requirements for lipids. An assessment of fatty acid methyl ester profiles of *T. grandis* leaves showed the presence of some early saturated fatty acids, lauric acid and linolenic acid in mature and young leaves, which are important among dietary fatty acids. The ability to synthesize linolenic acid is generally lacking in insects and hence should be available in the diet (Gilbert 1967; Fast 1970; Downer 1978). Absence of linolenic acid in the diet caused the failure of pupal/adult ecdysis in several lepidopterans, like *Ephestia*, *Spodoptera littoralis* (Vanderzant *et al* 1957; Levinson and Navon 1969). Acridids show fatty acid deficiency by the emergence of deformed adults at the final moult preceded by retarded nymphal growth (Dadd 1963; Nayar 1964). *Locusta migratoria* was found to be more sensitive to the absence of fatty acid in the diet than *Schistocerca gregaria* (Dadd 1960). Lower consumption by *A. scabiosae* on senescent leaves containing none of these two fatty acids but only one of the earlier saturated fatty acids could be the cause for poor weight gain and low growth rate.

In *L. migratoria*, Worm and Beenakkers (1980) reported maximum assimilation of carbohydrate during somatic growth which was accounted as a source for carbon to build up chitin to be deposited in the cuticle. In mature leaves of *T. grandis* the availability of carbohydrates was low when compared to young leaves. The feeding preference of *A. scabiosae* attest the results obtained by Cook (1977) where very high concentrations of sugars limit the amount of food consumed. In the present investigation the relationship between the food consumed and the additive effect of protein carbohydrate and amino acids shows a positive correlation (figure 2). But the total phenolic content of different age groups of *T. grandis* leaves appear to interfere with the food consumption. High phenol content in senescent leaves reduced the food consumption by *A. scabiosae* as evidenced in other acridids like *Oxya nitidula*, *Atractomorpha crenulata* and *Aiolopus thalassinus* (Sanjayan and

Ananthakrishnan 1987). On the contrary plant phenols which are regarded as deterrent to insects has been shown to improve growth and survival of the acridid *Anacridium melanorhodom* (Bernays and Woodhead 1982).

Hence it appears very evident that the chemical composition of *T. grandis* is of significance in consumption and utilization of food by *A. scabiosae*. Moreover the close phenological synchronization of *A. scabiosae* nymphs and adults with the appearance of lush green leaves of *T. grandis* by late January and the completion of growth and reproduction before the food quality declined (from late November to January when leaf shedding occurs) also appears noteworthy.

Acknowledgements

The author is thankful to Prof. T N Ananthakrishnan for valuable suggestions and critical perusal of the manuscript, to the Council of Scientific and Industrial Research, New Delhi for funding and to the COSIST for instrumentation facilities.

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