STUDIES ON THE CONSUMPTION, DIGESTION AND UTILISATION OF FOOD PLANTS BY *Pericallia ricini* (ARCTIIDAE: LEPIDOPTERA)

BY
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THESIS
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for the degree

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DECLARATION

I hereby declare that this thesis entitled "Studies on consumption, digestion and utilisation of food plants by Pericallia ricini (Arctiidae : Lepidoptera) is a bona fide record of research work done by me during the course of research and that the thesis had not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or society.

Vellanikkara,
7-4-1981.

(RANJITH, A.M.)

CERTIFICATE

Certified that this thesis entitled "Studies on the consumption, digestion and utilisation of food plants by Pericallia ricini (Arctiidae : Lepidoptera)" is a record of research work done independently by Sri. Ranjith, A.M. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

Vellanikkara,
7-4-1981.

Dr. D. Dale,
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CERTIFICATE

We, the undersigned members of the Advisory Committee of Sri. Ranjith, A.M., a candidate for the degree of Master of Science in Agriculture majoring in Agricultural Entomology agree that the thesis entitled "Studies on the consumption, digestion and utilisation of food plants by *Pericallia ricini* (Arctiidae : Lepidoptera)" may be submitted by Sri. Ranjith, A.M. in partial fulfilment of the requirements for the degree.

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Introduction

INTRODUCTION

The practical importance of the studies on consumption, digestion and utilisation of food plants by insects has been recognised and accepted throughout the world. Indices of consumption, digestion and utilisation of food plants by insects will give an insight into the overall suitability of the host plants for the multiplication and survival of insects. Consumption indices provide basic information on the extent of quantitative loss brought about by pests on particular plants. Some crop plants might be consumed only at very low rates and hence insecticidal applications are not at all necessary on such plants.

At times, a low consumption rate may be due to the presence of a phago-deterrent and, the isolation and application of such principles can bring about revolutionary changes in pest management without disrupting the agro-ecosystem.

It is reported (Malenotti, 1940) that the larvae feeding on certain plants show increased degree of resistance to insecticides, perhaps due to host nutritional factors which confer added ability to withstand the insecticidal action. Thus such studies on utilisation of plants might also throw light on the spectrum of susceptibility to insecticides.

Preference of a particular food plant may be due to the presence of "Secondary plant substances" such as phago and ovipositional stimulants. Isolation of these attractant principles and their application on adjoining weed species at biologically active levels is liable to attract the pest to those plants. This can, while reducing crop losses, simultaneously control the weeds also.

Studies on consumption, digestion and utilisation of food plants were too sparse until Waldbauer (1968) emphasised the importance of the problem.

The present studies were carried out to ascertain the levels of consumption, digestion and utilisation of host plants by Pericallia ricini F. (Arctiidae : Lepidoptera), and thereby to obtain relevant basic information which may ultimately help in the formulation of ecologically sound pest management strategies.

Review Of Literature

REVIEW OF LITERATURE

The relevant literature relating to the consumption, digestion and utilisation of food plants by insects is reviewed below:

2.1 Indices of consumption, digestion and utilisation

One of the outstanding contributions on consumption, digestion and utilisation of food by insects was made by Hiratsuka (1920) on silkworms. Studies on length of life-cycle on different foods were carried out by Thomas and Shepard (1940) and it was found that for Oryzaephilus surinamensis, rolled oats was a better food than walnuts or raisins.

On dry weight basis, 10.78 g of food eaten by sixty larvae of Prodenia eridania in the last two instars produced 5.55 g of excreta with a gain in weight of 3.62 g (Crowell, 1941). This represents 48.5 per cent efficiency of food utilisation and 33.5 per cent efficiency of conversion of food stuff into dry body weight.

In 1954, Davey reported the quantities of food eaten by the desert locust, Schistocerca gregaria in relation to growth. He found that the hoppers in all immature growth stages ate on an average, about one gram per gram body weight per day on the middle days of the instars. The adults consumed approximately half a gram per gram body weight each day. The percentage of food assimilated, on the basis of dry feces and estimated dry weight of the food eaten, were ranging from 78 in the first instar to 35 in the fifth instar.

Smith (1959) worked out the utilisation of food plants by *Melanoplus bilituratus*, the migratory grasshopper. He found differences in consumption, rate of development and utilisation by the larvae on different foods. Efficiency of conversion of food to body tissue was 38 per cent for oats, 32 per cent for wheat and 27 per cent for western wheat grass, and this was negatively correlated with the amount of food utilised.

According to Kasting and McGinnis (1959), a single larva of the pale western cutworm, *Agrotis orthogonia*, consumed about 10 g of fresh wheat sprouts during the larval period. Of the consumed food, 40-50 per cent of the dry matter was excreted.

Kasting and McGinnis (1962) found that for *Agrotis orthogonia* larvae fed on sprouts of two wheat varieties, Thatcher (*Triticum aestivum*) and Golden ball (*T. durum*), the correlations involving the food consumption were not consistently significant and therefore appeared to be of little value in the estimation of consumption of dry matter.

Waldbauer (1962) found that a correction factor was necessary for the loss of weight of plant leaves offered to insects. He gave the correction factor, 'C' as the ratio of the weight lost in 24 hours and weight of leaves after 24 hours. When leaves were offered in petridishes, in a moist atmosphere, the corrected weight was $\left[1 - \frac{C}{2}\right] \left[I - (L + CL)\right]$, where 'I' was the weight of introduced food, 'L' the weight of uneaten food and 'C' the correction factor.

Waldbauer (1964) has given an account of the consumption, digestion and utilisation of solanaceous and non-solanaceous plants by the larvae of tobacco hornworm, Protoparce sexta. The rates of growth, food intake, percentage digestibility and gross and net efficiency of utilisation of food for growth were measured on the basis of dry weights. The indices are given in 'Materials and Methods'. He found that there was a decrease in digestibility with age. The decrease occured because young larvae ate tender, easily digestible food.

McMillan *et al.* (1966) studied the utilisation of different plants by the corn earworm (*Heliothis zea*) and the fall armyworm (*Spodontera frugip rda*). Use of plant material ranged from 16 to 60 per cent and from 12 to 61 per cent for the corn earworm and fall armyworm respectively for different foods. Corn kernels were used to the greatest extent by both species. Dextrose, tobacco leaves and cotton leaves also were used by the two species, but no insects of either species fed on these materials survived through the ninth day.

In one of the most important works of the sixties, Soo Hoo and Fraenkel (1966) worked on the consumption, digestion and utilisation of food plants by *Prodenia eridania*. The rate of food intake, the percentage digestibility and the efficiency of conversion of ingested and digested food to body matter during the fifth instar of *Prodenia eridania* were determined for 18 different plants, representing 13 families. Low digestibility, low efficiency of conversion and low consumption rate caused low levels of larval growth. Digestibility ranged from 36 per cent to 76 per cent for poor and good food materials. Efficiency of conversion of digested material to body matter ranged from 16 per cent for a poor to 56 per cent for a good food. There appeared to be an inverse correlation between food consumption and efficiency of utilisation in a good food plant.

In his most exhaustive studies, Waldbauer (1968) discussed the consumption and utilisation of food by insects. The indices of consumption and the methods of calculation are given in great detail. Aspects of food consumption, digestion and conversion of fresh and dry matter, utilisation of dietary constituents and energy, etc. have been critically reviewed.

Taylor and Bardner (1968) fed the larvae of Plutella maculipennis and Phaedon cochleariae on leaves of turnip and radish. The weight of food consumed and the area of leaf injured were measured. The weight of food eaten depended on the nutritive value of the food, while, the area of leaf injured varied according to the leaf thickness and the method of feeding. They ate a greater weight of older than of younger leaves and injured relatively larger area of radish than of turnip leaf.

Investigation on the consumption, digestion and utilisation of food plants by the larvae of Euproctis fraterna were conducted by Dale and Chandrika (1971). The fresh weight consumption indices ranged from 1.09 in pomegranate to 1.28 in cowpea. The consumption indices of larvae on a dry weight basis for castor, pomegranate, cowpea and rose were 1.63, 3.11, 2.23 and 3.28 respectively. Growth rate, utilisation of dry matter, coefficient of apparent digestibility for nitrogen and efficiencies of conversion of ingested and digested nitrogen were also given.

A quantitative study of food consumption, assimilation and growth in Leptinotarsa decemlineata, the Colorado potato beetle on two host plants was conducted by Latheef and Harcourt (1972). Larvae reared on tomato fed longer, consumed more foliage and had a lower survival rate, than when reared on potato, its principal host. On both plants, a direct linear relationship was obtained between food consumption and larval growth. Potato was better converted to biomass as evidenced by increased weight gain of the larvae and greater pupal size.

The effect of different host plants on the climbing cutworm Agrotis ipsilon, was studied by El-Kifl et al. (1973). The larval stage was the shortest (average 20.9 days at 22.5°C) on lucerne and the longest on castor (average 28.3 days). The larval food plant did not affect the duration of the pupal stage, though it affected pupal weight. Larvae reared on castor leaves produced the heaviest pupae. The life cycle was the longest when the larvae were provided with cotton seedlings and the shortest with lucerne.

The consumption, nutritive value and utilisation of various food plants by the spotted boll worm, Earias fabia were worked out by Mehta and Saxena (1973). When both the duration of development and the percentage of larvae completing their development, and adult emergence were taken into consideration, it appeared that developing pods of Hibiscus esculentus were the most suitable for growth. Tender bolls of cotton were equally suitable, but other malvaceous species like Urena lobata and Althea rosea were much less suitable.

El-Shaarawy et al. (1975) in their work on Attacus ricini found that there were differences in consumption and digestibility of leaves of different varieties of castor. The efficiency of conversion of digested food to body matter also varied with season.

Singh and Byas (1975), in their work on larval development of Prodenia litura stated that the different food plants fed to larvae influenced the rate of larval development to an increasing degree through successive instars. The length and weight of larvae were not influenced by the amount of food consumed in the case of each food plant. Larvae with greater size and weight generally had a shorter duration.

Abulnasr et al. (1976) described the effect of six larval diets on the development and fecundity of corn earworm, Heliothis armigera. The larval stage was the shortest on maize and the longest on tomato and, fecundity was the highest on maize and the lowest on tomato.

Aslam and Akhtar (1976) found differences in consumption and utilisation among different plants in the case of Ailopus tamulus, an acridid.

In a study by Bailey (1976), differential survival, growth and egg production were obtained for the Bertha armyworm, Mamestra configurata feeding on four natural host plants and one artificial diet. He obtained a linear relationship between food consumption and growth.

In the case of the acridids Melanoplus bivittatus and M. femerrubrum, feeding and growth rate differed with different diets (Bailey and Mukerji, 1976). A direct linear relationship was obtained between food consumption and growth rate. The approximate digestibility, efficiency of conversion of ingested food and egg production for female were also calculated.

The subject matter of consumption, digestion and utilisation of food plants by insects has been discussed in detail by Bhattacharya and Pant (1976). The qualities of a good diet, qualitative evaluation of diets, calculation of growth indices, estimation of utilisation of food by various methods, a critical review of the problems and prospects of the topic and a summary of the details on the utilisation of food by insects were all critically reviewed.

In studies on the migratory locust Locusta migratoria, feeding different grasses, Hoekstra and Beenakkers (1976) demonstrated that there was no influence for the diets on the duration of the developmental period. The efficiency of conversion of ingested food as well as digested food to body substance were found to differ among various diets.

It was indicated that field collected beetles of the cotton boll weevil, Anthonomus grandis, ate 10 mg per day of cotton, while it was 13 mg for laboratory reared weevils (McGovern et al., 1976).

Utilisation of food was 9 per cent more for field collected weevils.

In investigations on the consumption and utilisation of food by larvae of *Malacosoma neustria testacea* on Japanese pear, the live weight appeared to increase exponentially from hatching to the beginning of the fifth instar, after which the growth rate declined. The ratios of growth to assimilation and to consumption decreased as consumption increased (Shiga, 1976).

Abdel-Fattah *et al.* (1977) in their studies on *Spodoptera littoralis* found five plants out of fifteen as suitable for growth. Feeding on these plants resulted in the shortest larval life and the greatest number of eggs.

Bilapate *et al.* (1977) found that *Heliothis armigera* population on lucerne increased with an infinitesimal rate of 0.12 and finite rate of 1.12 per female per day.

Gandhi (1977) worked on the utilisation of plant food by the hemipterans *Oxycarenus hyalipennis* and *Oxyrhachis tarandus*, and found that though the degree of overall utilisation of food by the two insects were almost similar, the degree of utilisation of its nutritiona constituents differed because of the great difference in the water content of their foods.

In studies on the consumption, digestion and utilisation of food by larvae of Spodoptera litura by Premkumar et al. (1977), they have reported marked difference in consumption of foliage, which ranged from 0.65 g to 1.20 g for bhindi and sweet potato respectively. The consumption indices ranged from 2.33 for tomato to 3.88 for sweet potato, on dry weight basis. The growth rates and efficiencies of conversion of ingested and digested food to body tissue also were found to differ significantly. The coefficient of apparant digestibility and the efficiencies of conversion of ingested and digested nitrogen to body tissue were also calculated.

Adults of the pale striped flea beetle, Systena blanda were seen to consume about 0.3 sq.cm of sugarbeet foliage per day, and the consumption did not vary significantly within the normal day time temperature (Capinera, 1978).

According to McCaffery et al. (1978), Zonocerus variegatus grasshoppers feeding on cassava produced greater egg pods, had a shorter somatic period and a greater efficiency of conversion of digested food to body tissue than on any of the other foods offered.

Ratan (1978) who worked on consumption, digestion and utilisation of food by Acrida exaltata and A. gigantia found differences in consumption, digestibility, growth rate and gross and net efficiencies of utilisation of food between maize and sugarcane, the two foods offered and between the two species.

Utilisation of different feeds for growth by hoppers of Schistocerca gregaria was studied by Rao et al. (1978). They found oats to be the best food and cabbage the worst, based on gross efficiency values and the percentage wet weight increase over initial body weight.

Scriber (1978) found that consumption rates, conversion rates and hence growth rates were lower in tree feeders than herb feeders because of the differences in the water content of the feeds.

Even within the same plant, different varieties had different potentialities to support growth of larvae as evidenced by Ram and Bhattacharya (1978).

In studies on *Diacrisia obliqua*, they found that the foliage consumption, weight of excrement and approximate digestibility varied with the varieties. There were also significant differences in the indices of growth between males and females.

Consumption and utilisation of a soyflour-wheat germ diet of *Heliothis armigera* and *H. Subflexa* has been described by Brewer and King(1979).

Chockalingam (1979) worked out the indices of growth for *Pericallia ricini* on castor. According to him, the larval period on castor lasted for 19 ± 1 days. The larvae consumed 742 mg of castor leaf on dry weight basis, the feces amounted to 308.7 mg, the assimilation being 433.7 mg and assimilation efficiency 58.4 per cent. The net conversion efficiency was 38.8 per cent.

McAvoy and Smith (1979) found out the consumption of foliage of soybean by the Mexican bean beetle *Epilachna varivestis* both on leaf area basis and on dry weight basis. They also worked out the total period of larval development.

On termites *Neotermes bosei*, Mishra (1979) found differences in digestibilities according to the wood (food) species. The digestibility of cellulose, hemicellulose, starches and lignin was also described.

In the case of *Diacrisia obliqua*, the Bihar hairy caterpillar, Premchand (1979) found that the E.C.I. was the greatest in the first three day period and that consumption increased with age.

Consumption and utilisation of castor by *Achaea janata* were studied by Ramdev and Rao (1979). They found that the larvae took 13.55 days for development and that food intake increased with age. The feces excreted, food balance and weight gain increased with age of larvae. The consumption index and growth rate was maximum in second instar and thereafter it decreased with age. Approximate digestibility decreased with age but efficiencies of conversion of ingested and digested food to body tissue increased with age.

Scriber (1979 a) offered a sequence of food plants to larvae of *Papilio glaucus* and *P. troilus* under a no choice situation and found that though the plants offered were of the same family, the larval development was greatly retarded. He also calculated the various parameters relating to consumption, digestion and utilisation of food plants by insects.

Scriber and Feeny (1979) found that larvae of nine North American swallowtail butterfly species reared on leaves of typical food plants exhibited wide variations in growth characteristics. Forb-feeding larvae fed faster and grew more rapidly than larvae feeding on shrub or tree leaves, and took about half as much time to complete each instar. Forb-feeding larvae were also more efficient at converting food and nitrogen into biomass and accumulated nitrogen more rapidly.

According to Scriber (1979 b), larvae feeding on legumes seemed to digest much of the food ingested and had a high nitrogen utilisation efficiency (N.U.E.). The approximate digestibility of legumes by penultimate instar larvae ranged from 76 to 94 per cent and nitrogen utilisation efficiency, from 89 to 96 per cent. Significant differences in metabolic costs of processing and converting plant biomass were reflected by efficiencies of conversion of digestion into bodymass which ranged from less than 20 to more than 75 per cent. Larvae compensated this by increased consumption.

According to Woodring *et al.* (1979), virgin females of house crickets, maintained a lower feeding rate. Of the dry weight of food eaten during the last larval stadium, 30 per cent was egested, 32 per cent was oxidised, 28 per cent appeared as growth and 10 per cent was condensed to lipid and became part of the 28 per cent growth.

Dandapani (1980) carried out studies relating to food utilisation of the gram pod borer, *Heliothis armigera* on eight food plants. The food intake, larval weight, consumption index, growth rate, approximate digestibility, efficiency of conversion of ingested and digested food and nitrogen to body tissue were calculated. He also found that consumption indices on dry or fresh weight basis decreased with age of the larvae.

Ottens and Todd (1980) used leaf area consumed as a parameter to study consumption of leaf. In their studies on *Graphognathus peregrinus* and *G. leucoloma*, they found significant differences in leaf area consumption of cotton, peanut and soybean foliage.

Philip and Jacob (1980), in their work on granulosis-infected and healthy larvae of Pericallia ricini, found that the consumption index, feeding period, mean weight of larvae during the feeding period and weight gained per larvae differed significantly between healthy and infected larvae.

2.2 Effect of temperature and relative humidity

Studies on the length of life cycle on different foods at different temperatures and relative humidity were done by Thomas and Shepard (1940). On Oryzaephilus surinamensis, the saw toothed grain beetle, they found that at 5 mm saturation deficit and rolled oats as food, the life cycle from egg to adult averaged 69.06, 30.31, 20.67 and 18 days at 20, 25, 30 and 35°C respectively.

David and Gardiner (1962) found that Pieris brassicae larvae took 46.5 and 11 days respectively for development at 12.5 and 30°C. The pupal period ranged from 7.5 days at 30°C to about 40 days at 12.5°C.

Percentage digestibility of cotton for Spodoptera littoralis was higher at 35°C than at 20°C, but digestibility of castor was not affected by temperature. Larvae reared at 35°C consumed more, digested more and had a higher conversion efficiency of food to body matter than those reared at 20°C (Soliman et al., 1974).

Singh and Byas (1975), in their work on larval development of Prodenia litura stated that little difference existed in the duration of the various instars reared at 27°C and 30°C, although 30°C was found to be more favourable for larval development.

Bhat and Bhattacharya (1978) determined the consumption and utilisation of soybean leaves by larvae of Spodoptera litura at 15, 20, 25 and 30°C and 80 ± 5 per cent relative humidity. The larval period increased and food consumption decreased as the temperature decreased.

The weight of fully grown larvae were seen to be twice as low at 5 per cent relative humidity than at 95 per cent relative humidity in the case of Tinea pellionella as observed by Chauvin and Gueguen (1978). The consumption index, digestibility of ingested food and the efficiency of conversion of ingested food to body tissue were low at 5 per cent relative humidity.

In the case of termite, Neotermes bosei, consumption increased with temperature and relative humidity. The maximum consumption was at 35°C and 100 per cent relative humidity and the minimum consumption was at 12.5°C and 76 per cent relative humidity. The digestibility coefficient was maximum (71.3 per cent) at 12.5°C and 100 per cent relative humidity (Mishra and Sensarma, 1979).

2.3 Effect of crowding

Davey (1954) found that food consumption increased with the number of *Schistocerca gregaria* hoppers per cage. But David and Gardiner (1962) found that isolated and crowded larvae of *Pieris brassicae* completed their development in approximately the same time. According to Teotia and Singh (1975), when larvae of *Corcyra cephalonica* were reared under similar conditions of food, temperature and relative humidity, but in limited space, the population increased at a much slower rate. McCaffery *et al.* (1978) found that somatic growth, maturation and reproduction were all faster in group fed insects than in isolated ones of *Zonocerus variegatus*. But beetle density did not affect the feeding activity in the case of the pale-striped flea beetle, *Systena blanda* (Capinera, 1978).

2.4 Analysis of host plant and insect nitrogen.

Crowell (1941) analysed the chemical constituents of leaves and the insect Prodenia eridania feeding on them. Chemical analyses of the food leaves and excrement of fifth and sixth instar larvae showed that they utilise most of the protein, reducing sugars and sucrose in the leaves. They also used the nitrogen of naturally occurring aminoacids and amides, but did not use nitrate nitrogen.

According to Kasting and McGinnis (1959), 60-70 per cent of the consumed nitrogen was excreted. The percentage of nitrogen utilised, about 50 per cent, remained constant during the last three instars. Nitrogen utilisation by fourth, fifth and sixth instar larvae ranged between 25 and 45 per cent.

McGovern et al. (1976) found that laboratory-reared weevils of Anthonomus grandis utilised 23 per cent of the nitrogen consumed.

2.5 Effect of water content in leaves

The importance of water content of the foods was realised and emphasised by Scriber (1977). In his paper on limiting effects of low leaf water content, he stated that larvae which were fed on leaves low in leaf water grew more slowly and were less efficient at utilising plant biomass, energy and nitrogen than those larvae fed leaves which were fully supplemented with water.

Scriber (1978) found that consumption rates, conversion rates and hence, growth rates were lower in tree-feeders than herb-feeders and assigned the reason to low leaf water content of tree leaves.

Scriber (1979 c) emphasised that unless leaf water content was maintained near the saturation level of excised leaves by high humidities and leaf water supplementation through the petiole, larval growth would be suppressed.

2.6 Utilisation of starch

Larvae of the rice stem borer, Chilo suppressalis utilised starch at an unexpectedly high rate, though the starch-hydrolysing enzyme of the digestive tract was very weak, and the nutritive value of starch in synthetic food very low (Hirano and Ishii, 1962).

2.7 Statistical analysis

Klein and Kogan (1974) gave a description of a computer programme, that produced an analysis of the intake and utilisation of food and the growth of phytophagous insects. The indices were based on the classic work of Waldbauer (1968).

Materials and Methods

MATERIALS AND METHODS

The present study was conducted in the Entomology Department of the College of Horticulture, Vellanikkara. Adult moths of <u>Pericallia ricini</u> F. were collected from light traps and allowed to lay eggs on sterile polythene sheets suspended in a cage. The resulting eggs were rinsed in 0.2 per cent solution of sodium hypochlorite and then transferred into beakers containing 10 per cent formaldehyde solution for one hour. Finally the eggs were placed under running tap water for one hour, then air dried and held in sterile cages for hatching. Such disease free larvae were allowed to pupate and emerge out. The second generation of larvae resulting from these moths were used for the experiment.

The mean temperature during the experimental period was 29 ± 2°C, with a mean photoperiod of 12 hours and a mean relative humidity of 75 ± 5 per cent.

Individual larvae were grown inside cylindrical plastic containers of 12 cm length and 9 cm diameter. Transparent containers were used to allow for the entry of light and reproduction of a near natural environment. The lid of each container was cut 4 cm square and polythene netting pasted in the space for the entry of air.

The insects were reared on the following eight food plants.

	Crop	Variety
1.	Banana	Palayankodan
2.	Castor	S A.2
3.	Cotton	Varalakshmi
4.	Brinjal	SM-6
5.	Sesamum	Kayamkulam-1
6.	Pumpkin	Co-1
7.	Sweet potato	Vellanikkara local
8.	Colocasia	Trichur local

Uniform tender leaves were selected and introduced at random to each larva. Mature leaves were spared because, the larvae in nature usually avoid them.

Since the early instar larvae were too delicate and small, the experiment was done with larvae from third instar onwards. A treatment was fixed to contain ten larvae each and were replicated thrice. To minimise any effect due to larval conditioning, each group of larvae during the earlier instars was raised on the particular food plant it would be fed during the subsequent experiment.

The weight of leaves offered and the weight of larvae were found out every 24 hours. About 5 g of the leaves were kept at the same time in an identical container and natural loss of weight was determined after 24 hours. The left over food was carefully taken out and weighed at the same time and then new leaves were introduced. The weight of excreta after the expiry of every 24 hours was separately determined. The feces was then oven dried at 80°C to constant weight to find out the dry matter percentage of the leaves.

The mean weight of the insects was calculated by summing up the initial and final weights determined every day and dividing by the number of weighings. To account for weight lost during a moult, the loss of weight at every moult was added to the weight gain.

3.1 Parameters of larval consumption and growth

The indices of larval consumption and growth were calculated according to Waldbauer (1968) and Scriber (1977) as follows:

o Consumption index (C.I.)

C.I. = F/TA

where,

F = fresh or dry weight of food eaten by the larvae,

T = duration of feeding period, and

A = mean fresh or dry weight of the insect during feeding period.

The dry weight - fresh weight C.I. was calculated from the dry weight of food eaten and fresh weight of larva. The fresh weight C.I. (calculated from fresh weight of food and insect), dry weight C.I. (calculated from dry weight of food and insect) and fresh weight - dry weight C.I. (from fresh weight of food eaten and dry weight of larva) were also calculated. Scriber (1977) refers to this index as Relative Consumption Rate or R.C.R.

o Consumption rate (C.R.)

C.R. = F/T

where,

F = fresh or dry weight of food eaten, and

T = duration of feeding period.

The C.R. also was calculated on fresh weight and dry weight bases.

Consumption of foliage by the larvae in the different instars and consumption by the two sexes were also determined.

o Growth rate (G.R.)

G.R. = G/T

where,

G = fresh or dry weight gain of insect during feeding period, and

T = duration of feeding period.

Growth rates on fresh weight and dry weight bases were calculated.

o Relative growth rate (R.G.R.)

R.G.R. = G/TA

where,

G = fresh or dry weight gain of the larvae during the feeding period,

T = duration of feeding period, and

A = mean fresh or dry weight of insect during feeding period.

Dry weight - fresh weight R.G.R., fresh weight - dry weight R.G.R. and dry weight R.G.R. were calculated. Dry weight R.G.R. was the same as fresh weight R.G.R.

3.2 Parameters relating to larval digestion and efficiency of food conversion.

o Approximate digestibility (A.D.)

$$A.D. = \frac{\text{Weight of food ingested} - \text{weight of feces} \times 100}{\text{Weight of food ingested}}$$

The A.D. was calculated both on fresh weight and dry weight bases.

o Efficiency of conversion of ingested food to body substance (E.C.I.)

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

This can also be obtained as $\frac{R.G.R.}{R.C.R.}$ or $\frac{G.R.}{C.R.}$

E.C.I. was determined as fresh weight E.C.I., dry weight E.C.I., fresh weight - dry weight E.C.I. and dry weight - fresh weight E.C.I.

o Efficiency of conversion of digested food to body tissue (E.C.D.)

$$E.C.D. = \frac{\text{Weight gained} \times 100}{\text{Weight of food ingested} - \text{Weight of feces}}$$

The E.C.D. also was calculated on fresh weight and dry weight bases. E.C.D. x A.D. gives the value for E.C.I. and can also be termed as 'overall efficiency' (Scriber, 1977).

3.3 Estimation of and indices for the utilisation of nitrogen

The estimation of nitrogen in the insect, leaf and feces was done according to the procedure given by Jackson (1967).

Before the start of the experiment, about fifty larvae from each treatment were killed by freezing and dried at 80°C to constant weight. At the end of the experiment also, two larvae each from every replication of all treatments were freeze-killed and dried. Similarly, representative samples of the leaves offered and the feces were oven-dried, powdered and analysed for the content of nitrogen in them, as with the insects. The following indices were worked out.

o The coefficient of apparent digestibility of nitrogen [C.A.D.(N)]

$$\text{C.A.D.(N)} = \frac{\text{amount of N in food ingested} - \text{amount of N in feces}}{\text{amount of N in food ingested}}$$

- Relative nitrogen accumulation rate (R.N.A.R.)

  R.N.A.R. = mg N gained per g larval biomass per day

- Relative nitrogen consumption rate (R.N.C.R.)

  R.N.C.R. = mg N ingested per gram larval biomass per day

- Efficiency of conversion of ingested nitrogen to body substance [E.C.I. (N)]

$$\text{E.C.I. (N)} = \frac{\text{amount of N in body} \times 100}{\text{amount of N in food ingested}}$$

The E.C.I. (N) has been described as 'nitrogen utilisation efficiency' (N.U.E.) by Scriber (1977).

- Efficiency of conversion of digested nitrogen to body tissue [E.C.D. (N)]

$$\text{E.C.D. (N)} = \frac{\text{amount of N in body} \times 100}{\text{amount of N in food ingested} - \text{amount of N in feces}}$$

3.4 Effect of different food plants on the pupae

The pupal period was determined by noting the dates of pupation and adult emergence.

The pupal weight was determined on the third day of pupation, after removing the hairy covering of the pupae.

The length of the pupae also were determined similarly on the third day of pupation. The per cent formation of pupae from the larvae and per cent emergence of adults from the pupae were found out.

3.5 Sex ratio

The effect of the food plants on the larvae caused different sex ratios for adults formed from them. This was also worked out. But in this case, since mortality of larvae differed between treatments, the total number of adults formed were not the same. However, the results obtained were transformed so as to contain the sex ratio of 30 insects in all the treatments. Results after such transformation are included.

3.6 Correction for water loss of leaves

Leaves lose water on removal from the plant. This leads to erroneous weights at the expiry of 24 hours. Waldbauer (1962) and Waldbauer (1964) has given formulae for the correction to be applied to the weights obtained. In 1968, Waldbauer further reviewed and corrected it and this formula was used to account for the water loss.

$$\text{Corrected weight of food eaten} = \left[1 - \frac{a}{2}\right] \left[W - (L + bl)\right]$$

W = Weight of food introduced

L = Weight of uneaten food

Here, the correction is applied both as the ratio of loss to the initial weight of the aliquot (a) and as the ratio of loss to the final weight of the aliquot (b).

3.7 Statistical analysis

The data were analysed as a completely randomised design with three replications and eight treatments.

Results

RESULTS

The indices relating to consumption and growth, utilisation of food and utilisation of nitrogen in food plants by Pericallia ricini F. were calculated. The effect of the different foods on the pupal period, pupal weight, pupal length and sex ratio was also investigated.

4.1 Indices of consumption and growth

4.1.1 Consumption index (C.I.)

Also referred to as 'relative consumption rate' or R.C.R., the consumption index was calculated on the basis of fresh weight of food to fresh weight of insect, fresh weight to dry weight basis, dry weight to fresh weight basis and dry weight basis. The results are tabulated in table 1 and are graphically represented as fig. 1.

On fresh weight basis, it was seen that the relative consumption by the larvae was maximum for brinjal leaves with a C.I. of 1.88 and the least for sweet potato with a C.I. of 1.25. But statistically, the indices for brinjal, castor, pumpkin and sesamum

Table 1. Consumption indices of larvae of *P. ricini* fed on eight food plants

Host plant	Treatments	Fresh/fresh	Fresh/dry	Dry/fresh	Dry/dry
Colocasia	T_1	1.46	6.75	0.21	0.99
Cotton	T_2	1.32	11.01	0.28	2.46
Sweet potato	T_3	1.25	9.10	0.19	1.38
Pumpkin	T_4	1.75	7.04	0.30	1.23
Castor	T_5	1.87	9.63	0.41	2.10
Brinjal	T_6	1.88	12.53	0.32	2.13
Banana	T_7	1.43	13.63	0.32	3.02
Sesamum	T_8	1.70	12.02	0.28	2.00
F' test		S**	S**	S**	S**
CD		0.3356	1.7188	0.0596	0.2871

Fresh/fresh $T_6\ T_5\ T_4\ T_8\ T_1\ T_7\ T_2\ T_3$

Fresh/dry $T_7\ T_6\ T_8\ T_2\ T_5\ T_3\ T_4\ T_1$

Dry/fresh $T_5\ T_6\ T_7\ T_4\ T_2\ T_8\ T_1\ T_3$

Dry/dry $T_7\ T_2\ T_6\ T_5\ T_8\ T_3\ T_4\ T_1$

S** - Significant at one per cent level of significance

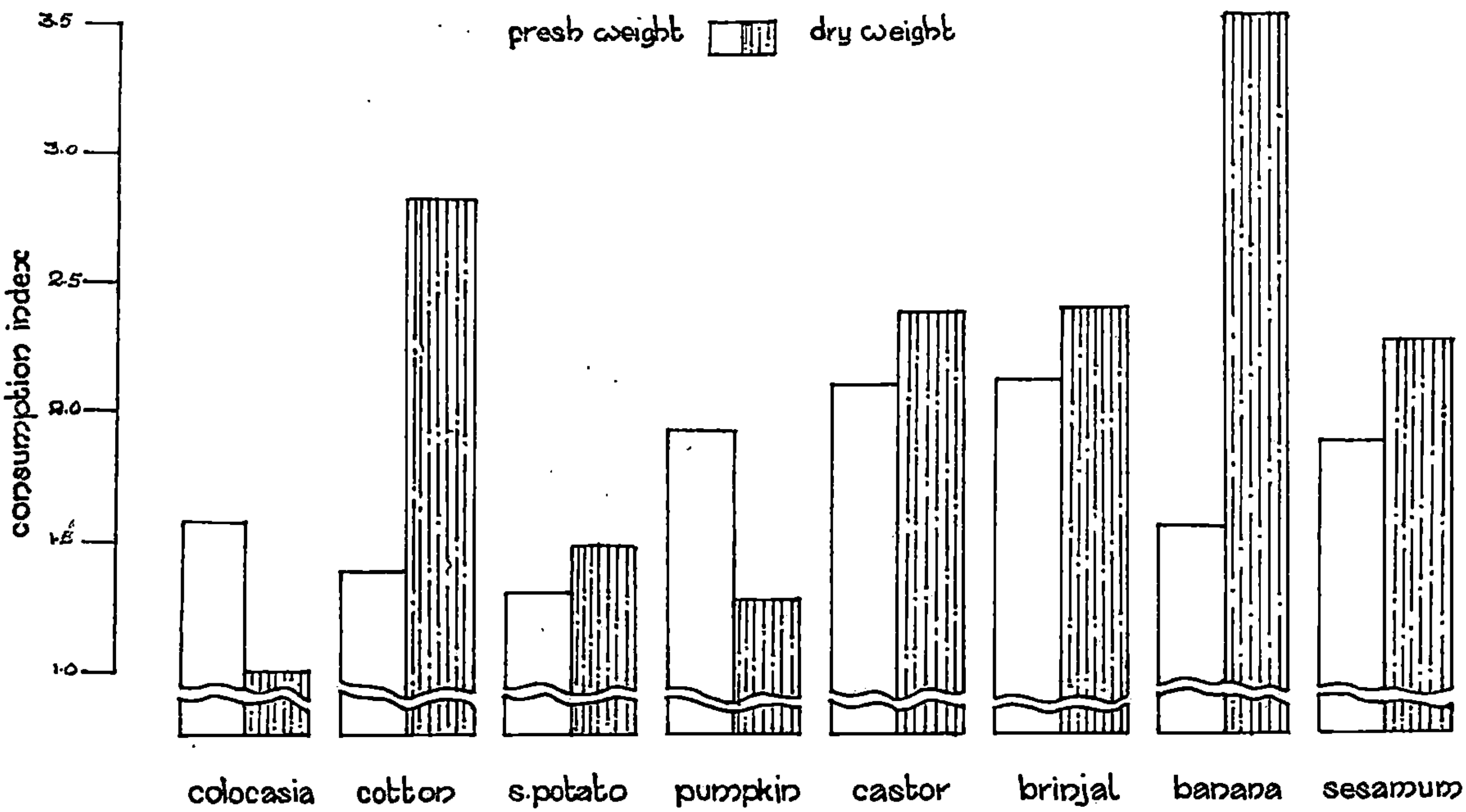

FIG.1 CONSUMPTION INDICES OF *Pericallia ricini*

were on par. The other foods, colocasia, banana, cotton and sweet potato had C.I. values which did not differ significantly.

On fresh/dry basis, banana fed larvae had the highest C.I. of 13.63, though the values for brinjal and sesamum were also on par. Larvae on colocasia had the least C.I. of 6.75 which was but on par with that of pumpkin.

On dry/fresh basis, castor-fed insects had the highest C.I. of 0.41, and colocasia along with sweet potato had lower C.I. values with the least contributed by larvae on sweet potato having the value of 0.19.

On dry weight basis, banana - fed insects with a C.I. of 3.02 ranked first, followed by cotton - fed larvae. Brinjal, cotton and sesamum produced C.I. values which were on par, and colocasia had the least C.I. of 0.99.

4.1.2 Consumption rate (C.R.) and mean weight gain of larvae.

4.1.2.1 Consumption rate (C.R.).

The consumption rate was also calculated on the bases of fresh and dry weights. The results are given in table 2 and fig. 2 graphically explains the same.

On fresh weight basis, larvae fed with brinjal had the greatest consumption rate of 734.5 followed by 699.0 relating to pumpkin. The lowest consumption rate of 411.3 was recorded with colocasia as a host plant.

It was seen that larvae fed on castor had the greatest consumption rate of 138.6, on dry weight basis, but was statistically on par with those fed with brinjal also. The least consumption rate of 60.3 was shown by colocasia in this case also.

4.1.2.2 Mean weight gain of larvae.

Larvae fed on brinjal showed the greatest weight gain of 1.06 g per larvae, followed by those grown on pumpkin. Weight gain of larvae reared on colocasia, cotton, and sweet potato differed only very slightly with that of pumpkin. The least weight gain of 0.66 g was exhibited by larvae fed with banana. The relevant data are shown in table 2.

4.1.3 Consumption of foliage by larvae in the different instars.

Table 3 explains the consumption of food plants

Table 2. Feeding performance and total gain in weight of larvae of *P. ricini* during the experimental period

Host plant	Treatments	Consumption rate(freshwt.) (mg per day)	Consumption rate(dry wt.) (mg per day)	Total weight gain/larvae (g fresh weight)
Colocasia	T_1	411.3	60.3	0.98
Cotton	T_2	559.0	120.6	0.94
Sweet potato	T_3	559.4	84.7	0.95
Pumpkin	T_4	699.0	121.7	0.99
Castor	T_5	634.2	138.6	0.77
Brinjal	T_6	734.5	124.7	1.06
Banana	T_7	533.8	118.1	0.66
Sesamum	T_8	447.2	73.6	0.67
F'test		S**	S**	S**
CD		83.3	16.6	0.0917

Consumption rate (fresh wt.) T_6 T_4 T_5 T_3 T_2 T_7 T_8 T_1

Consumption rate (dry wt.) T_5 T_6 T_4 T_2 T_7 T_3 T_8 T_1

Total weight gain/larvae T_6 T_4 T_1 T_3 T_2 T_5 T_8 T_7

S** - Significant at one per cent level of significance

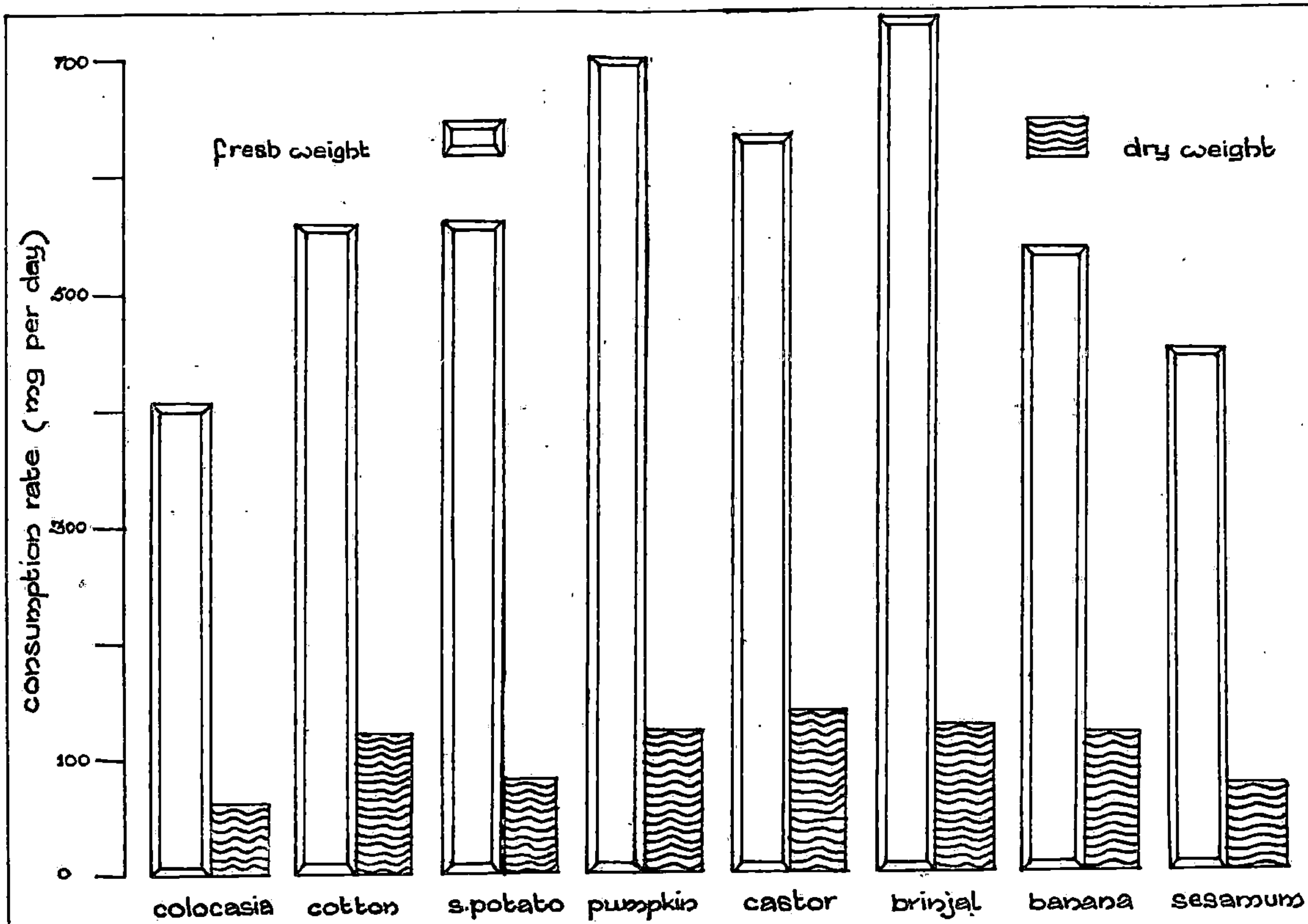

FIG.2. CONSUMPTION RATE OF Pericallia ricini ON EIGHT FOOD PLANTS

Table 3. Consumption of food plants by III, IV and V instar larvae of *Pericallia ricini* (g/larva)

Host plant	Treatments	III	IV	V
Colocasia	T_1	0.56	1.32	4.44
Cotton	T_2	0.97	1.85	5.55
Sweet potato	T_3	0.75	4.05	5.44
Pumpkin	T_4	1.00	4.82	5.74
Castor	T_5	2.48	4.19	5.30
Brinjal	T_6	1.47	4.49	6.25
Banana	T_7	2.08	3.85	5.88
Sesamum	T_8	0.76	2.60	4.50
F' test		S**	S**	S**
CD		0.7745	0.0624	0.0274

III - T_5 T_7 T_6 T_4 T_2 T_8 T_3 T_1

IV - T_4 T_6 T_5 T_3 T_7 T_8 T_2 T_1

V - T_6 T_7 T_4 T_2 T_3 T_5 T_2 T_8 T_1

S** - Significant at one per cent level of significance

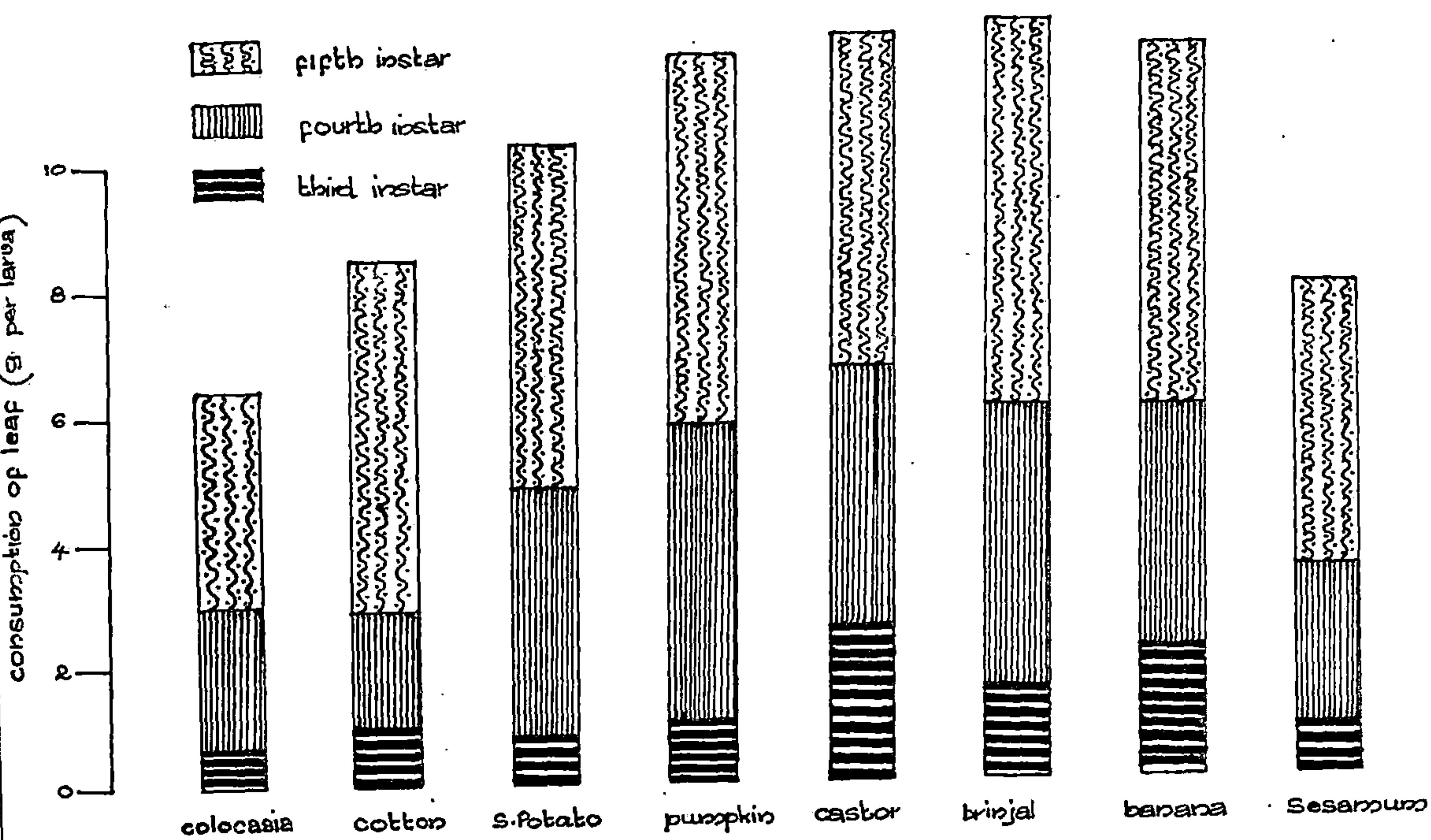

FIG.3. CONSUMPTION OF FOLIAGE BY IIIrd, IVth & Vth INSTAR LARVAE OF *P. ricini*

by III, IV and V instar larvae of <u>Pericallia ricini</u>. Fig. 3 is a graphic representation of the same.

The figures reveal that consumption of foliage increases with age. The great majority of food is eaten by larvae of the final instar. Penultimate instar larvae consume the foliage to a lesser extent. In most of the cases, consumption of leaves is very low by the third instar larvae. Leaf consumption is the maximum for larvae feeding on brinjal and is only just above the consumption of pumpkin, castor and banana. Colocasia is consumed to the least.

4.1.4 Foliage consumption by male and female larvae

The difference in consumption of leaves of food plants by the two sexes of the test insect can be understood from table 4 and its graphic representation, fig. 4.

In general, females were seen to consume more foliage than the corresponding males. Consumption by males ranged from 3.12 g to 5.78 g and a range of 3.20 to 7.27 g was observed in the case of females.

4.1.5 Growth rate (G.R.)

The growth rates were calculated both on fresh and

Table 4. Consumption of foliage (g wet weight per larva) by male and female larvae of *P. ricini* during the experimental period

Host plant	Treatments	Male larva	Female larva
Colocasia	T_1	3.12	3.20
Cotton	T_2	4.03	4.35
Sweet potato	T_3	4.97	5.26
Pumpkin	T_4	5.00	6.54
Castor	T_5	5.61	6.36
Brinjal	T_6	5.78	6.43
Banana	T_7	4.54	7.27
Sesamum	T_8	3.51	3.78
F' test		S**	S**
CD		0.0173	0.0173

Male larva - T_6 T_5 T_4 T_3 T_7 T_2 T_8 T_1

Female larva-T_7 T_4 T_6 T_5 T_3 T_2 T_8 T_1

S** - Significant at one per cent level of significance

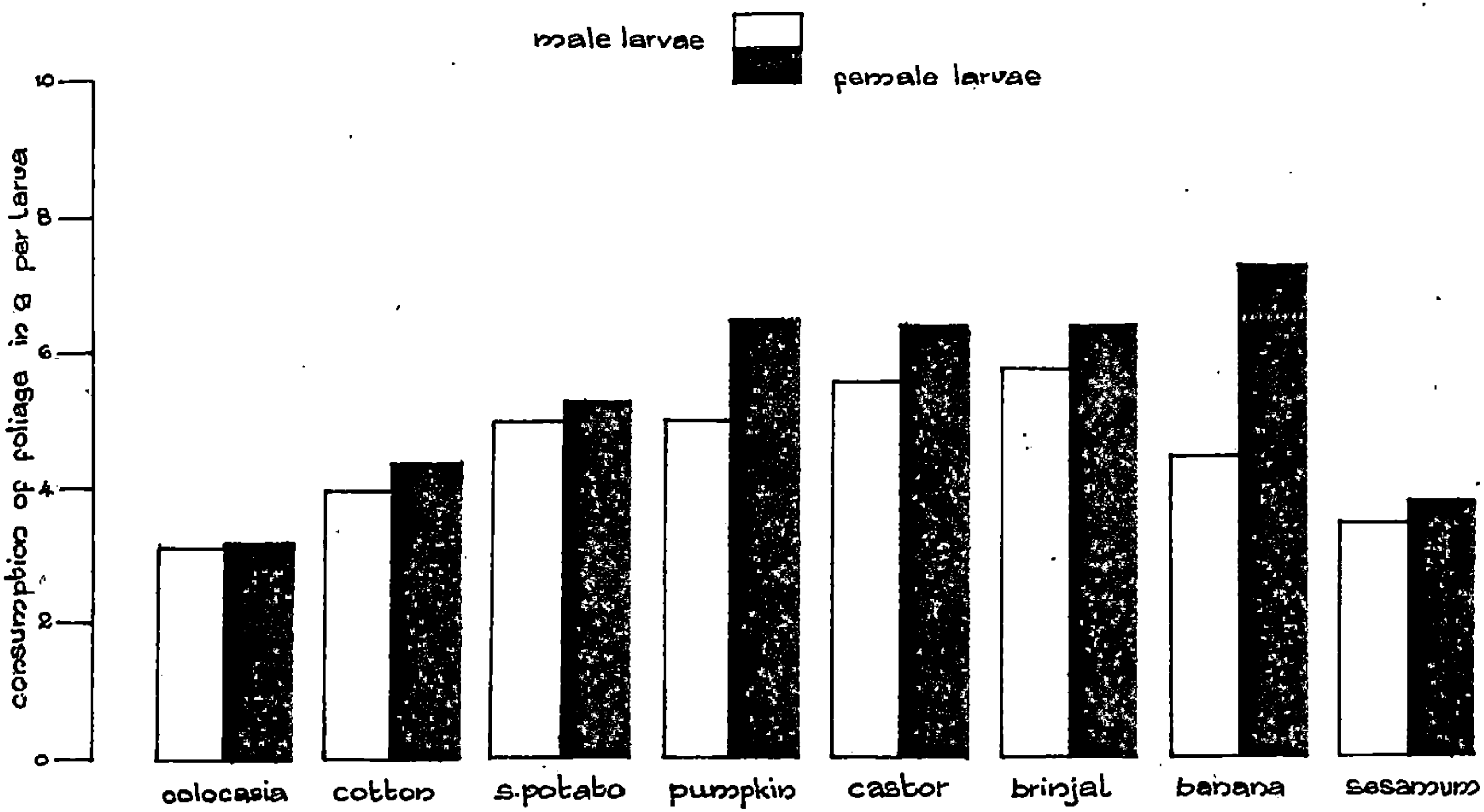

FIG.4. CONSUMPTION OF FRESH LEAVES BY LARVAE OF *P. ricini*

dry weight bases. The results are shown in table 5 and represented as a graph in fig. 5.

On fresh weight basis, larvae reared on brinjal had the highest growth rate of 65.7 and the least growth rate of 30.7 was exhibited by larvae grown on banana. But the corresponding values of brinjal, pumpkin, colocasia, cotton, sweet potato and castor were on par.

On dry weight basis, it was seen that pumpkin was superior to all others in supporting growth of the larvae with a G.R. value of 15.7, though those reared on colocasia and brinjal also were on par. In this case also, insects fed on banana leaves had the least growth as evidenced by the G.R. value of 3.2 for it.

4.1.6 Relative growth rate (R.G.R.)

R.G.R. could be calculated on the basis of fresh weight gain of insect to dry weight of insect, on dry weight gain of insect to fresh weight of insect basis and also as the ratio involving dry weight gain of insect and dry weight of insect. The results obtained are tabulated as table 6 and graphically represented as fig. 6.

Table 5. Growth rate (fresh and dry wt.) of *P. ricini* caterpillars on different host plants

Host plant	Treatments	Fresh weight (mg per day)	Dry weight (mg per day)
Colocasia	T_1	64.2	13.9
Cotton	T_2	61.8	7.3
Sweet potato	T_3	51.9	7.1
Pumpkin	T_4	64.3	15.7
Castor	T_5	40.1	7.8
Brinjal	T_6	65.7	9.8
Banana	T_7	30.7	3.2
Sesamum	T_8	36.0	5.1
F' test		S*	S**
CD		26.0	6.1

Fresh weight T_6 T_4 T_1 T_2 T_3 T_5 T_8 T_7

Dry weight T_4 T_1 T_6 T_5 T_2 T_3 T_8 T_7

S** - Significant at one per cent level of significance

S* - Significant at five per cent level of significance

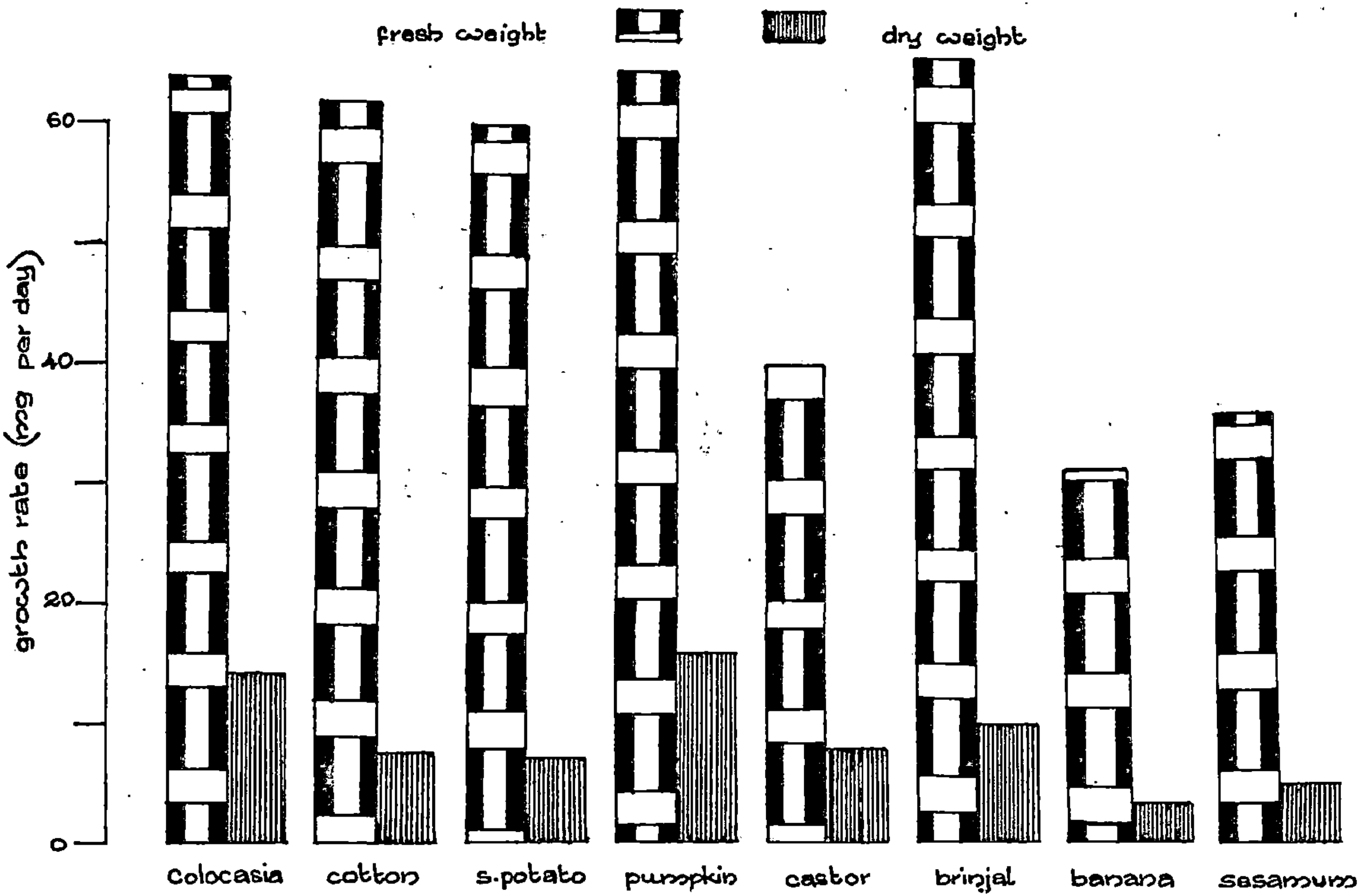

FIG.5. GROWTH RATE (FRESH AND DRY WEIGHT) OF *P. ricini* CATERPILLARS ON DIFFERENT HOST PLANTS

Table 6. Relative growth rate (R.G.R.) of *P. ricini* larvae on various food plants (mg/mg/day)

Host plant	Treatments	Fresh/dry	Dry/fresh	Dry/dry
Colocasia	T_1	1.06	0.05	0.23
Cotton	T_2	1.27	0.07	0.15
Sweet potato	T_3	0.84	0.02	0.12
Pumpkin	T_4	0.58	0.04	0.14
Castor	T_5	0.61	0.02	0.12
Brinjal	T_6	1.12	0.03	0.17
Banana	T_7	0.78	0.01	0.08
Sesamum	T_8	0.98	0.02	0.14
F' test		S**	S**	S**
CD		0.1640	0.0080	0.0344

Fresh/dry: T_2 T_6 T_1 T_8 T_3 T_7 T_5 T_4

Dry/fresh: T_2 T_1 T_4 T_6 T_5 T_8 T_3 T_7

Dry/dry: T_1 T_6 T_2 T_4 T_8 T_5 T_3 T_7

S** - Significant at one per cent level of significance

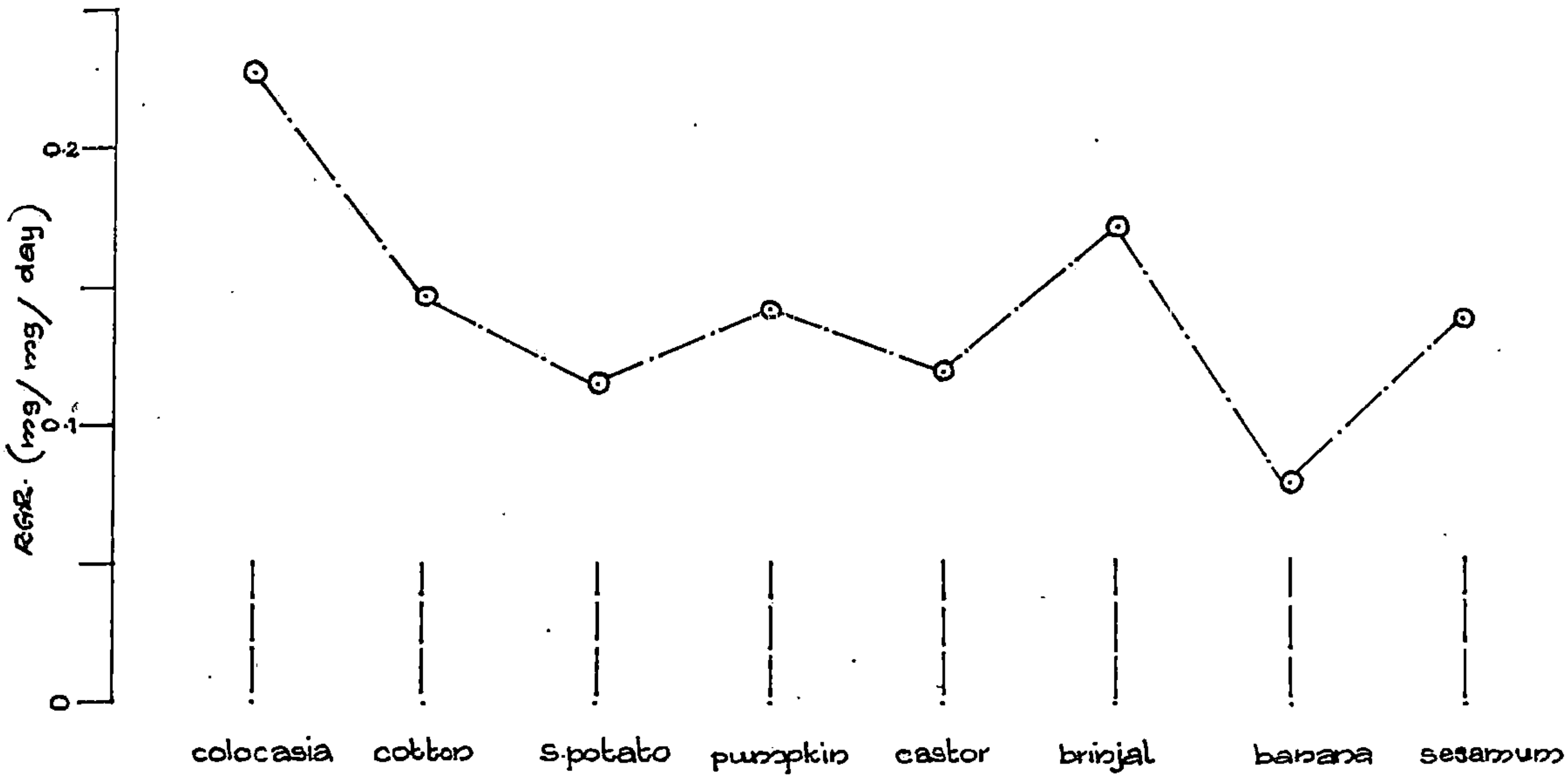

FIG.6. RELATIVE GROWTH RATE OF LARVAE OF *P. ricini* ON EIGHT DIFFERENT FOOD PLANTS

On fresh/dry weight basis, cotton-fed insects had the highest R.G.R. of 1.27, which was but on par with that of insects reared on brinjal. Pumpkin-fed insects recorded the lowest R.G.R. of 0.58.

On dry/fresh weight basis, the larvae fed on cotton indicated the highest R.G.R. value of 0.07. But banana-fed larvae with an R.G.R. of 0.01 were the poorest in relative growth.

On dry weight basis also, larvae grown on banana had the lowest R.G.R. of 0.08. Colocasia-fed insects had the highest R.G.R. of 0.23.

4.2 Indices of digestion and utilisation of food

4.2.1 Approximate digestibility (A.D.).

The approximate digestibility was calculated on the basis of fresh weight of the digestible portion of food and the weight of ingested food. A.D. on dry weight basis was also calculated. Represented as fig. 7, the figures are given in table 7.

It was seen that on fresh weight basis, sesamum was the most digested, with 91.40 as the approximate digestibility. Cotton, with an A.D. of 61.90 was the

Table 7. Indices relating to the approximate digestibility (A.D.) of different food plants fed to *P. ricini* caterpillars

Host plant	Treatments	Fresh weight (%)	Dry weight (%)
Colocasia	T_1	73.20	33.49
Cotton	T_2	61.90	29.74
Sweet potato	T_3	66.04	11.10
Pumpkin	T_4	89.96	57.22
Castor	T_5	90.54	72.65
Brinjal	T_6	85.38	53.25
Banana	T_7	86.59	53.16
Sesamum	T_8	91.40	59.78
F' test		S**	S**
CD		4.7876	15.183

Fresh weight – T_8 T_5 T_4 T_7 T_6 T_1 T_3 T_2

Dry weight – T_5 T_8 T_4 T_6 T_7 T_1 T_2 T_3

S** – significant at one per cent level of significance

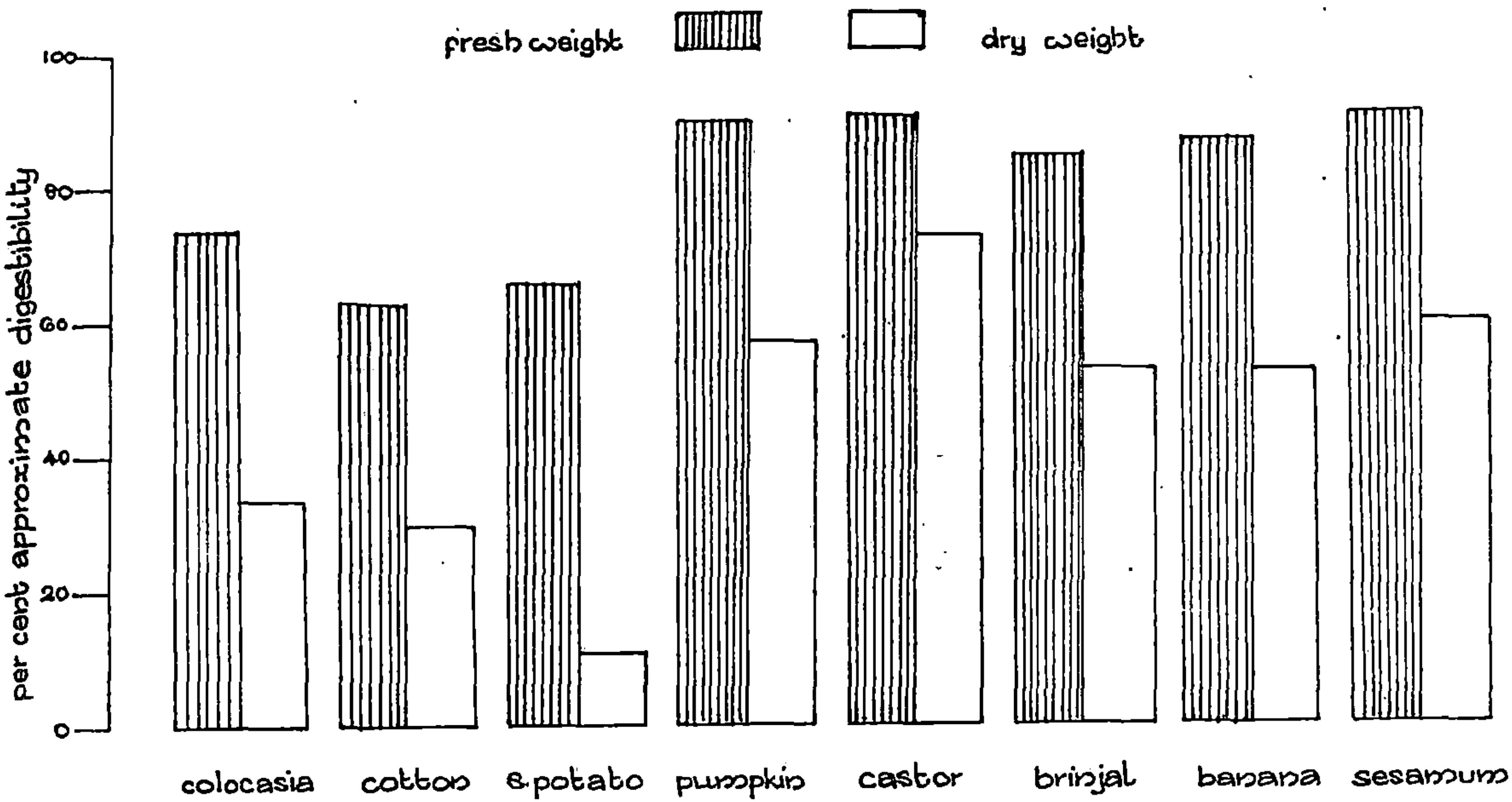

FIG.7. INDICES RELATING TO APPROXIMATE DIGESTIBILITY.[A.D]

least digested. A.D. values of sesamum, castor and pumpkin were, however, on par.

When the dry weights were considered, castor with an A.D. of 72.65 was the most digested, but was on par with sesamum and pumpkin in digestibility. Sweet potato had the least A.D. value of 11.10.

4.2.2 Efficiency of conversion of ingested food to body tissue (E.C.I.).

E.C.I. was calculated on the bases of fresh to fresh, fresh to dry, dry to fresh and dry to dry weights of weight gain of insect and mean weight of insect respectively. The results are provided in table 8 and are represented in fig.8.

Colocasia-fed insects outweighed all others in E.C.I. on fresh weight basis with an E.C.I. value of 15.61. Banana was the least converted to biomass, as evidenced by the lowest E.C.I. value of 5.77 of the larvae fed on it.

On fresh to dry basis, colocasia-fed larvae surpassed all others with an E.C.I. value of 15.63, though cotton, sweet potato, pumpkin, brinjal and sesamum also

Table 8. Efficiency of conversion of ingested food to body substance (E.C.I.) by the caterpillars of *P. ricini*

Host plant	Treatments	fresh/fresh (%)	fresh/dry (%)	dry/fresh (%)	dry/dry (%)
Colocasia	T_1	15.61	15.63	23.10	23.12
Cotton	T_2	11.12	11.61	6.05	6.10
Sweet potato	T_3	8.52	9.27	8.50	7.60
Pumpkin	T_4	9.22	9.24	13.14	13.17
Castor	T_5	6.38	6.38	5.65	5.66
Brinjal	T_6	9.01	9.01	7.95	7.95
Banana	T_7	5.77	5.74	2.73	2.74
Sesamum	T_8	8.16	8.16	6.92	6.93
F' test		S**	S**	S**	S**
CD		4.06	3.88	5.35	5.36

Fresh/fresh	T_1 T_2 T_4 T_6 T_3 T_8 T_5 T_7
Fresh/dry	T_1 T_2 T_3 T_4 T_6 T_8 T_5 T_7
Dry/fresh	T_1 T_4 T_3 T_6 T_8 T_2 T_5 T_7
Dry/dry	T_1 T_4 T_6 T_3 T_8 T_2 T_5 T_7

S** - Significant at one per cent level of significance

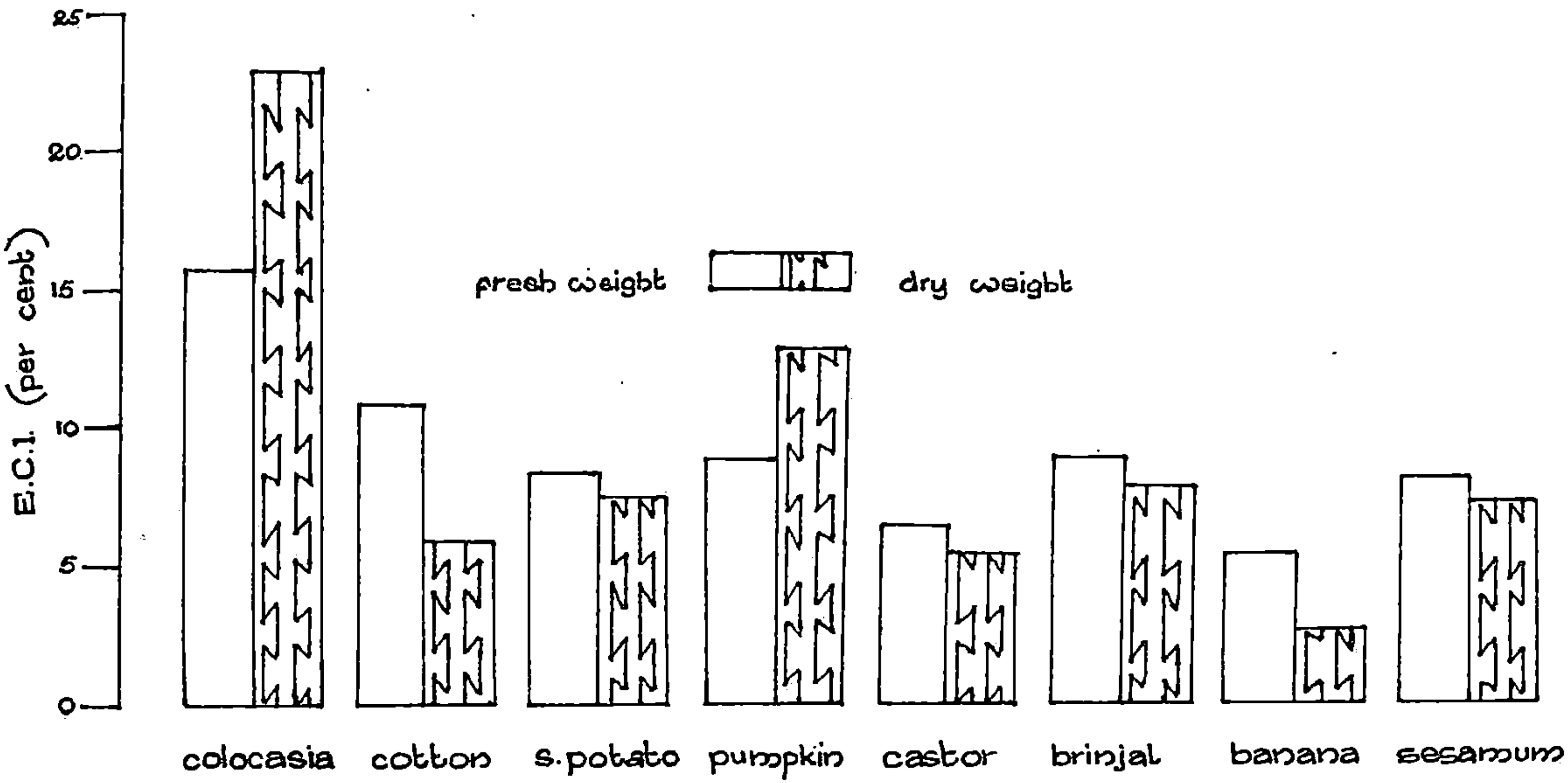

FIG. 8. EFFICIENCY OF CONVERSION OF INGESTED FOOD BY LARVAE OF *P. ricini*

were on par. Banana with an E.C.I. value of 5.77 was converted to body tissue to the lowest extent.

Dry to fresh E.C.I. values indicated a high efficiency in converting colocasia into body matter with a value of 23.10. The lowest efficiency was in the case of banana with only 2.73 as the E.C.I. value.

It was observed that on dry weight basis also, the trend in the dry/fresh E.C.I. was almost similar ie., with colocasia and banana ranking the first and last positions respectively. The E.C.I. for colocasia was 23.12 and that for banana, 2.74.

4.2.3 Efficiency of conversion of digested food to body matter (E.C.D.)

E.C.D. was calculated on the basis of fresh weights and dry weights. Table 9 and fig. 9 show the results of the experiment relating to E.C.D.

On fresh weight basis, the digested portion of colocasia leaves were best transformed to body tissue, as evidenced by an E.C.D. value of 23.09. Banana, with an E.C.D. value of 6.66, was converted to the least. It was also seen that E.C.D. values for colocasia, cotton, sweet potato, brinjal and pumpkin were statistically on par.

Table 9. Efficiency of conversion of digested food to body tissue (E.C.D.) by the larvae of *P. ricini*

Host plant	Treatments	Fresh weight (%)	Dry weight (%)
Colocasia	T_1	23.09	71.84
Cotton	T_2	18.07	20.61
Sweet potato	T_3	14.02	76.08
Pumpkin	T_4	10.38	54.91
Castor	T_5	7.00	78.04
Brinjal	T_6	10.54	15.07
Banana	T_7	6.66	57.22
Sesamum	T_8	8.94	11.65
F' test		S**	S**
CD		13.8929	32.7817
Fresh weight	T_1 T_2 T_3 T_6 T_4 T_8 T_5 T_7		
Dry weight	T_5 T_3 T_1 T_7 T_4 T_2 T_6 T_8		

S** - Significant at one per cent level of significance

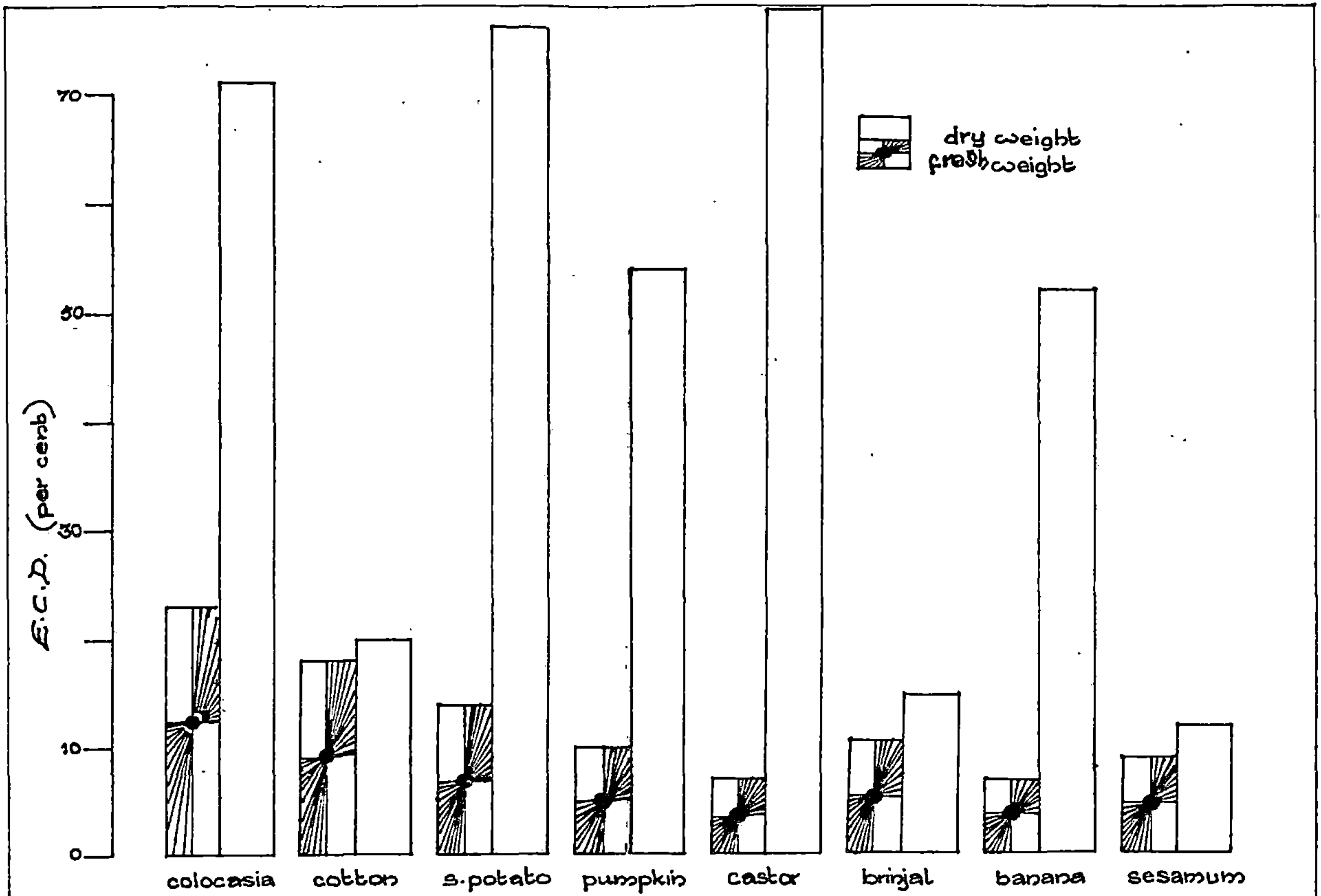

FIG.9. EFFICIENCY OF CONVERSION OF DIGESTED FOOD BY LARVAE OF *P. ricini*

Considering the E.C.D. values on dry weight basis, castor ranked top with an E.C.D. of 78.04, though sweet potato, colocasia, banana and pumpkin also had E.C.D. values on par with castor. Sesamum had the least E.C.D. of 11.65.

4.3 Indices of utilisation of nitrogen

The different indices relating to the utilisation of nitrogen are enumerated in table 10. R.N.A.R. and R.N.C.R. are represented as a graph in fig. 10 and E.C.I.(N), E.C.D.(N) and C.A.D.(N) in fig. 11.

4.3.1 The coefficient of apparent digestibility of nitrogen [C.A.D.(N)].

The coefficient of apparent digestibility of nitrogen in castor was 70.86 per cent and was the maximum. Sesamum, pumpkin, brinjal and colocasia also had values which did not differ significantly with that of castor. Sweet potato with a value of 25.85 per cent had the least digestion coefficient for nitrogen.

4.3.2 Relative nitrogen accumulation rate (R.N.A.R.)

The relative nitrogen accumulation rate was maximum in the case of larvae fed on cotton and sesamum, with

Table 10. Indices relating to the utilisation of nitrogen by the caterpillars of *P. ricini*

Host plant	Treatments	C.A.D.(N) (%)	R.N.A.R. (mg/mg/day)	R.N.C.R. (mg/mg/day)	E.C.I.(N) (%)	E.C.D.(N) (%)
Colocasia	T_1	54.85	0.1841	0.0068	27.19	56.60
Cotton	T_2	37.86	0.3693	0.0292	12.87	34.74
Sweet potato	T_3	25.85	0.1664	0.0175	9.42	38.93
Pumpkin	T_4	65.86	0.1798	0.0217	9.22	37.41
Castor	T_5	70.86	0.1651	0.0374	4.46	67.50
Brinjal	T_6	57.73	0.2256	0.0241	9.45	16.51
Banana	T_7	45.66	0.1340	0.0234	5.70	10.10
Sesamum	T_8	66.27	0.3571	0.0193	18.63	28.39
F' test		S**	S**	S**	S**	S**
CD		18.84	0.0441	0.0089	3.33	26.7913

C.A.D.(N) – T_5 T_8 T_4 T_6 T_1 T_7 T_2 T_3

R.N.A.R. T_2 T_8 T_6 T_1 T_4 T_3 T_5 T_7

R.N.C.R. T_5 T_2 T_6 T_7 T_4 T_8 T_3 T_1

E.C.I.(N) T_1 T_8 T_2 T_6 T_3 T_4 T_7 T_5

E.C.D. (N) T_5 T_1 T_3 T_4 T_2 T_8 T_6 T_7

S** – Significant at one per cent level of significance

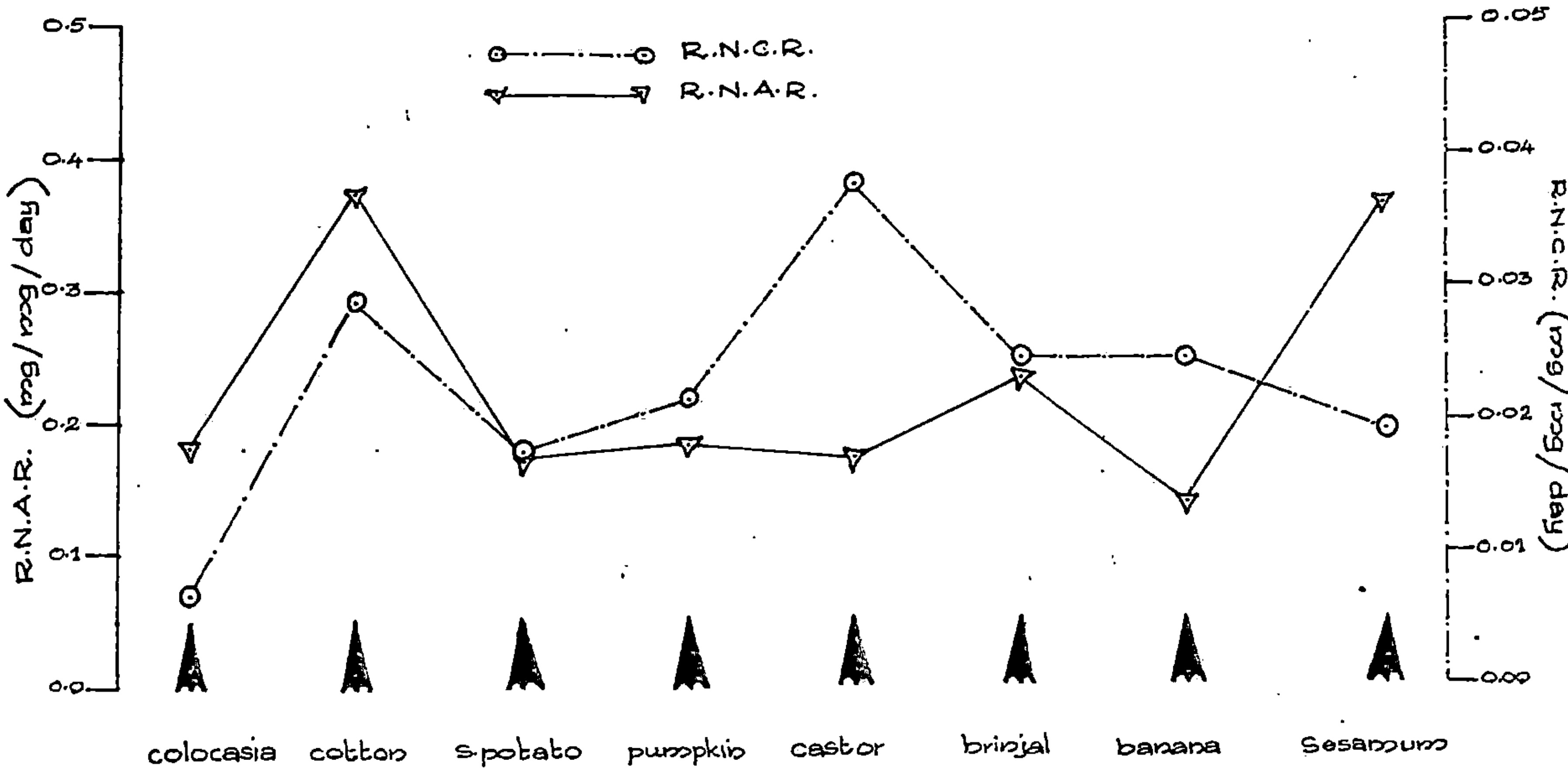

FIG.10. RELATIVE NITROGEN CONSUMPTION AND ACCUMULATION RATES BY THE LARVAE OF <u>P. ricini</u> ON EIGHT FOOD PLANTS

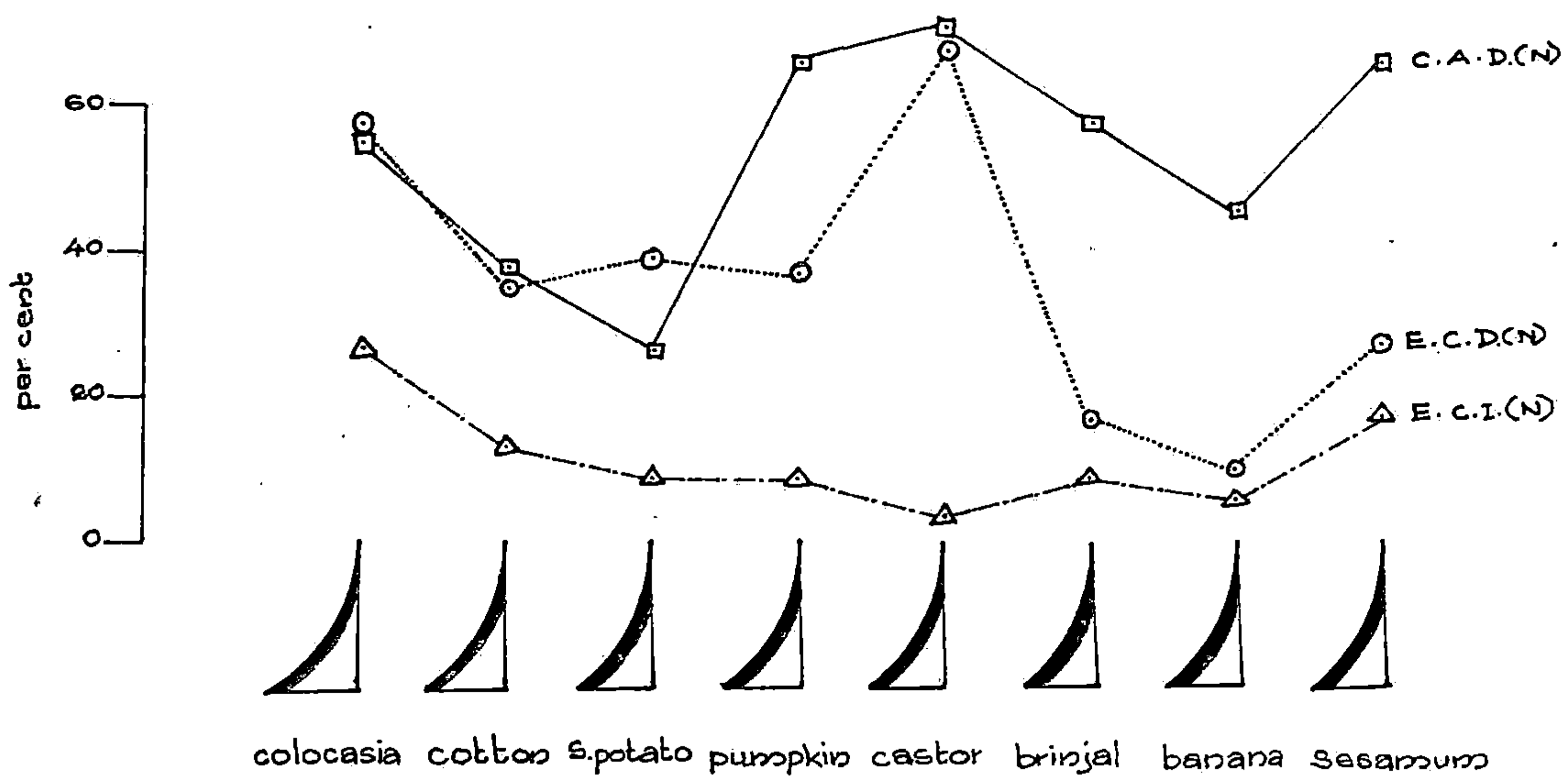

FIG.11. INDICES RELATING TO UTILISATION OF NITROGEN BY *P. ricini* CATERPILLARS

cotton having the highest value (0.3693). The least R.N.A.R. of 0.1340 was seen in the case of banana. It was also observed that R.N.A.R. for larvae on banana, castor and sweet potato did not differ significantly.

4.3.3 Relative nitrogen consumption rate (R.N.C.R.)

Castor-fed caterpillars had the highest R.N.C.R. of 0.0374, but was on par with those fed on cotton. Colocasia had the least value of R.N.C.R. (0.0068). All other foods had values which differed insignificantly among each other.

4.3.4 Efficiency of conversion of ingested nitrogen to body substance [E.C.I.(N)] .

Colocasia, sesamum and cotton had the higher values for E.C.I. (N) in the descending order and differed significantly among them.

Castor with an E.C.I.(N) value of 4.46 per cent was the least converted to body substance. The maximum conversion of ingested nitrogen to biomass was observed among larvae which fed on colocasia, the value being 27.19.

4.3.5 Efficiency of conversion of digested nitrogen to body substance [E.C.D.(N)].

Castor-fed larvae converted 67.50 per cent of the digested nitrogen into body substance while those fed on colocasia recorded the next lower value. The least value (10.10 per cent) was given with banana. The E.C.D. (N) values of other food plants were on par.

4.4 Influence of different food plants on the pupae

Table 11 expresses the effect of the different diets on the pupal period, pupal weight and pupal length. Pupal and adult emergence from larvae is shown in Table 12.

4.4.1 Pupal period

The pupal period ranged from 21.56 days at the maximum for colocasia to 11.83 days at the minimum in the case of pumpkin. But the pupal periods were not significantly different among each other statistically.

4.4.2 Pupal weight

Pupae resulting from feeding on cotton had the highest weight of 0.53 g. Pupae on banana were the lightest, and had only 0.25 g of weight.

Table 11. Effect of different foods on the period, weight and length of pupae of *P. ricini*

Host plant	Treatments	Pupal period (days)	Pupal weight (g)	Pupal length (cm)
Colocasia	T_1	21.56	0.50	1.88
Cotton	T_2	13.83	0.53	1.91
Sweet potato	T_3	17.47	0.35	1.67
Pumpkin	T_4	11.83	0.44	1.83
Castor	T_5	14.70	0.40	1.80
Brinjal	T_6	16.31	0.49	1.84
Banana	T_7	14.08	0.25	1.56
Sesamum	T_8	12.21	0.31	1.58
F' test		NS	S**	S**
CD		-	0.088	0.1124

Pupal weight T_2 T_1 T_6 T_4 T_5 T_3 T_8 T_7

Pupal length T_2 T_1 T_6 T_4 T_5 T_3 T_8 T_7

S** - Significant at one per cent level of significance

NS - Non Significant

Table 12. Per cent of pupae and adults of *Pericallia ricini* formed from larvae fed on different foods

Host plant	Treatments	Pupae formed (%)	Adults emerged (%)
Colocasia	T_1	95.83	95.83
Cotton	T_2	100.00	100.00
Sweet potato	T_3	100.00	100.00
Pumpkin	T_4	66.67	29.17
Castor	T_5	95.83	95.83
Brinjal	T_6	79.17	62.50
Banana	T_7	58.33	50.00
Sesamum	T_8	100.00	100.00
F' test		S**	S**
CD		8.185	0.0433

Pupae formed (%) $\overline{T_2 \; T_3 \; T_8 \; T_1 \; T_5}$ T_6 T_3 T_7

Adults emerged (%) $\overline{T_2 \; T_3 \; T_8}$ $\underline{T_1 \; T_5}$ T_6 T_7 T_4

S** - Signifiant at one per cent level of significance

4.4.3 Pupal length

The longest pupae resulted from cotton, with an average length of 1.91 cm. The least length of 1.56 cm was observed on pupae from banana.

4.4.4 Pupal and adult emergence

Larval mortality caused a decreased percentage of pupation in the larvae fed with colocasia, pumpkin, castor, brinjal and banana. The other foods enabled 100 per cent pupation of the larvae. Maximum mortality was in the case of banana, with only 58.33 per cent of larvae turned to pupae. Pupal formation was 66.67 per cent in the case of pumpkin and 79.17 per cent with brinjal.

In the case of pupae formed from pumpkin, brinjal and banana, a further decrease in the population of test insects was evidenced, as some of the pupae did not emerge out. From a 66.67 per cent pupation in the case of pumpkin, only 29.17 per cent emerged out as adults. Only 62.50 per cent of moths emerged in the case of brinjal while it was 50 per cent for banana.

4.4.5 Sex ratio

Table 13 indicates the influence of the different food plants on the sex ratio.

Insects fed with cotton and castor showed the near best sex ratio of 1 : 0.88. In the case of sweet potato and sesamum, the ratio was 10 to 20, which makes the worst of the values of 1 : 2 for them.

Table 13. Sex ratio of moths of *P. ricini* emerged at the end of the experimental period

Host plant	Treatments	Female : Male	Sex ratio
Colocasia	T_1	17 : 13	1 : 0.76
Cotton	T_2	16 : 14	1 : 0.88
Sweet potato	T_3	10 : 20	1 : 2.00
Pumpkin	T_4	13 : 17	1 : 1.31
Castor	T_5	16 : 14	1 : 0.88
Brinjal	T_6	18 : 12	1 : 0.67
Banana	T_7	11 : 19	1 : 1.73
Sesamum	T_8	10 : 20	1 : 2.00

Discussion

DISCUSSION

The parameters of consumption, digestion and utilisation for the larvae of Pericallia ricini, a polyphagous insect were worked out in detail. The indices are largely based on the scientific papers of Waldbauer (1968) and Scriber (1977). The parameters were measured on wet weight and dry weight bases. Eventhough the indices of consumption, digestion and utilisation at all possible combinations were worked out and enlisted in the tables, those on fresh weight to fresh weight and dry weight to dry weight basis alone may be of practical importance. Other indices assume only academic importance and hence, only fresh weight and dry weight indices are discussed.

5.1 Parameters of larval growth

5.1.1 Consumption index (C.I.)

The consumption indices at various combinations of fresh and dry weights are tabulated in table 1 and is graphically presented in fig.1.

Consumption indices will give an insight into the economic losses an insect can cause on a particular food plant. Use of consumption index in the case of insects was proposed by Waldbauer (1964; 1968), as the absolute quantities of food eaten cannot be used to compare the rate of food intake of animals growing at different rates. Consumption index thus helps in making comparisons of diets on which an insect grows at different rates (Bhattacharya and Pant, 1976).

Based on fresh weights, it is revealed that brinjal had the highest C.I. and sweet potato, the least one. The fresh weight C.I. is generally taken as a measure of the behavioural response of insects towards the food (Waldbauer, 1968). The rank order of either dry weight - fresh weight or dry weight C.I.'s is not necessarily the same as the rank order of corresponding fresh weight C.I.'s(Waldbauer, 1968). This is due to the difference in the per cent dry matter of the food. Thus dry weight intake may be higher on one food than another although fresh weight intake is lower. The C.I. values obtained in the present study also corroborate the above finding.

The dry weight C.I. was seen to differ considerably from that of the fresh weight C.I. Waldbauer (1968) assigns the reason to the different degrees of water content of the food plants. Banana had the highest C.I. and the least C.I. was shown by colocasia on dry weight basis.

The dry weight - fresh weight C.I. shows the highest value for castor. This is of nutritional interest since this index measures the rate at which the nutrients enter the digestive system (Waldbauer, 1968). Soo Hoo and Fraenkel (1966) and Waldbauer (1964) found that dry weight C.I.'s were always higher than the corresponding fresh weight C.I.'s because the insects in question contained a lower percentage of dry matter than their food. But the C.I. values (dry weight) relating to colocasia and pumpkin slightly deviated from the above finding. This anomaly can be explained by the higher gain in weight of larvae (fresh weight basis) during the experimental period.

A greater consumption index would mean the lack of or imbalance of nutrients in the plants. Thus colocasia and sweet potato may be having all the nutrients for growth of the larvae or a balance of nutrients, better than those of all other food plants. High C.I. values indicate the nutritional unsuitability of the particular food as a rearing medium. Total fresh weight consumption was seen to increase with increased dilution of nutrients in the case of artificial diets (House, 1965).

There appears to be a negative correlation between the rate of dry matter intake and the efficiency of conversion of ingested or digested food by Prodenia larvae (Soo Hoo and Fraenkel, 1966). A similar trend is discernible in the present study also between dry matter C.I. values on the one side and E.C.I. and E.C.D. values on the other.

5.1.2.1 Consumption rate

Consumption rate was calculated as mg of food eaten per day. The results are given in table 2 and fig. 2 graphically explains the same.

The fresh weight consumption rate was maximum for brinjal and the least for colocasia. On dry weight basis, castor had the best consumption rate and the least was shown by colocasia.

Consumption rate can be considered as an index of the ability of the food plant to support larval growth, though the weight of the larvae is not considered. But some workers (Waldbauer, 1964; Soo Hoo and Fraenkel, 1966) suspect an inverse relationship between consumption rate and larval growth. Consumption rate can give an overall idea of the crop losses the insect can incur on a particular plant. A higher consumption is usual of larger larvae and hence, brinjal-fed insects must have had a better growth. This is supported by the highest weight gain of 1.06 g per larva in the case of brinjal (table 2). But a higher consumption rate should not always lead us to the same conclusion. The presence of a phagodeterrent, absence or sub-optimal quantities of a phagostimulant can all cause a lesser consumption. A higher consumption can also be to compensate for a low utilisation. On the other hand, low consumption is compensated by a higher E.C.I., E.C.D. and A.D. also. Even though the consumption rate with colocasia was the least, the larvae feeding on these plants recorded a moderately high weight gain.

5.1.2.2 Mean weight gain of larvae.

The highest weight gain per larva is shown by larvae fed upon brinjal. This must mean a harmonious blending of good consumption and utilisation of food. Hence brinjal can be considered as an optimal diet for *Pericallia ricini*, though the insect in nature is mostly associated with castor (*Ricinus communis*). Sang (1959) suggested that there may be more than one optimal diet for a given species. But declaring a food plant as an optimal diet before analysing the survival potential, mortality of the larvae and other related factors would be premature. The total weight gain per larva was the least with insects which fed on banana leaves. The low water and nitrogen content of the leaves can be attributed to this finding.

5.1.2.3 Water and nitrogen content of food plants.

Table 14 indicates the data concerning the per cent of water and nitrogen content in the leaves. Colocasia showed the highest water content and banana, the least. The least nitrogen content also is of banana, while the best per cent nitrogen content is of castor. Higher water and nitrogen contents in the host plants encourage the best growth of larvae (Waldbauer, 1968; Scriber, 1977; 1978; 1979 a, b, c).

5.1.3 Consumption of foliage by larvae in the different instars

Table 3 explains the consumption of food plants by III, IV and V instar larvae of P. ricini.

Consumption is seen to increase with age of the

Table 14. Water and nitrogen content of plants used in the feeding experiment with larvae of *P. ricini*

Host plant	Treatments	Water content (% fresh weight)	Nitrogen content (% dry weight)
Colocasia	T_1	85.33	2.40
Cotton	T_2	78.42	2.61
Sweet potato	T_3	84.86	2.67
Pumpkin	T_4	82.59	3.80
Castor	T_5	78.15	3.99
Brinjal	T_6	83.03	3.15
Banana	T_7	77.87	1.42
Sesamum	T_8	83.32	2.18
F' test		S**	S**
CD		1.4308	0.1436

Water content $\overline{T_1\ T_3}\ \overline{T_8\ T_6\ T_4}\ \overline{T_2\ T_5\ T_7}$

Nitrogen content $T_5\ T_4\ T_6\ \overline{T_3\ T_2}\ T_1\ T_8\ T_7$

S** - Significant at one per cent level of significance

larvae. This is only expected, since when the larvae grow and gain weight, the metabolic requirements and the maintenance energy are bound to increase, and to compensate for it a higher consumption of food is necessary. There are earlier references also showing that more food is eaten during the last two or three instars. Bombyx and Protoparce, both lepidopterous leaf feeders, eat about 97 per cent of their total food during the last two instars (Hiratsuka, 1920; Wolcott, 1937).

5.1.4 Food consumption by male and female larvae.

The difference in consumptions of leaves of food plants by the two sexes of the test insect can be understood from table 4 and its graphic representation, fig. 4.

Females were observed to consume more food than the corresponding males. Probably, this may be for accumulation of greater amounts of nutrients necessary for the production and development of eggs. Davey (1954) similarly reported that total food intake during the nymphal stage is greater in the female than in the male of Schistocerca gregaria.

5.1.5 Growth rate (G.R.)

The values of growth rate of larvae on different food plants are shown in table 5 and represented as a graph in fig. 5. Growth rate as described by Scriber (1977) is adopted here.

Growth rate explains the rate of growth of larva per day and hence is another index of the ability of the food plant to support larval growth. The results indicate a superiority of brinjal in supporting growth, and an inferior ability of banana on fresh weight basis. On dry weight basis also, banana-fed insects had the least growth rate. Hence it may be assumed that banana supports larval growth to the least extent, probably due to the least amount of water and nitrogen content (Table 14). This hypothesis has been supported by the findings of other workers also (Gandhi, 1977; Scriber, 1977; Scriber, 1979 b). The high leaf water content of brinjal and pumpkin must have aided the insects fed on them to have a better weight gain per day. This can partially be due to the lesser expense on production of metabolic water also, which hinders the growth of larvae on other foods (Scriber, 1977).

5.1.6 Relative growth rate (R.G.R.)

The weight gained by the larvae in g as a ratio of mean body weight in g through out the larval period and the duration of feeding period in days was designated as R.G.R. The results are shown in table 4 and fig. 4.

R.G.R. values reveal a clear superiority of colocasia-fed larvae over larvae reared on other food plants. R.G.R. also explains the rate at which the digested matter is available to the larvae during the experimental period (Bhattacharya and Pant, 1976). Considering the duration of feeding period and the mean body weight, it could hence be assumed that digested portions of colocasia were readily available for the larvae for biomass production.

5.2 Indices of digestion and utilisation of food

The utilisation of ingested food is another important criterian to be considered while analysing the usefulness of a particular food for the larvae grown on them. A lower ingestion of food is usually compensated by way of a better utilisation of ingested food.

5.2.1 Approximate digestibility (A.D.)

The approximate digestibility of a particular food is important while interpreting the utilisation of it. A.D. is also called as 'Assimilation Efficiency' which reveals the importance of this index in connection with the digestibility or assimilation of a particular food. As can be seen from table 7 and fig. 7, sesamum had the best digestibility on fresh weight basis and on dry weight basis, castor was best digested.

Though insect feces contain urine, a correction has not been made. Urine of insects consists mostly of uric acid and it has been observed that the feces of phytophagous insects contain very low quantities of uric acid (Waldbauer, 1968). Uric acid ranged from only 0.24 to 0.51 per cent for the 5th instar in the dried feces of Bombyx mori (Hiratsuka, 1920). Hence, the A.D. values obtained here will give an almost dependable estimate of digestibility.

It is commonly observed that A.D. declines with age. Reasons for the decline are not clearly understood. One would expect digestive efficiency to decline with growth, since an animal which doubles its weight and volume will increase the surface area of the digestive tract by a factor of only 1.8 (Gordon, 1959). First instar larvae eat from between the small veins of the leaf. The larger larvae eat almost the whole leaf. Thus it is likely that the older larvae ingest a larger proportion of indigestible crude fibre. But the relation between age of the larvae and the digestibility of food plants has not been worked out in the present study.

5.2.2 Efficiency of conversion of ingested food to biomass (E.C.I.)

E.C.I. was calculated as the ratio of the weight gained by the larvae to the weight of the food ingested and expressed as per cent. E.C.I. explains the ability of the insect to utilise for growth, the food which it ingests. When a food plant contains a high percentage of indigestible material like crude fibre, the E.C.I. is usually low. But the water content of the leaves also poses problems because expenses for production of metabolic water from the ingested food will also lower the E.C.I. This index can also be obtained as the product of approximate digestibility and efficiency of conversion of digested food to body mass and is otherwise termed as 'overall efficiency' (Scriber, 1977). An insect may utilise a food which it does not normally eat, far less efficiently than its natural food (Waldbauer, 1968).

The fresh weight E.C.I. values and dry weight values show that larvae fed on colocasia had the best E.C.I. and those on banana the least. It is obvious that the low leaf water content of banana must have forced the larvae fed with it to spend more of the energy from the food for production of metabolic water and for sustenance of life.

5.2.3 Efficiency of conversion of digested food to body matter (E.C.D.)

E.C.D. for the larvae on a particular food is dependant mainly on the intake of food and on the amount of energy required for the maintenance of physiological functions of the body. The influence of the nutritional value of the food on the E.C.D. also cannot be overruled.

E.C.D. provides an indication of the biomass expended in respiration, assuming activity to be constant. Thus it should reflect the metabolic costs associated with the detoxication of allelochemics, or of energy "waste" associated with production of metabolic water by larvae (Scriber, 1977).

Colocasia offered the best E.C.D. for larvae reared on it on fresh weight basis and banana, the least. On dry weight basis, however, castor and sesamum were the best and least respectively.

E.C.D. is a measure of the efficiency with which digested food is converted to body substance. E.C.D. will decrease as the proportion of digested food metabolised for energy increases. E.C.D. is not directly dependent on digestibility, but it does vary with the level of nutrient intake. Since the maintenance requirement is more or less constant, the proportion of food available for growth will decrease as intake decreases (Waldbauer, 1968).

The results of the present study thus lead us to the conclusion that colocasia and castor had the least amount of allelochemics to be detoxified and that expenses for production of metabolic water was the minimum. The highest consumption rate for castor and the highest E.C.I. for colocasia have helped the larvae fed on them to have the highest conversion of digested food to biomass. E.C.D. is also termed as "net growth efficiency".

5.3 Utilisation of nitrogen by the larvae

Utilisation of particular nutrients can be of great significance in a study of the physiology of an insect species. Answering questions on metabolism of nutrients, ecological relationships and adaptation of insects to their natural food plants will necessitate determination of absolute quantities of food eaten and their utilisation. Indices of utilisation of nitrogen can also throw light on several aspects of acceptability of food and overall understanding of the physiology of insects. It may also explain the role of various nutrients in host selection and feeding behaviour of insects (Bhattacharya and Pant, 1976).

Analysis of nitrogen of leaves and its utilisation by the larvae have been attempted, which would pave way for a better understanding of the uptake and utilisation of protein by insects. Utilisation indices for nitrogen are complicated by the presence of urine in the feces as explained by Waldbauer (1968). E.C.I.(N) alone is not affected by this phenomenon since this index does not involve the values of excreted nitrogen. Waldbauer (1968) explains that C.A.D.(N) and E.C.I.(N) must be identical and that E.C.I.(N) must be 100 per cent . He attributes deviations from this to incomplete recovery of nitrogen during analysis. Utilisation indices for nitrogen in consonance with the explanation of Waldbauer (1968) have not been attained by any worker who calculated the indices with the uncorrected fecal nitrogen. Hence it may be assumed that the difference between the ingested nitrogen and fecal nitrogen is not actually the amount of nitrogen retained in the body. When considerable amount of nitrogen is lost as metabolic fecal nitrogen, there is a chance that the difference between ingested nitrogen and nitrogen in the feces is greater than the nitrogen in the body.

Probably, if the nitrogen in the body is calculated as the difference in the nitrogen content of the last instar larva and the egg, and a precise estimation of nitrogen conducted, utilisation indices for nitrogen very near to that expected by Waldbauer (1968) may be obtained.

The values of utilisation of nitrogen can be compared or correlated with only the corresponding dry weight indices, since per cent nitrogen was calculated on dry weight basis only.

5.3.1 Coefficient of apparent digestibility of nitrogen [C.A.D. (N)] .

Castor and sweet potato ranked best and least in the ability to digest the nitrogen in them by larvae fed on these foods. Since the uric acid, allantoin and allantoic acid contents of the feces are not estimated and correction for these chemicals not applied in the nitrogen content of the feces, this estimation may be lower than the actual values.

5.3.2 Relative nitrogen accumulation rate (R.N.A.R.)

The rate at which nitrogen is accumulated in the body is expressed as mg nitrogen gained per mg larval biomass per day. Nitrogen in cotton was accumulated to the greatest extent by the larvae and the nitrogen accumulation from banana was the least. This must partially be due to the low content of nitrogen in banana leaves and also due to a lesser intake and utilisation of banana leaves.

5.3.3 Relative nitrogen consumption rate (R.N.C.R.)

R.N.C.R. was expressed as mg nitrogen ingested per mg larval biomass per day. When the consumption rate of a particular food increases, R.N.C.R. is also probable to increase, subject to the per cent of nitrogen in the leaf and the utilisation of food.

The highest R.N.C.R. was shown by larvae feeding on castor and the least by those on colocasia. Since the consumption rate and nitrogen content was maximum in the case of castor it was only expected of castor to have a high value for R.N.C.R. Colocasia was consumed to the least and had a nitrogen content which was far below the nitrogen per cent of castor and hence, the least R.N.C.R.was shown by the larvae grown on this food. But E.C.I., E.C.D., E.C.I.(N) and E.C.D.(N) also can contribute significantly on the values of the relative nitrogen consumption rate.

5.3.4 Efficiency of conversion of ingested nitrogen to body tissue [E.C.I.(N)] .

This index is also referred to as 'nitrogen utilisation efficiency' or N.U.E. The amount of nitrogen retained in the body as a ratio of the nitrogen in the food ingested and expressed as a percentage was denoted as E.C.I.(N). Colocasia and castor-fed insects showed the best and least values of E.C.I.(N) respectively. The E.C.I. value for larvae reared on colocasia was the highest and the nitrogen content of this food was moderate. This may explain the best E.C.I.(N) value obtained for larvae reared on colocasia. Castor fed insects had the least E.C.I., second only to banana. E.C.I.(N) values for the larvae on castor and banana were on par. E.C.D. also has an influence on the E.C.I.(N) because, nitrogen from the digestible portions of the food alone is available.

5.3.5 Efficiency of conversion of digested nitrogen to larval biomass [E.C.D.(N)].

Nitrogen in the body of the larvae when expressed in percentage as a ratio of nitrogen in the food ingested less feces was termed as E.C.D.(N). Efficiencies of conversion of ingested and digested food, A.D., E.C.I.(N) and even consumption rate are factors which influence E.C.D.(N). The nitrogen content of the host plant leaves is also one of the influencing factors.

The highest value for E.C.D.(N) was recorded by the caterpillars which fed on castor and the least E.C.D.(N) was registered by larvae on banana. Castor had the highest per cent of nitrogen whereas it was the lowest in case of banana. The influence of a combination of all other indices along with this difference in per cent nitrogen explains the above observation.

5.4 Influence of the different food plants on the pupae

5.4.1 Pupal period.

The pupal period did not vary significantly among the pupae which were developed from the different food plants. Hence it seems that the influence of the food plants on the pupal duration is very little. Results obtained by El-Kifl *et al.* (1973) also were the same. Pandey and Srivastava (1967) found that larvae with higher growth indices do not necessarily yield pupae having shorter pupal durations. The present study also is in agreement with this finding. A difference of about ten days, however, was exhibited by the pupae in their duration between the longest and shortest pupal periods.

5.4.2 Weight of pupae

The heaviest pupae were observed from feeding on cotton. Considering the growth rate and weight gain per larva, it was seen that there were other food plants which performed better as food for the larvae. Hence, it seems lesser expenses for pupation may be the reason for the heaviest pupae on cotton. Banana-fed larvae produced the lightest pupae, more so because of the least weight gain per larva observed on insects feeding on this plant.

5.4.3 Length of pupae

The longest pupae also were obtained from caterpillars fed with cotton. The shortest length was obtained from pupae resulting from banana. There is a positive relationship between length of pupae and its weight.

5.4.4 Pupal and adult emergence

The number of pupae emerging out from the larvae fed on a diet was one of the major criteria for evaluating a food material. But for a better comparison, both percentage pupal and adult emergence should be recorded. Further calculation of the adult formation from larval and pupal stages may throw light on the nature of inhibitory effect or nutritional requirements for a definite stage of the insect (Bhattacharya and Pant, 1976).

The present study revealed larval mortality in five out of the eight foods. Maximum mortality was in the case of banana-fed larvae. All the pupae formed in the case of larvae reared on pumpkin, brinjal and banana did not emerge. These data indicate the possible occurrence of an inhibitory effect of some of the food plants on the larval and pupal development.

5.4.5 Sex ratio

Sex ratio of 1 : 1 or a slightly greater number of females to males is considered best (Bhattacharya and Pant, 1976). The different food plants may play an important role in better development of one sex and suppression or mortality of the other. The best sex ratio very near to 1 : 1 was shown by insects which were fed with cotton and castor. The worst value of twice the number of males to females was exhibited by adults from sesamum and sweet potato. Even when a particular food supports growth to the best extent and also is utilised to the best, if it fails to produce adults having a good sex ratio, the survival of the species is endangered. Through ecological adaptation, insects overcome this and egg laying is done mostly on those plants alone which support normal development in all the stages. The heavy and consistent infestation of Pericallia ricini on cotton and castor might probably be due to this reason.

Summary

SUMMARY

Various indices relating to the consumption, digestion and utilisation of eight food plants by the larvae of the castor hairy caterpillar, *Pericallia ricini* F. were calculated. The food plants used in the experiment were colocasia, cotton, sweet potato, pumpkin, castor, brinjal, banana and sesamum. The effect of these different foods on the pupal period, pupal weight, pupal length and sex ratio was also investigated.

The consumption index on fresh weight basis was maximum for brinjal and the least with sweet potato. But on dry weight basis, banana-fed insects reported the highest C.I. followed by cotton-fed larvae. The least C.I. value was obtained with colocasia.

Among the III, IV and V instar larvae used for the experiment, it was the final instar larvae which consumed the highest quantity of food. Females were seen to consume more foliage than the corresponding male larvae.

The growth rates were calculated both on fresh and dry weight bases. On fresh weight basis, larvae

reared on brinjal had the highest growth rate and the least growth rate was exhibited among larvae grown on banana. On dry weight basis, pumpkin was superior to all other food plants in supporting growth of the larvae.

The approximate digestibility, on dry weight basis, was the highest with sesamum and the corresponding index was the least with cotton. A.D. values of other food plants were, however, on par.

Indices relating to efficiency of conversion of ingested and digested food to body matter were also calculated. Colocasia-fed insects outweighed all others in E.C.I. on fresh weight basis. Banana was the least converted to biomass. The digested portion of colocasia leaves were transformed to body tissue to the maximum as evidenced by its high E.C.D. value of 23.09. The lowest value which was equal to 6.60 was recorded with banana.

Various indices relating to the utilisation of nitrogen were also worked out. The maximum conversion of ingested nitrogen to insect biomass was observed among larvae which fed on colocasia.

But it was castor-fed larvae which converted the highest amount (66.50 per cent) of digested nitrogen into body substance. The lowest value was obtained from banana-fed larvae.

It is very clear from the data obtained from the experiment, that the pupal period, pupal weight and pupal length differed much among the larvae fed on different food plants. Pupal and adult emergence of the test insects were also significantly affected by the food plants. Maximum larval mortality was recorded in the case of larvae which were fed on banana. But the overall percentage of adult emergence was the least (29.17 per cent) with pumpkin.

The sex ratio of the emerging adults was also found to differ significantly according to the food plant supplied during the experiment. Insects fed on cotton and castor showed the near best sex ratio of 1 : 0.88; the worst was recorded with sweet potato and sesamum. Sex ratios which greatly deviated from these were recorded with all other food plants.

References

REFERENCES

Abdel-Fattah, M.I., Y.S. Salem, and M.I. Abdel-Megeed. (1977). Effect of larval diet on the development and fecundity of the cotton leaf worm, Spodoptera littoralis (Boisd). Z. Angew Entomol., 84(3): 311-315.

Abul-Nasr, S.E., K.T. Awadallah and H.E. Abubakr. (1976). Effects of different diets on the development and fecundity of corn earworm Heliothis armigera (Lepidoptera : Noctuidae). Z. Angew. Entomol., 81: 285-291.

*Aslam, M. and M. Akhtar. (1976). Consumption and utilisation of food by Aiolopus tamulus Fabr. (Orthoptera: Acrididae). Pak. J. Zool., 6: 41-46.

Bailey, C.G. (1976). A quantitative study of consumption and utilisation of various diets in Bertha armyworm, Mamestra configurata (Lepidoptera: Noctuidae). Can. Entomol., 108: 1319-1326.

*Bailey, C.G. and M.K. Mukerji. (1976). Consumption and utilization of various host plants by Melanoplus bivittatus (Say.) and M. femerrubrum (De Geer) (Orthoptera: Acrididae). Can. J. Zool., 54(7): 1044-1050.

Bhat, N.S. and A.K. Bhattacharya. (1978). Consumption and utilisation of soybean by Spodoptera litura (Fabr.) at different temperatures. Indian J. Entomol., 40(1): 16-25.

Bhattacharya, A.K. and N.C. Pant. (1976). Studies on the host plant relationships: Consumption and utilisation profile in insects. Proc. Nat. Acad. Sci., India, 46(B), I & II: 273-301.

Bilapate, G.G., V.M. Pawar and A.K. Raodeo. (1977). Growth of population of Heliothis armigera Hbn. on lucerne. Indian J. Agric. Sci., 47: 540-542.

Brewer, F.D. and E.G. King. (1979). Consumption and utilisation of soyflour-wheat germ diets by Heliothis spp. Ann. Ent. Soc. Am., 72: 415-417.

Capinera, J.L. (1978). Consumption of sugarbeet foliage by the pale striped flea beetle. J. Econ. Entomol., 71(2): 301-303.

*Chauvin, G. and A. Gueguen. (1978). Larval development and energy utilisation in the hygrometric function in Tinea pellionella L. (Lepidoptera: Tineidae). Can. J. Zool., 56(10): 2176-2185.

Chockalingam, S. (1979). A study of food consumption and utilisation in Pericallia ricini (Lepidoptera: Arctidae). Comp. Physiol. Ecol., 4(2): 78-80.

Crowell, H.H. (1941). The utilisation of certain nitrogenous and carbohydrate substances by the southern armyworm, Prodenia eridania Cram. Ann. Ent. Soc. Am., 34: 503-512.

Dale, D. and S. Chandrika. (1971). Studies on the consumption, digestion and utilisation of food plants by the larvae of Euproctis fraterna M. (Lymantridae: Lepidoptera). Agri. Res. J. Kerala, 9(2): 68-71.

Davey, P.M. (1954). Quantities of food eaten by the desert locust, Schistocerca gregaria (Forsk.) in relation to growth. Bull. Ent. Res., 45: 539-551.

David, W.A.L. and B.O.C. Gardiner. (1962). Observations on the larvae and pupae of Pieris brassicae (L.) in a laboratory culture. Bull. Ent. Res., 53: 417-436.

Dandapani, N. and M. Balasubramanian. (1980). Consumption and utilisation of food plants by Heliothis armigera (Hubner) (Noctuidae : Lepidoptera). Entomon, 5(2): 99-103.

*El-Kifl, A.H., E.S.A. Nasr., M.M. Ibrahim and G.M. Moawad. (1973). Effect of host plants on various stages of Agrotis ipsilon (Hufn.) (Lepidoptera : Noctuidae). Bull. Soc. Entomol. Egypte, 56: 103-111.

El-Shaarawy, M.F., A.A. Gomaa and A.T. El-Garhy. (1975). The consumption, digestion and utilization of two castor-bean varieties by larvae of Eri silkworm, Attacus ricini (Lepidoptera : Saturnidae). Z. Angew. Entomol., 79: 123-128.

Gandhi, J.R. (1977). Utilization of plant food in the heteropteran Oxycarenus hyalipennis Costa. and homopteran Oxyrhachis tarandus Fabr. Indian J. Entomol., 39: 107-113.

*Gordon, H.T. (1959). Minimal nutritional requirements of the German roach, Blattella germanica L. Ann. N.Y. Acad. Sci., 77: 290-351.

Hirano, C. and S. Ishii. (1962). Utilization of dietary carbohydrates and nitrogen by rice stem borer larvae, under axenic conditions. Ent. exp. & appl., 5: 53-59.

*Hiratsuka, E. (1920). Researches on the nutrition of the silkworm. Bull. Ser. Exp. Sta. Japan, 1: 257-315.

Hoekstra, A. and A.M.T. Beenakkers. (1976). Consumption, digestion and utilization of various grasses by fifth instar larvae and adults of the migratory locust. Ent. exp. & appl., 19(2): 130-138.

*House, H.L. (1965). Effects of low levels of nutrient content of a food and of nutrient imbalance on the feeding and the nutrition of a phytophagous larva, Celerio euphorbiae (Linnaeus) (Lepidoptera : Sphingidae). Can. Entomol., 97: 62-68.

Jackson, M.L. (1967). Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, 2nd Edition, pp. 1-498.

Kasting, R. and A.J. McGinnis. (1959). Nutrition of pale western cutworm Agrotis orthogonia (Lepidoptera : Noctuidae). II. Dry matter and nitrogen economy of larvae fed on sprouts of a hard red spring and a durum wheat. Can. J. Zool., 37: 713-720.

Kasting, R. and A.J. McGinnis. (1962). Quantitative relationship between consumption and excretion of dry matter by larvae of pale western cutworm, Agrotis orthogonia Morr. (Lepidoptera: Noctuidae). Can. Entomol., 94: 441-443.

Klein, I. and M. Kogan. (1974). Analysis of food intake, utilisation and growth in phytophagous insects - a computer program. Ann. Ent. Soc. Am., 67(2): 295-297.

Latheef, M.A. and D.G. Harcourt. (1972). A quantitative study of food consumption, assimilation and growth in Leptinotarsa decemlineata (Coleoptera : Chrysomelidae) on two host plants. Can. Entomol., 104: 1271-1276.

*Malenotti, E. (1940). Peach and Pear as regards winter measures against Epidiaspis leperii (Variations in the resistance of this coccid to insecticides due to the food plant). VI Congr. int. Ent. Madrid, 2: 611-619.

McAvoy, T.J. and J.C. Smith. (1979). Feeding and developmental rates of the Mexican bean beetle on soybeans. J. Econ. Entmol., 72(6): 835-836.

McCaffery, A.R., A.G. Cook., W.W. Page and T.J. Perfect. (1978). Utilization of food by Zonocerus variegatus(L. (Orthoptera : Pyrgomorphidae). Bull. Ent. Res., 68(4): 589-606.

McGovern, W.L., G.H. McKibben., W.H. Cross., H.W. Essig and O.H. Lindig. (1976). Boll weevil : Square ingestion and utilization studies. Ann. Ent. Soc. Am., 69(4): 738-739.

McMillan, W.W., K.J. Starks and M.C. Bowman. (1966). Use of plant parts as food by larvae of the corn earworm and fall armyworm. Ann. Ent. Soc. Am., 59: 863-864.

Mehta, R.C. and K.N. Saxena. (1973). Growth of the cotton spotted bollworm, *Earias fabia* (Lepidoptera : Noctuidae) in relation to consumption, nutritive value and utilization of food from various plants. Ent. exp. & appl., 16(1): 20-30.

*Mishra, S.C. (1979). Studies on deterioration of wood by termites. IV. Digestibility and digestion of major wood components by the termite *Neotermes bosei* (Isoptera : Kalotermitidae). Mater. Org., 14(4): 269-277.

*Mishra, S.C. and P.K. Sensarma. (1979). Studies on deterioration of wood by insects. V. Influence of temperature and relative humidity on wood consumption and digestibility in *Neotermes bosei* Snyder. (Isoptera : Kalotermitidae). Mater. Org., 14(4): 279-286.

Ottens, R.J. and J.W. Todd. (1980). Leaf area consumption of cotton, peanuts and soybeans by adult *Graphognathus peregrinus* and *G. leucoloma*. J. Econ. Entomol., 73(1): 55-57.

Pandey, S.N. and R.P. Srivastava. (1967). Growth of larvae of *Prodenia litura* F. in relation to wild food plants. Indian J. Entomol., 29: 229-233.

Phillip, B.M. and A. Jacob. (1980). Effect of granulosis on food consumption, growth rate and utilisation of food by caterpillars of *Pericallia ricini* F. (Arctiidae : Lepidoptera). Entomon, 5(1): 61-63.

Premchand. (1979). Utilization of food by the Bihar hairy caterpillar, Diacrisia obliqua Walker. Indian J. Entomol., 41(3): 237-239.

Premkumar, M., D. Dale and M.R.G.K. Nair. (1977). Consumption, digestion and utilization of food by larvae of Spodoptera litura F. (Lepidoptera : Noctuidae). Entomon, 2: 7-10.

Ramdev, Y.P. and P.J. Rao. (1979). Consumption and utilization of castor, Ricinus communis Linn. by castor semilooper, Achaea janata Linn. Indian J. Entomol., 41(3): 260-266.

Ram, S. and A.K. Bhattacharya. (1978). Consumption of soybean by Diacrisia obliqua Walker. Indian J. Entomol., 40(3): 335-336.

Rao, P.J., T.N.A. Farooqi and K.N. Mehrotra. (1978). Utilization of different feeds for growth by Schistocerca gregaria Forskal hoppers. Indian J. Entomol., 40: 458-460.

Ratan, R. (1978). Consumption, digestion and utilization of food by Acrida exaltata Walk. and A. gigantia Hbst. Indian J. Entomol., 40(3): 277-279.

*Sang, J.H. (1959). Circumstances affecting the nutritional requirements of Drosophila melanogaster. Ann. N.Y. Acad. Sci., 77: 352-365.

Scriber, J.M. (1977). Limiting effects of low leaf water content on the nitrogen utilization, energy budget, and larval growth of Hyalophora cecropia (Lepidoptera : Saturnidae). Oecologia, 28: 269-287.

Scriber, J.M. (1978). The effects of larval feeding specialisation and plant growth form on the consumption and utilization of plant biomass and nitrogen: An ecological consideration. Ent. exp. & appl., 24: 494-510.

Scriber, J.M. (1979 a). The effects of sequentially switching food plants upon biomass and nitrogen utilization by polyphagous and stenophagous Papilio larvae. Ent. exp. & appl., 25: 203-215.

Scriber, J.M. (1979 b). Post ingestive utilization of plant biomass and nitrogen by lepidoptera : Legume feeding by the southern armyworm. Proc. New York Entomol. Soc., 87(2): 141-153.

Scriber, J.M. (1979 c). Effects of leaf water supplementation upon post ingestive nutritional indices of forb-, shrub-, vine-, and tree-feeding lepidoptera. Ent. exp. & appl., 25: 240-252.

Scriber, J.M. and P. Feeny. (1979). Growth of herbivorous caterpillars in relation to feeding specialisation and to the growth forms of their food plants. Ecology, 60(4): 829-850.

*Shiga, M. (1976). A quantitative study on food consumption and growth of the tent caterpillar, Malacosoma neustria testacea Motschulsky (Lepidoptera : Lasiocampidae). Bull. Fruit. Tree. Res. Stn., 3: 67-86.

Singh, H.N. and Byas. (1975). Larval development of Prodenia litura F. in relation to certain cultivated food plants. Indian J. Entomol., 37: 1-6.

Smith, D.S. (1959). Utilization of food plants by the migratory grasshopper, Melanoplus bilituratus (Walker) (Orthoptera : Acrididae), with some observations on the nutritional value of the plants. Ann. Ent. Soc. Am., 52: 674-680.

*Soliman, A.A., Z.M.F. Rostom and A.M.M. Gad. (1974). Effects of different temperatures on the consumption, digestion and utilization of food by the fifth instar larva of the cotton leaf worm, Spodoptera littoralis (Boisd.) (Lepidoptera : Noctuidae). Bull. Soc. Entomol. Egypte, 58: 179-183.

Soo Hoo, C.F. and G. Fraenkel. (1966). The consumption, digestion and utilization of food plants by a polyphagous insect, Prodenia eridania (Cramer). J. Insect Physiol., 12: 711-730.

Taylor, W.E. and R. Bardner. (1968). Leaf injury and food consumption by larvae of Phaedon cochleariae (Coleoptera : Chrysomelidae) and Plutella maculipennis (Lepidoptera : Plutellidae) feeding on turnip and radish. Ent. exp. & appl., 11: 177-184.

Teotia, T.P.S. and Y. Singh. (1975). Studies on growth of population of Corcyra cephalonica Stainton. Indian J. Entomol., 37: 277-285.

*Thomas, E.L. and H.H. Shepard. (1940). The influence of temperature, moisture and food upon the development and survival of the saw-toothed grain beetle. J. Agric. Res. 60(9): 605-615.

Waldbauer, G.P. (1962). The growth and reproduction of maxillectomized tobacco hornworms feeding on normally rejected non-solanaceous plants. Ent. exp. & appl., 5: 147-158.

Waldbauer, G.P. (1964). The consumption, digestion and utilization of solanaceous and non-solanaceous plants by larvae of tobacco hornworm Protoparce sexta (Johan.) (Lepidoptera : Sphingidae). Ent. exp. & appl., 7: 253-269.

Waldbauer, G.P. (1968). The consumption and utilization of food by insects. In Adv. Insect Physiol., 5: 229-288. (Ed. Rockstein, M.). Academic Press, New York.

*Wolcott, G.N. (1937). An animal census of two pastures and a meadow in northern New York. Ecol. Monogr., 7: 1-90.

Woodring, J.P., C.W. Clifford and B.R. Beckman. (1979). Food utilization and metabolic efficiency in larval and adult house crickets. J. Insect Physiol., 25: 903-912.

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* Originals not seen

STUDIES ON THE CONSUMPTION, DIGESTION AND UTILISATION OF FOOD PLANTS BY *Pericallia ricini* (ARCTIIDAE: LEPIDOPTERA)

BY

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ABSTRACT OF A THESIS

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ABSTRACT

The present investigation was carried out in the Entomology Department of the College of Horticulture, Vellanikkara. It was aimed at working out indices relating to consumption, digestion and utilisation of eight food plants by the larvae of *Pericallia ricini* F., a polyphagous pest in Kerala. The study was also meant to assess the relative growth of the caterpillars on the different food plants so that a general idea can be obtained on the suitability of the food plants to the larvae. Data on the pupal and adult emergence were also collected with a view to probing further into the identification of probable insect growth inhibitory substances among the host plants.

The most preferred plants with regard to the consumption of foliage were pumpkin, castor and brinjal. Consumption index was calculated on fresh and dry weight bases. It was seen that the consumption of brinjal leaves was the maximum and the index was the least for sweet potato. The other foods did not differ among them significantly. On dry weight basis, banana-fed

insects with a C.I. of 3.02 ranked first, followed by larvae fed on cotton.

Larval weight gain on brinjal was the maximum followed by those grown on pumpkin. The least weight gain of 0.66 g was exhibited by larvae which were fed on banana leaves.

The last instar larvae consumed the largest quantity of food during their larval period. Consumption of food was very low among the third instar larvae.

Females were seen to consume more foliage than the corresponding male counterparts. The differences in consumption by the two sexes were statistically significant.

The growth rates were calculated both on fresh and dry weight basis. On fresh weight basis, larvae reared on brinjal had the highest growth rate of 65.7 and the least growth rate of 30.7 was obtained from larvae grown on banana. On dry weight basis, it was seen that pumpkin was superior to all others in supporting larval growth of <u>P. ricini</u>.

The approximate digestibility was calculated on the basis of fresh weight of the digestible food and the weight of the ingested food. A.D. was the maximum (91.40 per cent) with sesamum on fresh weight basis, but on dry weight basis, it was castor that the larvae digested most.

Indices relating to efficiencies of converting ingested food and digested food to biomass were also calculated both on fresh and dry weight bases. The reasons for the observed values deviating from the expected ones are discussed.

Utilisation of nitrogen, both ingested and digested, by the larvae varied among food plants significantly. Colocasia, sesamum and cotton had the higher values of E.C.I. (N). in the descending order. But taking into consideration of the E.C.D.(N) values, the numerical figure was the highest with castor and the least with banana.

The present study has clearly indicated that the food plants have a significant effect on the pupal period, pupal weight and pupal length. It is also seen that some host plants cause larval and pupal mortalities at varying degrees.

The effect of larval feeding on the sex ratio of emerging adults was also recorded. Insects fed on castor and cotton leaves showed the near best sex ratio of 1 : 0.88. In the case of sweet potato and sesamum, the ratio was 1 : 2. All other foods led to sex ratios ranging from 1 : 0.67 to 1 : 2.