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Nayan Roy
Ecology Research Unit, M. U. C. Women's College, Department of Zoology, Burdwan, West Bengal, India

Correspondence:
Nayan Roy
Ecology Research Unit, M. U. C. Women's College, Department of Zoology, Burdwan, West Bengal, India

Role of *Chorchorus capsularis* phytochemicals on the feeding dynamics of *Diacrisia casignetum* Kollar (Lepidoptera: Arctiidae)

Nayan Roy

ABSTRACT
The role of jute leaf phytochemicals on feeding, growth and reproduction of *Diacrisia casignetum* Kollar (Lepidoptera: Arctiidae) was studied under laboratory conditions. The larval and post larval developmental duration was shorter on mature jute leaf fed insects whereas adult longevity was higher in it ($P < 0.05$) relative to young and senescent leaf fed insects. Fecundity of *D. casignetum* was also highest on mature leaves followed by young and senescent leaves. The growth and development of *D. casignetum* were related to the nutrient content relative to the secondary metabolites of these three types of jute leaves. Higher levels of nutritional factors (total carbohydrates, proteins, lipids, nitrogen and amino acids including water content) and lower levels of anti-nutritional factors (secondary metabolites) in mature jute leaves have influenced lower developmental time along with higher growth rate, fecundity and accumulated survivability of *D. casignetum* than the young and senescent leaves.

Keywords: Jute, Phytochemicals, *Diacrisia casignetum*, Fecundity, Accumulated survivability

1. Introduction

Jute (Chorchorus capsularis) is a bio-degradable and recyclable natural fiber after cotton. In India, many improved jute varieties belonging to white jute (*C. capsularis*) and tossa jute (*C. olitorius*) are intensively cultivated today. A diverse group of harmful insect species have been associated with this crop yield reduction at different stages worldwide [1, 2]. Among the insect pests, advanced instars of the major defoliator, Diacrisia casignetum (Lepidoptera: Arctiidae), a polyphagous pest, cause severe defoliation in India and many other Asian countries [3, 4]. The chemical signals and nutritional constituents in relation with the secondary metabolites play an important role in the interactions between plants and phytophagous insects [5-13]. The concentration and proportion of nutrients vary considerably within a particular species throughout its different developmental stages, which influences food utilization, development and reproduction of herbivorous insects [10, 14]. Therefore, understanding of fundamental nutritional ecology of *D. casignetum* in relation to the phytochemicals will enhance effective strategies to control this economic pest. The previous study on the biological parameters of *D. casignetum* on sunflower and other host plants indicated influence of phytochemicals on development of this insect pest [3, 4, 14]. Though some transgenic varieties of jute have been developed recently to cope with such hazards of defoliation and yield loss, etc. there is a little account available on the jute variety (cv. Sonali; JRC-321) having any resistance against its major defoliator, *D. casignetum* in the field. Earlier researchers neither designed any experiments to deal with the phytochemical analysis of the cv. Sonali; JRC-321, nor considered to examine the effects of any of the chemicals on its insect pests. It has become imperative now to have a precise knowledge on the phytochemicals present in the cv. Sonali; JRC-321 and to enumerate the impact these chemicals have on the lepidopteran defoliator. The present study is an attempt to analyze the phytochemicals present in the jute leaves and to examine their role in feeding dynamics of the defoliator, *D. casignetum*, which will help in better understanding about host suitability of this insect pest for proper control strategy.

2. Materials and methods

2.1 Plant materials

Three types of fresh jute, *C. capsularis* (cv. Sonali; JRC-321), leaves [young (<1 week), mature (1-3 weeks) and senescent (4-5 weeks)] were collected randomly from jute fields near Chinsurah Rice Research Center (22°53' N, 88°23' E), Hooghly, West

Bengal, India. In Leaves were initially rinsed with distilled water and dried by paper toweling for phytochemical analysis.

2.2 Extraction and phytochemical estimation

The freshly harvested young, mature, and senescent jute leaves were dipped in different solvents for extraction of different primary and secondary biochemicals. Finally, the variability of the phytochemicals present in the three kinds of leaves was estimated by subjecting the fresh undamaged jute leaves to various biochemical analysis, such as total carbohydrates [15], total proteins [16], total lipids [17], total amino acids [18], total nitrogen [19], moisture [20], total phenols [21], total flavonoids [22], tannin [23], saponin [23], alkaloid [24], phytate [25] and oxalate [26]. Determination of each biochemical analysis was repeated for three times.

2.3 Mass culture

Diacrisia casignetum adults (male and female) were originally collected from the same jute field near Chinsurah Rice Research Center and were subsequently reared in cages (60 cm × 60 cm × 60 cm) containing fresh young, mature and senescent *C. capsularis* leaves separately for their oviposition. Two pairs of adults of identical age were released in sterilized glass jars (20 cm × 10 cm) covered with a fine nylon net at 27 ± 0.5 °C, 12 L : 12 D, 65± 5% relative humidity (R. H.). The adults were fed with 10% sucrose solution through a cotton ball in a small Petri dish (1 cm × 0.5 cm). The jute leaves (i.e., young, mature, and senescent leaf) were provided for oviposition separately in different sterilized glass jars. To maintain natural condition of leaves, a moist piece of cotton was placed around the cut ends of leaves followed by wrapping with aluminum foil to prevent moisture loss. Fresh leaves were given daily by replacing the previous ones until eggs were laid by the test insects, and the eggs with each type of jute leaves were placed in new sterilized glass jars separately. *D. casignetum* larvae developed from the eggs were fed with the respective type of jute leaves separately for three generations and from fourth generation onwards, comparative rate of development of this insect on the three types of jute leaves was enumerated depending on the total body weight, survival, food intake and duration of post-embryonic development.

2.4 Food utilization

The weight gain of insects, the weight of food consumed and the weight of faeces produced were determined in a monopan microbalance (± 0.01 mg). Fourth generation larvae of approximately same size were selected and weighed initially and reared separately in separate sterilized glass jars. They were allowed to feed on weighed quantity of three types of jute leaves for 24 h and were reweighed. The fresh weight gain during the period of study was estimated by determining the differences in weight of larvae. The quantity of the food consumed was estimated by determining the difference between the dry weight of diet remaining at the end of each experiment and total dry weight of diet initially provided. All the values were expressed on dry weight basis through dry conversion values as described by Roy and Barik [4]. Twenty larvae were used in each type of jute leaf treatment for each instar with five replicates.

2.5 Food utilization indices

Food utilization indices (on dry weight basis) were calculated by the formulas of Waldbauer [27] with slight modifications [4, 28-30] to assess the feeding efficiencies of *D. casignetum* as follows:

Growth rate (GR)	= P/Q
Consumption rate (CR)	= R/Q
Relative growth rate (RGR)	= P/QS
Consumption index (CI)	= R/QS
Egestion rate (ER)	= T/QS
Host consumption rate (HCR)	= CI+ER
Approximate digestibility (AD) (%)	= 100 (R-T)/R
Efficiency of conversion of ingested food (ECI) (%)	= 100P/R
Efficiency of conversion of digested food (ECD) (%)	= 100P/(R-T)
Host utilization efficiency (HUE) (%)	= 100 R/(R+T)
Hatchability (%)	= 100A/B
Effective rate of rearing (ERR) (%)	= 100C/D
Moth emergence (ME) (%)	= 100E/C
Accumulated survivability (AS) (%)	= Nb% X Na% / 100
Feeding index (FI)	= F/G
Growth index (GI)	= ME%/H

Where, P: dry weight gain of insect; Q: duration of experimental period; R: dry weight of food eaten; S: mean dry weight of insect during time Q; T: dry weight of faeces produced; A: number of eggs hatched; B: number of eggs laid by per female; Na: number of larvae in beginning of instar; Nb: number of larvae in succeeding instar; C: number of cocoons harvested; D: number of last instar larvae reached pupation; E: number of moths emerged; F: pupal weight; G: total weight of food consumed by the larvae H: Duration of immature period.

2.6 Statistical analysis

The data on food utilization indices of *D. casignetum* and biochemical analyses of the three developmental stages of jute leaves were analyzed using one way ANOVA. Means associated with all the data for each variable were separated using Tukey's test (HSD) when significant values were obtained [31].

3. Results

The biochemical analyses of the three types of jute leaves are presented in figure 1. Total carbohydrates, proteins, lipids, nitrogen and moisture content varied significantly among the jute leaves (F2, 6=58.528, 132.037, 67.101, 65.886 and 131.309, respectively, P < 0.0001) (Figure 1). Total amino acid content in mature leaves was highest and significantly differed (F2, 6=32.792, P< 0.001) followed by young and senescent leaves. Among the secondary metabolites, total phenol concentration was lowest in mature leaves and differed significantly (F2, 6=33.831, P < 0.0001) with the other types of jute leaves (Figure 1). Whereas, total flavonoid, saponin and alkaloid concentrations also differed significantly among the three jute leaves (F2, 6= 236.354, 103.939 and 165.258, respectively, P < 0.0001). Tanin, phytate and oxalate content in senescent leaves was highest and significantly differed (F2, 6=228.055, 27.388 and 69.360, respectively, P< 0.001) followed by mature and young leaves (Figure 1). Thus the nutritional factors (primary metabolites) were well balanced with the anti-nutritional factors (Secondary metabolites) in the three types of jute leaves.

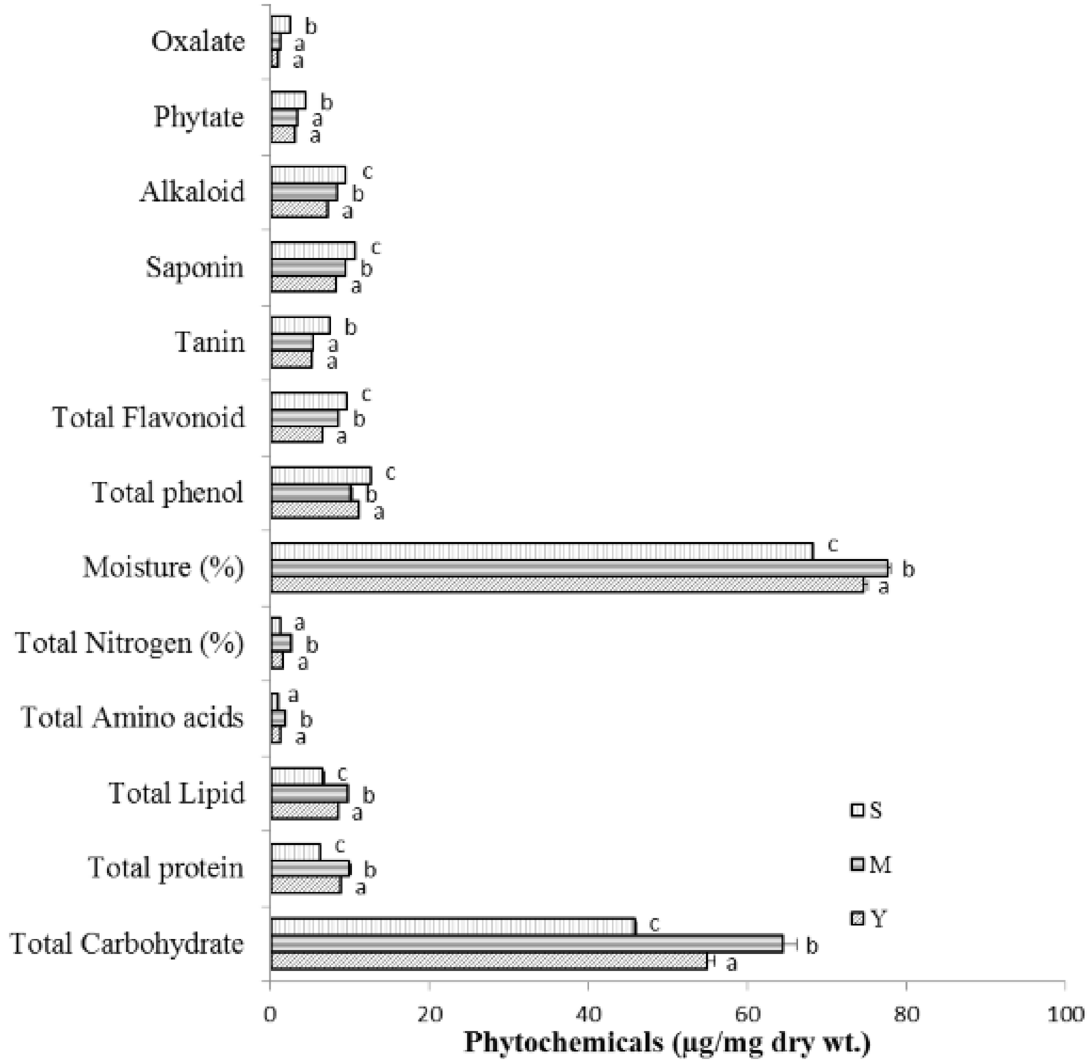

Fig 1: Phytochemical variations of the young (Y), mature (M) and senescent (S) jute leaves. Different letters over the bars indicate that the means (Mean ± SE of 3 observations) are significantly different ($P < 0.05$).

The life cycle and food utilization indices of this moth were investigated in the laboratory by providing three types of jute leaves separately and showed four distinct stages with six larval instars (i.e., egg, larva, pupa, and adult) (Figure 2). As only the larval stages feed on the leaves and defoliate the plants, the food utilization indices were relevant for the six instars which influence total life history parameters of *D. casignetum*. When they were reared on the three types of jute leaves, the significant difference in their food utilization indices ultimately led to the variation in larval duration, fecundity and accumulated survivability of *D. casignetum.*

Food utilization efficiency measures of the all six larval instars of *D. casignetum* are given in Tables 1-6. There were significant differences in all the food utilization indices (GR, CR, RGR, CI, ER, HCR, AD, ECI, ECD and HUE) between all the treatments ($P < 0.05$) and displayed different patterns throughout all instars of *D. casignetum* (Table 1-6). The AD and HUE values were differed significantly on all types of jute leaves, except 1st instar of *D. casignetum.* On the other hand, only the 2nd instar of *D. casignetum* showed significant difference in all indices on three types of leaves, except ECI, ECD and ER values. For all the remaining indices for all instars, except 1st instar, only senescent leaves showed significant difference with the mature and young leaf-fed insects. The GR, CR, RGR, CI, ER and HCR of *D. casignetum*, were significantly higher in insects fed with mature leaves followed by young and senescent leaves ($P < 0.01$) for all six instars (Table 1-6). The AD and HUE values were higher in case of young leaf-fed insects followed by mature and senescent leaves for all instars except, 2nd instar and 1st and 2nd instars, respectively. The ECI and ECD values were always higher in insects fed with senescent leaves followed by mature and young leaves ($P < 0.01$) for all six instars, except 1st instar of *D. casignetum* (Table 1-6).

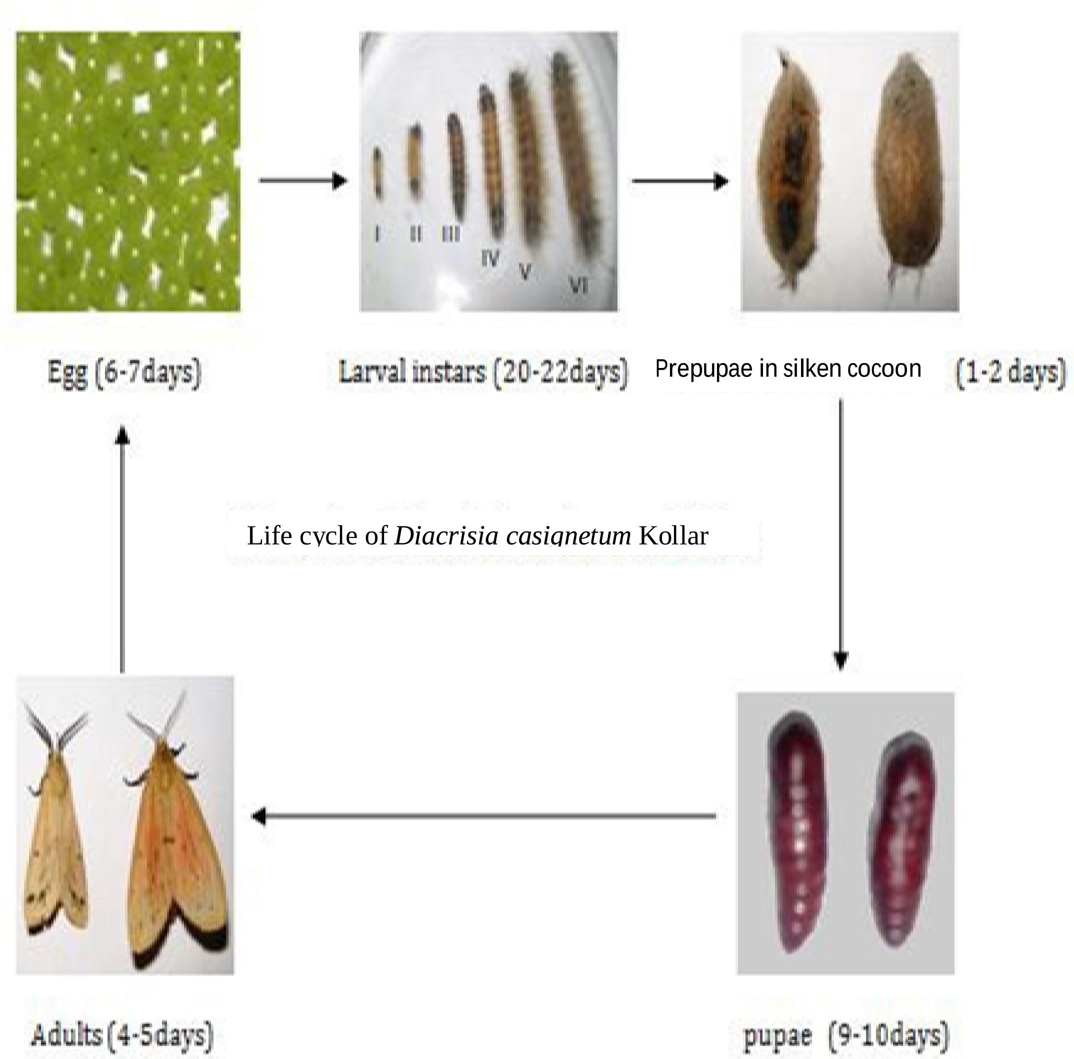

Fig 2: Schematic representation of the life cycle of *D. casignetum* Kollar.

Table 1: Feeding dynamics of first instar larva of *D. casignetum* reared on young, mature and senescent jute leaves.

Parameter	Young	Mature	Senescent	*F*2,6	*P*
GR (mg/day)	0.046±0.006	0.072±0.004a	0.038±0.355	13.713	0.006
CR (mg/day)	5.965±0.160	6.264±0.052	4.514±0.035a	88.781	0.0001
RGR (mg/day)	0.006±0.001	0.014±0.001a	0.004±0.001	27.804	0.001
CI (mg/day)	0.769±0.069	1.290±0.057a	0.537±0.025	50.695	0.0001
ER (mg/day)	0.072±0.005	0.119±0.005a	0.066±0.001	41.741	0.0001
HCR (mg/day)	0.842±0.075	1.409±0.062a	0.603±0.027	50.076	0.0001
AD (%)	90.489±0.242	90.774±0.083	87.649±0.326a	51.897	0.0001
ECI (%)	0.772±0.081	1.153±0.078a	0.849±0.054	7.764	0.022
ECD (%)	0.852±0.087	1.271±0.087a	0.969±0.059	7.418	0.024
HUE (%)	91.316±0.202	91.553±0.069	89.008±0.259a	52.556	0.0001

Mean ± SE of 3 observations. Within the rows means followed by different letters are significantly different ($P < 0.05$).

Table 2: Feeding dynamics of second instar larva of *D. casignetum* reared on young, mature and senescent jute leaves.

Parameter	Young	Mature	Senescent	*F*2,6	*P*
GR (mg/day)	0.391±0.003a	0.434±0.008b	0.355±0.007c	36.803	0.0001
CR (mg/day)	10.150±0.036a	11.159±0.045b	8.053±0.089c	663.719	0.0001
RGR (mg/day)	0.381±0.011a	0.467±0.012b	0.312±0.013c	37.098	0.0001
CI (mg/day)	9.896±0.296a	11.997±0.200b	7.083±0.249c	95.826	0.0001
ER (mg/day)	1.457±0.044	1.669±0.032a	1.306±0.041	20.882	0.002
HCR (mg/day)	11.353±0.338a	13.666±0.223b	8.389±0.291c	84.056	0.0001
AD (%)	85.275±0.141a	86.079±0.208b	81.548±0.071c	255.472	0.0001
ECI (%)	3.855±0.019	3.898±0.080	4.413±0.040a	34.238	0.001
ECD (%)	4.521±0.029	4.529±0.104	5.411±0.044a	57.252	0.0001
HUE (%)	87.165±0.107a	87.781±0.160b	84.423±0.051c	240.344	0.0001

Mean ± SE of 3 observations. Within the rows means followed by different letters are significantly different ($P < 0.05$).

Table 3: Feeding dynamics of third instar larva of *D. casignetum* reared on young, mature and senescent jute leaves.

Parameter	Young	Mature	Senescent	*F*2,6	*P*
GR (mg/day)	0.744±0.003	0.763±0.012	0.662±0.007a	36.84	0.0001
CR (mg/day)	20.106±0.179	20.644±0.206	15.398±0.183a	229.998	0.0001
RGR (mg/day)	2.098±0.015	2.167±0.043	1.706±0.034a	56.923	0.0001
CI (mg/day)	56.638±0.170	58.632±0.664	39.653±0.808a	290.017	0.0001
ER (mg/day)	24.114±0.019a	25.520±0.125b	20.942±0.408c	90.307	0.0001
HCR (mg/day)	80.753±0.169	84.152±0.789	60.596±1.217a	227.956	0.0001
AD (%)	57.423±0.135a	56.466±0.281b	47.185±0.061c	945.023	0.0001
ECI (%)	3.704±0.017	3.696±0.034	4.302±0.016a	202.954	0.0001
ECD (%)	6.450±0.019	6.546±0.038	9.118±0.030a	2415.143	0.0001
HUE (%)	70.138±0.066a	69.670±0.136b	65.438±0.026c	844.821	0.0001

Mean ± SE of 3 observations. Within the rows means followed by different letters are significantly different ($P < 0.05$).

Table 4: Feeding dynamics of fourth instar larva of *D. casignetum* reared on young, mature and senescent jute leaves.

Parameter	Young	Mature	Senescent	*F*2,6	*P*
GR (mg/day)	5.940±0.074	6.171±0.104a	5.698±0.045	9.013	0.016
CR (mg/day)	61.463±0.664	63.207±0.780	48.940±0.308a	162.249	0.0001
RGR (mg/day)	89.836±1.248	93.920±1.709	84.218±0.474a	15.121	0.005
CI (mg/day)	929.462±11.517	961.891±13.181	723.347±2.755a	159.939	0.0001
ER (mg/day)	236.019±2.816a	247.822±3.532b	223.32±0.947c	21.143	0.002
HCR (mg/day)	1165.482±14.244	1209.714±16.663	946.667±3.696a	120.421	0.0001
AD (%)	74.606±0.087a	74.236±0.068b	69.126±0.021c	2196.602	0.0001
ECI (%)	9.665±0.048	9.763±0.057	11.642±0.023a	599.226	0.0001
ECD (%)	12.955±0.079a	13.151±0.070b	16.842±0.039c	1128.901	0.0001
HUE (%)	79.748±0.055a	79.514±0.043b	76.409±0.012c	2033.789	0.0001

Mean ± SE of 3 observations. Within the rows means followed by different letters are significantly different ($P < 0.05$).

Table 5: Feeding dynamics of fifth instar larva of *D. casignetum* reared on young, mature and senescent jute leaves.

Parameter	Young	Mature	Senescent	*F*2,6	*P*
GR (mg/day)	29.422±0.335a	30.695±0.279ab	27.822±0.492ac	14.359	0.005
CR (mg/day)	74.799±0.930	76.765±0.778	58.440±1.064a	116.503	0.0001
RGR (mg/day)	1682.79±18.761a	1760.935±15.278ab	1587.976±29.809ac	15.268	0.004
CI (mg/day)	4278.05±52.105	4403.807±42.729	3335.546±64.262a	117.947	0.0001
ER (mg/day)	1364.125±14.876a	1417.711±14.564ab	1284.265±24.566ac	13.046	0.007
HCR (mg/day)	5642.175±66.936	5821.518±57.273	4619.811±88.802a	80.577	0.0001
AD (%)	68.112±0.051a	67.807±0.027b	61.497±0.041c	8113.538	0.0001
ECI (%)	39.336±0.043a	39.987±0.046b	47.608±0.047c	10033.162	0.0001
ECD (%)	57.752±0.095a	58.972±0.047b	77.415±0.049c	26185.057	0.0001
HUE (%)	75.822±0.029a	75.647±0.015b	72.200±0.021c	7816.783	0.0001

Mean ± SE of 3 observations. Within the rows means followed by different letters are significantly different ($P < 0.05$).

Table 6: Feeding dynamics of sixth instar larva of *D. casignetumm* reared on young, mature and senescent jute leaves.

Parameter	Young	Mature	Senescent	*F*2,6	*P*
GR (mg/day)	6.166±0.065a	6.546±0.062b	5.619±0.086c	41.925	0.0001
CR (mg/day)	32.540±0.308	33.522±0.436	24.686±0.447a	144.682	0.0001
RGR (mg/day)	878.824±9.183a	935.249±8.725b	797.630±12.888c	43.963	0.0001
CI (mg/day)	4637.583±43.468	4789.233±61.492	3504.002±65.539a	148.492	0.0001
ER (mg/day)	2555.163±27.752a	2719.752±24.914b	2353.137±39.945c	33.87	0.001
HCR (mg/day)	7192.746±71.049	7508.986±86.354	5857.140±105.481a	97.591	0.0001
AD (%)	44.904±0.114a	43.205±0.214b	32.839±0.119c	1742.811	0.0001
ECI (%)	18.949±0.021a	19.529±0.071b	22.766±0.111c	710.393	0.0001
ECD (%)	42.200±0.150a	45.205±0.379b	69.327±0.514c	1536.48	0.0001
HUE (%)	64.476±0.047a	63.778±0.087b	59.822±0.042c	1615.429	0.0001

Mean ± SE of 3 observations. Within the rows means followed by different letters are significantly different ($P < 0.05$).

Data on developmental period of *D. casignetum* reared on three types of jute leaves are presented in figure 3. The females laid greenish eggs in masses on the abaxial surface of the jute leaves and larvae passed through six distinct instars along with pre-pupal and pupal stages. The developmental duration (i.e., larval and post larval duration along with the adult longevity) of the different stages of *D. casignetum* on the three types of jute leaves varied significantly ($P < 0.01$) and could be arranged as mature leaves < young leaves < senescent leaves (Figure 3) Whereas, the adult longevity (both male and female) was in the reverse order (Figure 3). The fecundity was always higher in mature leaves (384.666±5.487 eggs/female) and significantly differed ($F_{2,6}=46.563$, $P < 0.0001$) than the other two types of jute leaves (Figure 4). Males always outnumbered the females and the sex ratio (male : female) of *D. casignetum* reared on young, mature and senescent jute leaves was 1.3 : 1, 1.1 : 1 and 1.5 : 1, respectively.

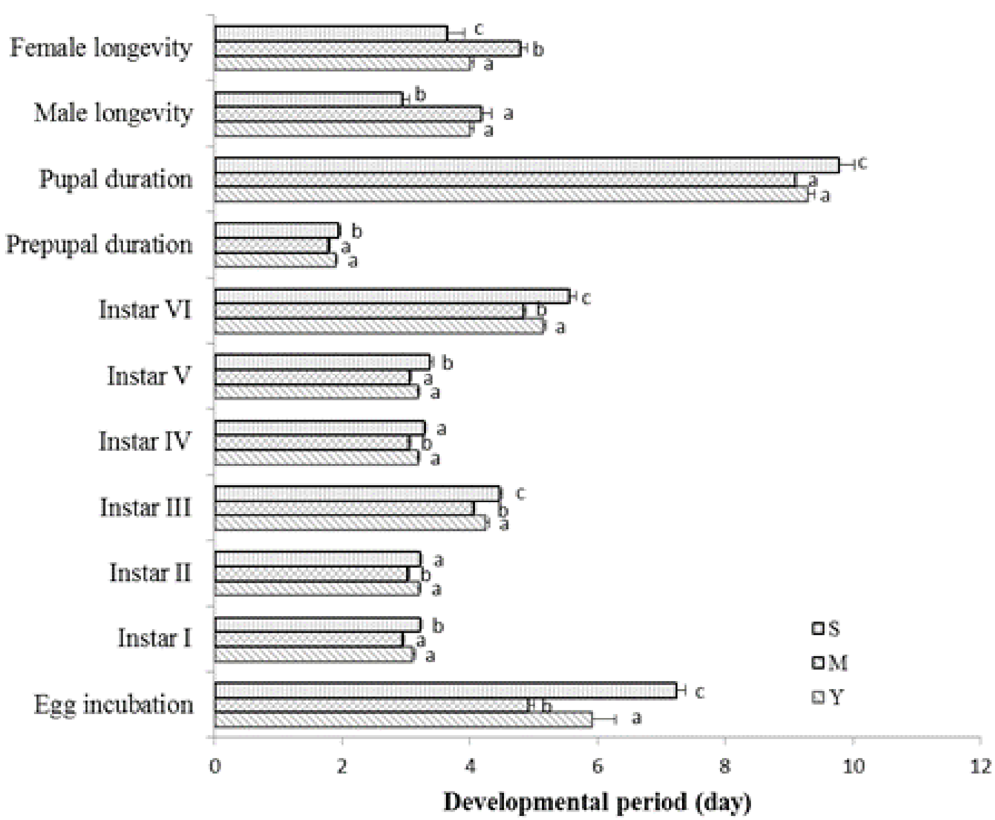

Fig 3: Developmental duration of the different stages of *D. casignetum* reared on young (Y), mature (M) and senescent (S) jute leaves. Different letters over the bars indicate that the means (Mean ± SE of 3 observations) are significantly different ($P < 0.05$), while comparing one type of jute leaf as food with the other within the column.

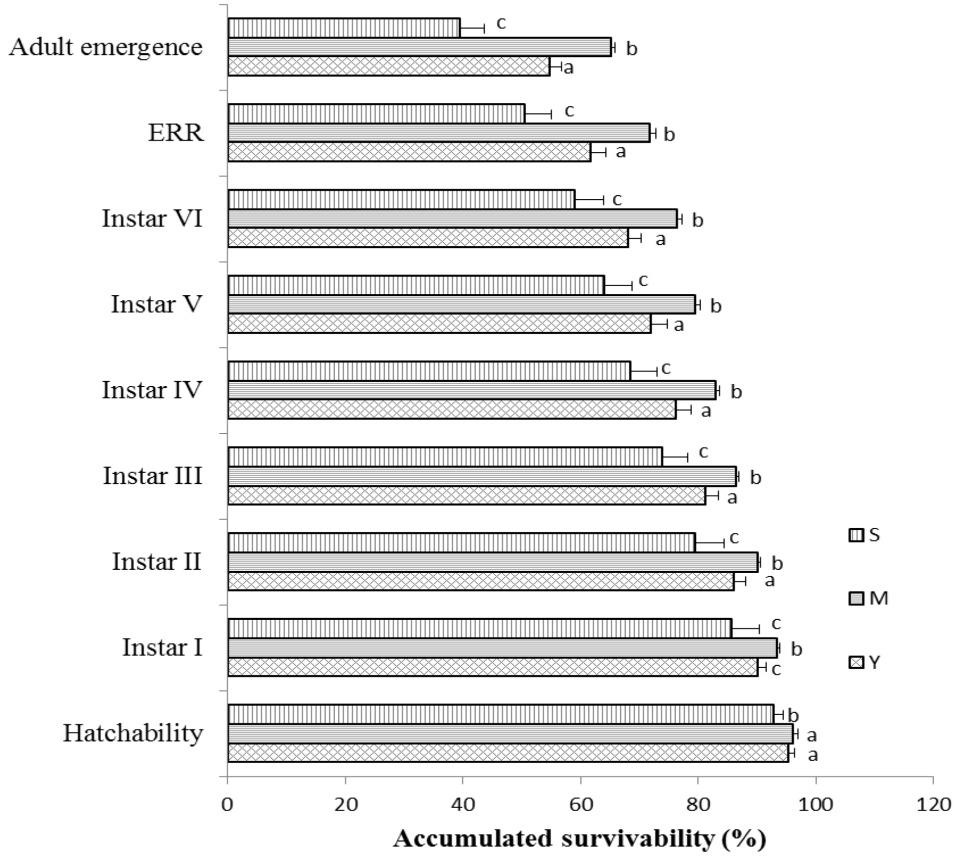

Fig 4: Accumulated survivability (%) of *D. casignetum* reared on young (Y), mature (M) and senescent (S) jute leaves. Different letters over the bars indicate that the means (Mean ± SE of 3 observations) are significantly different ($P < 0.05$), while comparing one type of jute leaf as food with the other within the column.

The hatchability, larval survivability and adult emergence were significantly differed (P <0.05) among the three jute leaves (Figure 5). The overall accumulated survival rate in all the larval stages was greatest when the insects were fed with mature leaves followed by young and senescent leaves ($P < 0.05$) (Figure 5). The ERR was comparatively higher in mature leaves followed by young and senescent leaves ($F2$, 6=11.020, $P < 0.01$) (Figure 5). The emergence of adult moths from the hatched eggs was greatest when the larvae were reared on mature leaves followed by young and senescent leaves ($F2$, 6=21.858, $P < 0.002$) (Figure 5). The feeding index (FI) ($F2$,6=618.239, $P < 0.0001$) and growth index (GI) ($F2$, 6=28.691, $P < 0.001$) significantly differed on the three types of jute leaves (Figure 6). The FI and GI value was higher in insects fed with senescent (0.112±0.001) and mature (2.027±0.011) leaves, respectively (Figure 6).

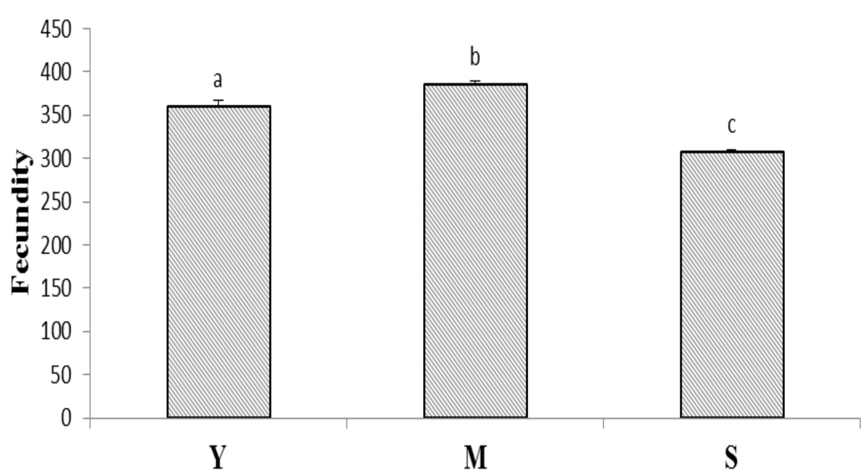

Fig 5: Fecundity of *D. casignetum* reared on young (Y), mature (M) and senescent (S) jute leaves. Different letters over the bars indicate that the means (Mean ± SE of 3 observations) are significantly different ($P < 0.05$), while comparing one type of jute leaf as food with the other within the column.

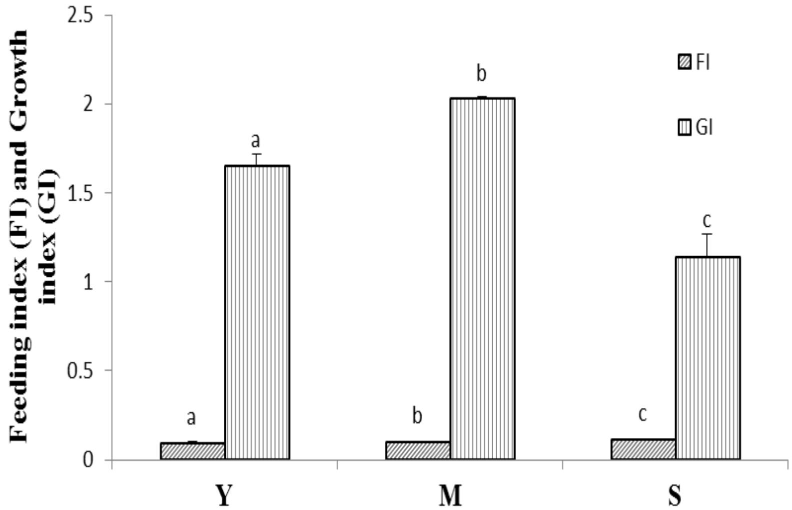

Fig 6: Feeding index (FI) and Growth index (GI) of *D. casignetum* reared on young (Y), mature (M) and senescent (S) jute leaves. Different letters over the bars indicate that the means (Mean ± SE of 3 observations) are significantly different ($P < 0.05$), while comparing one type of jute leaf as food with the other within the column.

In the present study, it was observed that *D. casignetum* showed significant differences in growth rate, consumption rate, utilization efficiency, developmental time and fecundity when reared on young, mature and senescent jute leaves, separately. This was correlated with nutrient constituents of three types of jute leaves as depicted by their biochemical analysis. Hence, higher amount of total carbohydrates, proteins, lipids, nitrogen, amino acids including water and lower amount of total phenols and other secondary chemicals in mature leaves have influenced less developmental time, higher growth rate, higher fecundity and higher accumulated survivability of *D. casignetum* followed by young and senescent jute leaves.

4. Discussion

Phytochemicals are the key factor in nutritional ecology and development of a phytophagous insect [4, 7, 9-11, 13]. Host-plant utilization is influenced by the ability of insect to ingest, assimilate and convert food into body tissues [32-34]. The growth duration such as, developmental time, longevity, fecundity and survival of insects showed significant differences with respect to their food quality [4, 13, 35, 36]. Carbohydrate deficiency results in reduction of general vitality, activity, and growth rate of phytophagous insects though proteins and lipids serve as an alternative source of energy [8, 10, 33]. The protein content of host leaves is generally a limiting factor for the optimal growth of phytophagous insects [7, 10]. Further, growth and reproduction of insects could be explained in part in relation to amino acid composition of diet [8, 10]. During diapause, lipids serve as primary source of energy and also act as precursors of ecdysteroid [37, 38]. Water content in host leaves plays an important role in growth rate of plant-fed caterpillars [5, 7, 39]. Secondary metabolites including Phenols, flavonoids, terpenoids, alkaloids etc. determine the suitability of the substrate for exploitation by the herbivores and thus govern host preferences and acceptability [8, 10, 12]. Consumption of greater amount of secondary chemicals was found to significantly reduce adult longevity, fecundity, and retardation of larval growth [4, 8, 10].

In the present study, all nutritional indices varied when *D. casignetum* fed on the three kinds of jute leaves (Table 1-6). The growth rate (GR) of insects depends on efficiency of conversion of digested food; where as a reduction in ECD indicates higher metabolic maintenance cost [7, 30, 32]. The current data reveal that all the larval instars of *D. casignetum* had higher GR on mature leaves due to good nutritional quality relative to the secondary chemicals (Table 1-6). The consumption rate (CR) of all the instars was lower when feeding on senescent leaves compared to those of mature and young leaves. The other feeding indices are also affected by the jute leaves phytochemicals in relation to efficiency of nutrient digestion or absorption in their nutritional process. Thus, all the instars were efficiently converting mature jute leaf tissues into their biomass along with young leaves due to homeostatic adjustment of consumption rates and other efficiency parameters of the insect for ideal growth and development [4, 40].

The developmental duration of the immature stages of *D. casignetum* was lower on mature leaves, whereas, the adult longevity (both male and female) was higher on mature jute leaves due to the nutritional factors relative to the anti-nutrients than the young and senescent leaves (Figure 3). The food utilization indices also influence survival of *D. casignetum* during their developmental stages like duration of growth and reproduction. Egg survival was highest (96.015%) on mature leaves followed by young (95.353%) and senescent (92.734%) leaves (Figure 4). High survival rate and shorter developmental time indicates better nutritional quality of their larval food in relation to greater amount of carbohydrates, proteins, lipids, and amino acids [7]. These results of this study are also in good agreement with previous work [14] when they were reared on mature leaves followed by young and senescent leaves (Figure 4). Larval dietary nitrogen and adult carbohydrate diets influence the development of male and female reproductive system of lepidopteran insects [41]. Nutrients accumulated during larval feeding including quality and quantity of adult food influence the quality and quantity of eggs laid [6]. Hence, a reduction in larval consumption may result in longer developmental time, smaller size of the adult, and ultimately lower fecundity [7]. The caterpillars of *D. casignetum* reared on mature jute leaves show more fecundity when compared to young and senescent leaves (Figure 5).

Furthermore, the growth index (GI) was higher in mature leaf (Figure 6) than the other two types of leaves due to higher moth emergence with respect to shorter developmental period. Thus, all the feeding indices reveal the suitability of mature jute leaves towards the caterpillars of *D. casignetum* in comparison to other types of jute leaves.

5. Conclusion

The study on *D. casignetum* nutritional ecology in relation to jute leaf constituents reveals the suitability of their larval food for growth, survival and fecundity in laboratory conditions. It can be concluded that mature leaves of jute plant provide the best quality food for proper feeding, growth and development of the major defoliator, *D. casignetum*, because of higher nutritional factors relative to the anti-nutritional secondary metabolites, followed by young and senescent leaves. The study suggests that, *D. casignetum* may be guided by some volatile secondary compounds but their nutritional ecology is controlled by the primary metabolites relative to the secondary ones for better growth and development, thus supporting the hypothesis that polyphagous species prefer mature leaves [10].

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7. References

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