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# Influence of temperature on food consumption and utilization parameters of the common cutworm, *Spodoptera litura* (Fab.) (Lepidoptera: Noctuidae)

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## Abstract
Laboratory experiments were conducted to assess the influence of controlled temperature regimes (20, 25 and 30 ºC) on the nutritional parameters of different host plants (castor, cabbage and tomato) by the last larval instar of *Spodoptera litura* (Fab.) on dry weight basis. The results of the present study indicated that the temperature (30 °C) was favourable for the food consumption and utilization of castor, cabbage and tomato by the 6$^{th}$ instar *S. litura* larva. The pattern of the nutritional indices on the three host plants at 30 ºC revealed high feeding and food assimilation activities as characterized by significantly higher values for relative consumption rate (RCR), relative growth rate index (RGR), the efficiency of conversion of ingested food (ECI) and digested food (ECD). The values of larval approximate digestibility (AD) on the three host plants were significantly higher at 2 5ºC and least at 30ºC. The reduced food consumption and utilization by 6$^{th}$ instar *S. litura* at 20 ºC was evidenced by the low feeding activity as well as the relatively reduced capacity to assimilate the food materials.

**Keywords:** *Spodoptera litura*, temperature, nutritional indices, food consumption, utilization.

## Introduction
The common cutworm, *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae) is a highly polyphagous pest, distributed throughout the tropical and subtropical parts of the world, causing severe damage to more than 290 species of plants belonging to 99 families [24, 26]. About 26 to 100 per cent economic losses by this pest have been reported depending upon the crop stage and its infestation level in the field [1]. Due to its nocturnal habit, high adult mobility and wide host range, *S. litura* has gradually emerged as a devastating pest of field crops in recent years [7].Moreover; it has the characteristic to survive in the soil during cold spells without undergoing diapauses [19]. Thus, *S. litura* has huge potential to invade new areas and has the capacity to adapt to a wide range of ecological situations [8].
Knowledge on host plant-insect interactions is useful for elucidating the suitability of various host plants as food to insect pests [27]. Nutritional indices serve as appropriate tools that could provide a profound understanding of the behavioural and physiological bases of insect-host plant interactions [6]. The rates of food consumption, growth and utilization efficiency are key indicators of herbivore’s performance. The responses of insect herbivores to changes in host plant quality vary in accordance with food sources [3]. From a nutritional point of view, utilization efficiency reflects the quality of food consumed [4].
Temperature plays a critical role in determining the distribution range, development, food consumption and multiplication of insects [8]. Since temperature affects all life processes of insects, it also affects the physiology of food consumption and utilization [10, 22]. As the temperatures rise, the metabolic demands of insects increase exponentially; the insects are likely to fulfill these demands by means of increased food consumption [20]. To manage insects efficiently, it is essential to determine the influence of temperature on its food consumption and utilization parameters. Many studies have focused on the nutritional parameters of *S. litura* on different host plants, including chickpea, mulberry, parthenium, chillies, citrus, castor, tomato, mint, cotton, cabbage, Chinese cabbage, cowpea, sweet potato, and tobacco [1, 9, 23, 27]. There have been a number of studies on the influence of constant temperatures on the nutritional parameters of *Spodoptera littoralis* (Boisd.) larvae on semi-artificial diets [10, 13]. However, the relevant information is scarce on how the nutritional indices of *S. litura* on

various host plants are been influenced at different temperature regimes. Keeping the knowledge gaps in view, the present study was conducted to elucidate the effect of three constant temperatures (20, 25 and 30 ºC) upon food consumption and utilization parameters of final instar *S. litura* larvae on different host plants.

## Materials and methods

Three different host plants were selected for the experiment, namely Cabbage (*Brassica oleracea var. capitata* L., family: Brassicaceae), Castor (*Ricinus communis* L., family: Euphorbiaceae) and Tomato (*Lycopersicum esculentum* Mill, family: Solanaceae). These plants were grown under field conditions without any insecticidal application at Central Research Farm, Krishi Vigyan Kendra, Gayeshpur, West Bengal during October 2016. *S. litura* larvae were obtained from laboratory culture maintained at 28 ± 1 ºC, 60 % RH and 12:12 hr L:D photoperiod on an artificial diet[28].

The experiments on nutritional parameters of *S. litura* were conducted at Directorate of Research, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal. Newly exuviated sixth instar larvae of *S. litura* were utilized for the experiments on nutritional indices. To defecate the larvae, the newly moulted larvae were initially starved for 10 hrs; such that guts of the final instar larvae were almost free of residual fecal material. Each larva was weighed individually. Larvae of approximately similar weight were selected for the experiments. The larvae were equally divided into control and treatment groups. Measurements of the present study were made on dry weight basis. For the control group, five leaves of equal weight collected from each host were taken and air-dried in an oven at 80 ºC. Similarly, five larvae each of equal weight were air dried and considered as control. These were weighed after drying. Leaves of same weight from each of the three host plants (castor, cabbage and tomato) were given to five equal weight larvae maintained at three constant temperatures of 20, 25 and 30 ºC at 60 % RH and 12:12 hr L:D photoperiod; were considered as treatment groups. The larvae were fed with the leaves for 24 hrs. The larvae, remaining leaf tissues after feeding, and faeces for each treatment were air dried at 80 ºC. The dried larvae, leaf tissues and faeces were weighed. The nutritional indices of *S. litura* larvae were calculated based on the dry weights using the formulae [25]:

- Relative growth rate = (D-C)/ [(C+D)/2]
- Relative consumption rate = (A-B)/ [(C+D)/2]
- % Efficiency of conversion of ingested food = [(D-C)/ (A-B)] ×100
- % Efficiency of conversion of digested food = [(D-C)/ (A-B-E)] ×100%)
- Approximate digestibility = [(A-B-E)/ (A-B)] ×100

(Where A is the weight of dried leaf tissues in the control, B is the weight of the dried leaf tissue in each treatment, C is the weight of dried larvae in the control, D is the weight of dried larvae in each treatment, and E is the weight of dried faeces in each treatment).

The data on nutritional indices of final instar *S. litura* larvae on different host plants were analyzed with SPSS (version 22.0: Inc., Chicago, IL, USA) software to compute ANOVA for testing the significance of differences among different temperature regimes using completely randomized design (CRD). The significance of differences was tested by F-tests, and the significance of differences between treatment means was compared using Tukey's HSD test ($P<0.05$). All data were checked for normality prior to statistical analysis.

## Results and Discussion

The results of the nutritional indices of 6th larval instar of *S. litura* are shown in Table 1. Food consumption and utilization parameters of *S. litura* differed significantly among the tested temperature regimes for different host plants ($P<0.05$). The larvae reared on castor leaves at 30 ºC exhibited the highest values of relative consumption rate (1.41), followed by that on 25 ºC (1.27) (F=206.40; df=2,12; $p<0.0001$). While the lowest value of relative consumption rate (1.25) was at 20 ºC. The relative consumption rate (RCR) on cabbage was highest for *S. litura* larvae reared at 30 ºC (1.13), followed by 25 ºC (1.11) and 20 ºC (1.09) ($F=10.82$; df=2,12; $p=0.002$). The relative consumption rate at 30 ºC (1.09) and 25 ºC (1.07) were higher than that at 20 ºC (1.03) ($F=23.66$; df=2,12; $p<0.0001$) when larvae were fed on tomato. Similarly, the relative growth rate (RGR) of *S. litura* larvae was highest on castor (0.31) ($F=297.31$; df=2,12; $p<0.0001$), cabbage (0.24) ($F=272.60$; df=2,12; $p<0.0001$) and tomato (0.22) ($F=347.87$; df=2,12; $p<0.0001$) when reared at 30 ºC. The lowest rates of relative larval growth were recorded on castor (0.10), cabbage (0.07) and tomato (0.05) at 20 ºC. However, the lowest value of approximate digestibility (AD) was for larvae reared on castor at 30 ºC (28.98). While the significantly higher value of approximate digestibility was recorded for larvae reared on castor at 25 ºC (46.89) followed by 20 ºC (37.56) (F=59.02; df=2,12; $p<0.0001$). The approximate digestibility of *S. litura* was highest on cabbage (43.91) (F=4.52; df=2,12; $p=0.034$) and tomato (47.54) (F=14.56; df=2,12; $p=0.001$) at 25 ºC, followed by the other tested temperatures (Table 1).

The efficiency of conversion of ingested food (ECI) and digested food (ECD) of *S. litura* larvae on the three host plants differed significantly among the three constant temperatures (Table 1). The highest (22.19) and lowest (13.21) ECI values (F=147.98, df=2,12; $p<0.0001$) were for those 6th instar *S. litura* larvae reared on castor at 30 and 25 ºC, respectively. In the case of cabbage, the larvae reared at 30 and 25 ºC had the highest (20.64) and lowest (11.41) values of ECI, respectively ($F=267.88$; df=2,12; $p<0.0001$). A similar trend of ECI values was observed for tomato at the three tested temperatures, with significant differences ($F=314.26$; df=2,12; $p<0.0001$). The highest value of ECD (46.56) and lowest one (25.11) (F=301.62, df=2,12; $p<0.0001$) were observed for *S. litura* larvae reared on castor at 30 and 25 ºC, respectively. Our results indicated also that, the highest (45.88) and lowest (23.99) values of ECD ($F=924.60$; df=2,12; $p<0.0001$) were for larvae reared on cabbage at the 30 and 25 ºC respectively. The 6th instar *S. litura* larvae showed the highest (38.00) and lowest (20.65) values of ECD ($F=633.75$, df=2,12; $p<0.0001$) at 30 and 25 ºC, respectively.

The results of the present investigation on nutritional parameters of 6th instar *S. litura* larva are in conformity with the findings of previous studies on the effects of food consumption and utilization parameters of *S. littoralis* larvae on a semi-artificial diet at different tested temperature conditions [10, 13]. The relative consumption rate (RCR) calculated from the dry weight of food consumed by *S. litura* is an indicator of its relative intake of nutrients. Relative growth rates (RGR) describes the physiological capacity of *S. litura* to convert food material into biomass. RGR is positively correlated with temperature which supports our findings [10]. Both of relative consumption rates and relative growth rates were observed to be significantly higher at 30 ºC in comparison with those reared at 20 and 25 ºC on castor, cabbage and tomato. However, the values of larval approximate digestibility on the three host plants were significantly higher at 25 ºC and least at 30 ºC. It may be apprehended that the low approximate digestibility (AD) of *S. litura* larvae on the three host plants at 30 ºC was perhaps compensated by higher values of the efficiency of conversion of ingested food (ECI) and digested food (ECD). ECI is an index of an insect's ability to utilize the food consumed for growth and development, while ECD is a general index of the efficiency of conversion of digested food into biomass [19]. The significant decline in AD at 30 ºC was perhaps due to the combination of the highest RCR and a quick food passage through the insect gut [10]. Conversely, the poor food assimilation activity by *S. litura* larvae at 25 ºC seems to be compensated by significantly higher approximate digestibility. The food consumption and utilization by 6th instar *S. litura* on various host plants at 20 ºC were characterized by the low feeding activity as well as the relatively reduced capacity to assimilate the food materials.

Moreover, our findings on nutritional indices of *S. litura* on castor, cabbage and tomato are in consistent with previous studies [9]. Previous studies revealed castor as the most preferred host plant for fifth instar *S. litura* larvae in comparison with tomato, cabbage, cotton and mint [9]. *S. litura* larvae reared on castor leaves exhibited significantly higher values of dry weight gain, AD, ECI and ECD. High larval performance of *S. litura* on castor due to higher nitrogen content and lower phenolics: nitrogen ratio in leaves has been reported [9]. Dry weight gain and ECI values of *S. litura* did not differ significantly when reared on tomato and cabbage leaves [9]. However, the least efficiency of conversion of digested food for *S litura* was observed on castor in comparison with chickpea, mulberry, parthenium and chilli; although the relative consumption rate was high on castor [1]. Studies on nutritional indices of *Spodoptera exigua* (Hübner) on tomato, exhibited significantly lower values of ECI and ECD as compared to pepper [18]. The final instar of *Helicoverpa armigera* (Hübner) exhibited the lowest ECD and ECI values on tomato cultivar-Meshkin, possibly due to the lack of nutritional components and the presence of some secondary chemicals [11]. The low protein content of tomato has been reported to affect the larval performance of *H. armigera* [14]. Significant negative correlation between ortho–dihydroxy phenols in tomato leaves and larval feeding rate has also been demonstrated [5]. Acidity factor in tomato leaves may be negatively correlated with larval feeding [12]. Leaf texture, nutritional quality and secondary metabolic content may have influenced low feeding activity of *S. litura* larva on cabbage [6, 15, 16]. However, experiments on the nutritional indices of third to fifth larval instars of *Pieris brassicae* L. indicated that white cabbage was nutritionally rich food as evidenced by significantly higher values of ECI and ECD among brassicas [17].

**Table 1:** Nutritional parameters of *S. litura* on various host plants at different temperature regimes

| Trail | Host plant | Temperature (ºC) | | | $F_{2,12}$ | P value |
|---|---|---|---|---|---|---|
| | | 20 | 25 | 30 | | |
| Relative consumption rate (RCR) | Castor | 1.25±0.11$^{b}$ | 1.27±0.18$^{b}$ | 1.41±0.12$^{a}$ | 206.40 | <0.0001 |
| | Cabbage | 1.09±0.13$^{b}$ | 1.11±0.12$^{ab}$ | 1.13±0.10$^{a}$ | 10.82 | 0.002 |
| | Tomato | 1.03±0.13$^{b}$ | 1.07±0.11$^{a}$ | 1.09±0.11$^{a}$ | 23.66 | <0.0001 |
| Relative growth rate (RGR) | Castor | 0.10±0.01$^{c}$ | 0.22±0.02$^{b}$ | 0.31±0.02$^{a}$ | 297.31 | <0.0001 |
| | Cabbage | 0.07±0.01$^{c}$ | 0.15±0.01$^{b}$ | 0.24±0.02$^{a}$ | 272.60 | <0.0001 |
| | Tomato | 0.05±0.01$^{c}$ | 0.13±0.02$^{b}$ | 0.22±0.03$^{a}$ | 347.87 | <0.0001 |
| Efficiency of conversion of ingested food (ECI) | Castor | 17.69±0.30$^{b}$ | 13.21±0.50$^{c}$ | 22.19±0.26$^{a}$ | 147.98 | <0.0001 |
| | Cabbage | 16.50±0.26$^{b}$ | 11.41±0.31$^{c}$ | 20.64±0.42$^{a}$ | 267.88 | <0.0001 |
| | Tomato | 15.89±0.28$^{b}$ | 12.71±0.31$^{c}$ | 19.32±0.32$^{a}$ | 314.26 | <0.0001 |
| Efficiency of conversion of digested food (ECD) | Castor | 38.00±1.03$^{b}$ | 25.11±1.21$^{c}$ | 46.56±0.69$^{a}$ | 301.62 | <0.0001 |
| | Cabbage | 31.65±0.53$^{b}$ | 23.99±0.65$^{c}$ | 45.88±0.34$^{a}$ | 924.60 | <0.0001 |
| | Tomato | 29.39±0.74$^{b}$ | 20.65±0.68$^{c}$ | 38.00±0.29$^{a}$ | 633.75 | <0.0001 |
| Approximate digestibility (AD) | Castor | 37.56±0.47$^{b}$ | 46.89±0.40$^{a}$ | 28.98±0.17$^{c}$ | 59.02 | <0.0001 |
| | Cabbage | 33.45±0.25$^{ab}$ | 43.91±0.70$^{a}$ | 30.93±0.56$^{b}$ | 4.52 | 0.034 |
| | Tomato | 33.43±0.66$^{b}$ | 47.54±0.37$^{a}$ | 32.84±0.32$^{b}$ | 14.56 | 0.001 |

Means (±SE) within a row followed by the same letter are not significantly different ($P$ <0.05)

## Conclusion

It can be concluded that the temperature change has a direct impact on nutritional parameters of *S. litura* on various host plants. The tested temperature (30 ºC) was most favourable for the food consumption and utilization of castor, cabbage and tomato by final instar *S. litura* larva as evidenced by higher values of RCR, RGR, ECI and ECD; largely due to its relatively higher feeding and highest efficiency of conversion of digested food into biomass at 30 ºC. Moreover, based on nutritional requirements of *S. litura*, the three host plants were ranked as castor > cabbage > tomato in suitability. The present study may provide useful information for developing forecasting models and implementing a timely intervention for the management of *S. litura* on field crops.

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**Author Contributions:** Both the authors have contributed equally

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