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Influence of the leaf extracts of lotus, *Nelumbo nucifera* G. on nutritional indices of tobacco caterpillar, *Spodoptera litura* Fab.

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Abstract
An experiment conducted to assess the effect of *Nelumbo nucifera* leaf extract on nutritional indices of *Spodoptera litura* at various concentrations, showed that 10 & 15% leaf extracts of *N. nucifera* had influence on growth rate, consumption index, approximate digestibility and efficiency of conversion of digested and ingested food. *N.nucifera* leaf extract @ 5% concentration showed very low influence on nutritional indices and it was more or less similar to untreated castor discs. 5% concentration had no antifeedant effect and 10 &15% of the extract had high influence on nutritional indices and confirmed as strong antifeedant.

Keywords: *Nelumbo nucifera*, lotus, Nutritional indices, *S.litura*

Introduction
Spodoptera litura (F.) a polyphagous pest, seasonally common in agro-eco systems, is called as common cut worm, cotton leaf worm, tobacco cutworm and tropical armyworm. This noctuid insect cause a severe damage in tobacco, cotton, tomato, corn, potato, groundnut *etc.*, including plantation and forest crops, which results in significant yield reduction and in few occasions total crop failure experienced. Thus farmers use increased doses of insecticides to manage *S.litura* which in turn ended with resistance, resurgence and intolerable food residue. As an alternate to chemical insecticides, researchers shown interest on botanicals which were used traditionally. Phyto-insecticides posses numerous modes of action against the target insects and is the most desired quality in pest management. Further the activity of botanicals in insect physiology is dose dependent. Kamaraj *et al.* (2011) [4]. recorded cent per cent mortality of *A.stephensi* and *C.quinquefasciatus* when treated with ethyl acetate and methanol based leaf extract of *N.nucifera* at 500 ppm. Santhoshkumar *et al.* (2011) [4, 8]. reported that highest mortality was found in methanol, aqueous and synthesized AgNPs against the larvae of *A.subpictus* and *C.quinquefasciatus* at the rate of LC_{50}=8.89,11.82 & 0.69 ppm, LC_{90}= 28.65, 36.06 & 2.15 ppm and LC_{50}= 9.51, 13.65 and 1.10 ppm, LC_{90}= 28.13,35.83 and 3.59 ppm respectively. Anushree *et al.* (2015) also reported the larvicidal action of seed coat extract of *Nelumbo nucifera* against *A.stephensi* at 5 % concentration. To identify the dose dependent activity of lotus leaf extract, studies were carried out on various parameters of nutrition indices.

Materials and Methods
Culturing of *Spodoptera litura*
Larvae of *S.litura* were reared on castor leaves up to second instar and then on Bengal gram flour based semi synthetic diet up to pupation. Culturing was initiated with egg masses collected from the field in and around Annamalainagar. Larvae hatched out from the collected egg masses were transferred on castor leaves *Ricinus communis* L. and kept aside a plastic container of 10 L. capacity and covered with muslin cloth. Fresh leaves of castor were supplied daily and the old leaves were removed. When the caterpillars became third instar, they were transferred onto semi synthetic diet.
Third instar onwards larvae of *S. litura* were maintained on Bengal gram based semi synthetic diet. Cut pieces of semi synthetic diet were placed on iron stands and kept inside the plastic containers (10 L. capacities) which were filled with sterilized sand up to 15 cm. height. Twenty five larvae were released per container and covered with the lid fitted with muslin cloth (Selvamuthukumaran, 2009) [9].
Pieces of fresh diet were provided once in three days and pupation took place in the sand layer provided. Pupae were collected and washed with 1% formaldehyde solution, sexed and transferred into oviposition cages (1'x1'x1') at the rate of ten pairs per cage. After adult emergence, 10% honey solution fortified with vitamin E provided as adult food in a cotton wig. Then a *Nerium oleander* twigs (petiole immersed in water) were kept inside the cage which acted as oviposition substrate. Eggs laid were collected daily, washed with 0.05 % sodium hypochlorite solution and incubated. The hatched neonates were transferred to castor leaves and recycled. Rearing was done at 24 ± 2°C and 70 ± 5% RH.

Preparations of Water extract of *N.nucifera*
The fresh leaves of *N.nucifera* collected from the pond in the University campus were washed thoroughly with tap water and then distilled water. Then the leaves were dried under shade for about two weeks and finely ground with electric blender. The leaf powder was weighed, made into thimbles using Whatman No 40 filter paper and soaked for 48 h in known quantity of distilled water. The content recovered from extraction was filtered and used in the studies. 5, 10 and 15% concentrations were prepared by dilution.

Studies on nutritional indices

Castor leaf discs (4cm dia) treated on both the sides with 5, 10 and 15% concentration of *N.nucifera* leaf extract separately were kept individually in plastic containers (200ml capacity). Third instars of *S.litura* which weighed individually were released into the container @ one/ container and reared for 3 days by giving treated leaf discs. Each treatment was replicated 10 times and treated leaf discs were replaced once in 12 h. The fresh leaf discs and larvae were weighed prior to treatment and then unfed leaf discs, faeces were collected once in 12 h and dried and weighed immediately. On third day, the experiment was terminated and the larvae were dried and weighed. Nutritional indices of food consumption and utilization were calculated as proposed by Waldbauer (1968) [10].

$$\text{Approximate digestibility (AD)} = \frac{\text{Weight of food ingested} - \text{weight of faeces}}{\text{Weight of food ingested}} \times 100$$

$$\text{Efficiency of conversion of digested food into body matter (ECD)} = \frac{\text{Larva weight gained during feeding period}}{\text{Weight of food ingested} - \text{weight of faeces}} \times 100$$

$$\text{Consumption rate (CR)} = \frac{\text{Weight of food consumed}}{\text{Duration of feeding period}}$$

$$\text{Approximate digestibility (AD)} = \frac{\text{Weight of food ingested} - \text{weight of faeces}}{\text{Weight of food ingested}} \times 100$$

$$\text{Efficiency of conversion of digested food into body matter (ECD)} = \frac{\text{Larva weight gained during feeding period}}{\text{Weight of food ingested} - \text{weight of faeces}} \times 100$$

$$\text{Efficiency of conversion of ingested food into body matter (ECI)} = \frac{\text{Larva weight gained during feeding period}}{\text{Weight of food consumed}} \times 100$$

Result and Discussions

Relative growth rate (RGR)

The RGR value was highest in the larvae fed on castor leaf discs (0.245). The larvae fed on castor leaf discs treated with 5% *N.nucifera* leaf extract exerted 0.196 of relative growth rate. The lowest RGR (0.098) was in larvae fed on castor leaf discs treated with 15% *N.nucifera* leaf extract. Lower RGR value indicates lower speed in the development. Thus, it is evident that 10 and 15% concentrations of *N.nucifera* leaf extracts reduced the speed of development and 5% did not inhibit the speed of development. However the quantity of dry matter increased per day per gram of body weight was reduced in 10 and 15%. Daniel and Samiayyan (2017) [1]. recorded higher growth rate of *S.litura* on castor (0.45). Narvekar *et al.* (2018) [6]. quoted castor as the best host for *S.litura* and increases the growth rate sufficiently. In general RGR have direct link with ECI.

Relative consumption Index (RCI)

Relative consumption index is the indicator of the rate of food intake and relative to the mean larval weight during the feeding period. It was shown that the highest RCI was noticed in the larvae fed on castor (1.711) and followed by the larvae fed on treated castor discs @ 5 and 10% which recorded the RCI as 1.470 and 1.393 respectively. The lowest consumption rate of 1.253 was observed @ 15%. Daniel and Samiayyan (2017) [1]. recorded average consumption index of *S.litura* grown on chickpea, mulberry, parthenium, castor and chillies were 3.88, 3.34, 3.26, 3.07 and 2.87. Our findings explained that, the increased dose (15%) of *N.nucifera* leaf extracts reduced the consumption index.

Consumption rate (CR)

Narvekar *et al.* (2018) [6]. reported the consumption rate of third instar larvae of *S.litura* on castor as 0.92. It is accordance with our present findings that the CR when fed on castor was 1.05 and on *N.nucifera* 5% leaf extract treated disc was 0.90. At 10% extract the CR was 0.85. Higher concentration of 15% showed lower consumption rate (0.76). Consumption rate is the concept related to host preference in general and the results showed that the leaf discs treated with 10 and 15% concentrations of leaf extract of *N.nucifera* were not preferred. It is the indication of antifeedant effect.

Approximate Digestibility (AD)

The amount food digested from the amount of food ingested is shown by approximate digestibility. Highest approximate digestibility of 92.7 was seen in castor fed larvae and the AD of 89.3 per cent was seen in *N. nucifera* leaf extract @ 5%. Daniel and Samiayyan (2017) [1]. observed that, rearing of *S.litura* on castor had 89.3 per cent AD. According to Nesari *et al.* (2016), the digestibility rate of *S.litura* on beetroot was 85.41 per cent. Narvekar *et al.* (2018) [6]. recorded AD was highest on taro (98.82%) and lowest in castor (95.01%).

Efficiency of conversion of digested food (ECD)

The assimilation of food is converted into insect biomass is called efficiency of conversion of digested food. The tabled data revealed that, castor fed larvae had highest ECD (16.42) and 15.38% of ECD was noticed in the larvae exposed to treated food @5% concentration. Narvekar *et al.* (2018) [6]. reported 23.14% ECD for *S.litura* fed on castor. The concentrations 10 and 15% explored 8.78 and 8.63% ECD. Khedr *et al.* (2015) [5]. reported that the conversion rate of digested food of *S. littorolis* on different cultivars of soybean exerted 22.34, 25.34 and 28.94% and Xue *et al.* (2010) [11]. observed ECD of *S.litura* was 24.36, 21.77, 44 and 72.60 % on Chinese cabbage, cowpea, sweet potato and tobacco respectively.

Efficiency of conversion of ingested food (ECI)

Efficiency of conversion of ingested food value is an indication of conversion of overall ingested food into various nutrients. The high ECI of 19.49 was noticed in larvae fed with castor and followed by 13.33% @ 5% concentrations and the lowest rate of ECI (7.6%) was obtained at 15% concentration. Daniel and Samiayyan (2017) [1]. reported that the higher ingested food conversion rate of *S.litura* reared on castor had 15.70.

The report of Narvekar *et al.* (2018) [6]. showed 21.82% ECI when *S.litura* fed on castor. Xue *et al.* (2010) [11]. reported that the ECI of *S.litura* on tobacco was 29.75% and followed by 17.85 and 14.04 on Chinese cabbage and cowpea. In our study, it was evident that the *N.nucifera* leaf extract treated diet reduced the ECI of *S.litura*.

Table 1: Effect of different concentrations of *N.nucifera* leaf extracts on nutritional indices of *S.litura*

Treatment	Nutritional indices					
	Relative growth rate (RGR)	**Relative Consumption index (RCI)**	**Consumption rate (CR)**	**Approximate digestibility (AD)**	**Efficiency of conversion of digested food (ECD)**	**Efficiency of conversion of ingested food (ECI)**
N.nucifera leaf extract 5 %	0.196 (0.193)^{c}	1.470 (1.572)^{c}	0.90 (1.377)$^{b\ c}$	89.3 (70.878)^{c}	15.38 (23.22)^{b}	13.3 (21.380)^{c}
N.nucifera leaf extract 10 %	0.106 (1.051)^{b}	1.393 (1.547)^{b}	0.85 (1.360)^{b}	85.9 (67.781)^{b}	8.78 (17.229)^{a}	7.81 (16.232)^{b}
N.nucifera leaf extract 15 %	0.098 (1.047)^{a}	1.253 (1.501)^{a}	0.76 (1.323)^{a}	82.4 (65.069)^{a}	8.63 (17.067)^{a}	7.60 (15.996)^{a}
Castor	0.245 (1.116)$^{c\ d}$	1.711 (1.646)^{d}	1.05 (1.432)^{d}	92.7 (74.185)^{d}	16.42 (28.890)^{c}	19.49 (26.180)^{d}
CD	0.006	0.001	0.006	0.212	0.242	0.082

Conclusion

It is concluded that the effect of leaf extracts of *N.nucifera* at various concentrations had influence on the nutritional indices of *S.litura*. *N.nucifera* leaf extract @ 5% concentration when applied over the castor leaf discs and fed to third instar of *S.litura*, showed very low influence on nutritional indices. The data related to 5% extract treated discs and untreated castor discs were more or less similar. This shows that 5% concentration had no antifeedant effect. Higher concentrations (10 &15%) of the extract had high influence on nutritional indices and confirmed as strong antifeedant.

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