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Biology and life table study of *Spilarctia obliqua* Walker (Arctiidae: Lepidoptera) on different bast fibre crops

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ABSTRACT

The influence of different bast fibre crops i.e. jute (*Corchorus olitorius* and *C. capsularis*), mesta (*Hibiscus sabdariffa* and *H. cannabinus*), ramie (*Boehmeria nivea*) and sunnhemp (*Crotalaria juncea*) on biology and life table parameters of jute hairy caterpillar, *Spilarctia obliqua* Walker was carried out to understand the host suitability under laboratory condition. Adult longevity and fecundity of *S. obliqua* and its life table parameters were differed significantly with bast fibre crops. The larval, pupal period and adult longevity of *S. obliqua* were shortest on *C. olitorius* and longest on *H. sabdariffa*. The larval survival and adult fecundity (eggs/female) significantly highest (80.68 ± 1.41%, 477.00 ± 21.12 eggs) in *C. olitorius* and the lowest (53.92 ± 1.20%, 260.00 ± 21.41 eggs) was on *H. sabdariffa*, respectively. The net reproductive rate was higher on *C. olitorius* (384.84 ± 21.56 females/female/generation) and minimum (163.80 ± 14.65 females/female/generation) on *H. sabdariffa*. The intrinsic rate of natural increase was higher on *C. olitorius* (0.15 ± 0.00 females/female/day) and lowest (0.12 ± 0.00 females/female/day) on *H. cannabinus*. The study indicated that *C. olitorius* was the most suitable host as compared to other crops for *S. obliqua* growth and reproduction.

Key words : Bast fibre crops, Bihar hairy caterpillar, biology, life table.

INTRODUCTION

Spilarctia (=*Spilosoma*) *obliqua* Walker (Arctiidae: Lepidoptera) is popularly known as jute hairy caterpillar in India. It is highly polyphgaous and cosmopolitan insect pest and it attacks pulses, oilseeds, cereals, vegetables, mulberry, medicinal, aromatic plants and bast fibre crops such as jute (*Corchorus olitorius* and *C. capsularis*), mesta (*Hibiscus sabdariffa* and *H. cannabinus*, ramie (*Boehmeria nivea*) and sunnhemp (*Crotalaria juncea*) and often causes severe economic damage. There are several constraints in increasing the productivity of fibre crops, of which the losses due to insect pests is one of the major concern. Among the insect, *S. obliqua* is one of the major which causing substantial yield loss as well as fibre quality (Satpathy *et al.*, 2013). Timely management of this pest is very important as delay may lead to even complete defoliation of crop. Although many insecticides are effective against this pest, chemical control is not desirable and moreover, the acute toxicity and relative resistance of *S. obliqua* to chemical pesticides were also reported (Dhingra *et al.*, 2007). Identifying the mechanisms of resistance, proper selection of resistant genotypes can be used in plants breeding programs (Li *et al.*, 2004). Host plant availability and quality is a key determinant of herbivorous insect population dynamics including fecundity, growth rate, and development of insect and adult performance (Awmack and Leather, 2002; Roy, 2015). The interaction between adult preference and progeny performance, development, survival, and fecundity of phytophagous insects is mainly due to variation in qualitative and quantitative amounts of nutrients in the host plants (Rios *et al.*, 2013; Du Plessis *et al.*, 2015).

Insect life tables are powerful tools ecological research for analyzing and understanding the impact that has an effect on the growth, survival, reproduction, predicting life history evolution and outbreaks, life expectancy and rate of increase of an insect population (Ali and Rizvi, 2007; Soleimannejad *et al.*, 2010) and important in the measurement of population growth capacity of species under specified conditions (Southwood and Henderson, 2000). Currently life tables are generally constructed to calculate the reproductive parameters relating to the

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intrinsic rate of increase and analyze the effects of specific mortality factors (Hasan and Ansari, 2011). Biology, life cycle and breeding potential of *S. obliqua* and *Diacrisia casignetum* on various hosts, including jute have been carried out by many workers (Taleb *et al.*, 1998; Gotyal *et al.*, 2013; Roy and Barik, 2013; Roy, 2015). Life-fecundity table for *S. obliqua* was constructed on sunflower (Varatharajan *et al.*, 1998) and jute (Das and Chaudhuri, 2005). However, there is no information available with respect to the effect of this pest on bast fibre crops. Therefore, the prime objective of the present investigation was to examine the effect of bast fibre crops on life table parameters of *S. obliqua* which is useful for its management and has a potentiality in breeding for resistance.

MATERIALS AND METHODS

The present field experiments was conducted on six host plant species in the laboratory of Crop Protection Division of ICAR-Central Research Institute for Jute and Allied Fibres, Barrackpore (longitude 88°26'E; latitude 22°45'N), Kolkata, West Bengal, India during February-July, 2014. The seeds of bast fibre crops were procured from seed bank of CRIJAF. The seeds were sown during February-June, 2014 in earthen pots (37.5 cm upper radius × 15.5 cm lower radius × 27 cm height) which were filled with farm yard manure and soil at a ratio of 1:3. All the crops maintained as per their standard agronomic package of practices to get good crops which include recommended fertilizer (60:30:30 NPK/ha, regular irrigation and manual weeding has be done. Healthy plants of these crops were maintained under insecticide free conditions. These host plant leaves were used to study the biology of *S. obliqua* under laboratory conditions. The *S. obliqua* culture was maintained on respective test host plant leaves separately in the rearing container (13 cm height × 13 cm width) with temperature 25 ± 2°C, relative humidity 85% and 12 L: 12 D light in BOD. Progeny (F_1) of laboratory reared *S. obliqua* was used for the study.

From each of the host, 150 eggs were placed into Petriplates (7.5 × 1.5 cm) in a BOD incubator with 25 ± 2°C temperature, relative humidity 80 ± 5% and photoperiod of 12L : 12D. After hatching, 100 healthy larvae were placed in 20 each rearing jar (13 cm height × 13 cm width) with respective food plant leaves. The experiment replicated five times. The food plant leaves were placed over wet filter paper to maintain turgidity and moisture levels of leaves. The fresh leaves from respective bast fibre crops were replenished daily after removing excreta and leaves. Observations on egg incubation period, hatching, larval and pupal period of various life stages were made at 24 hour interval. In another experiment, ten pairs freshly emerged adults were released on the 45 days old six potted host-plant caged with mylar film sheet (100 cm wide base) to determine fecundity and adult longevity. The honey solution 10% soaked on cotton swab provided as a food for adults. After 48 h of moths release, eggs were found in clusters on the lower sides of the leaves in the respective plants. Observations on the number of eggs laid on each plant/female were recorded. Adult male and female longevity was also measured and the whole experiment was replicated five times.

To study the effect of host plants on life table parameters of *S. obliqua* under laboratory conditions, the freshly laid eggs were collected from the nucleus culture and kept for hatching. After hatching, 100 larvae were transferred with fine camel brush in to the respective host plants leaves in five rearing jar (13 cm height × 13 cm width). Each rearing jar contained 20 larvae (5 replications) and the host plants leaves were changed daily till all larvae turned into pupation. The emerged adults were paired for mating and released in separate cages for egg laying. The fecundity of the females on subsequent days was noticed daily till all the females died. From these data, the intrinsic rate of increase (rm, females/female/day), the net reproductive rate (R_0, females/female/generation), finite rate of increase (λ, individuals/females/day), the mean generation time (T, day) and the doubling time (DT, day) were estimated from cohort of 100. The survival rate and development time were obtained for all immature stages on respective food plants and are replicated in 10 times. Leaves of respective food plants containing 80-100 newly laid eggs were placed in rearing jars with a wet filter paper and incubated at 25 ± 2°C, 80 ± 5% RH and photoperiod of 12L : 12D. These conditions maintained throughout the developmental stages except the adult. All the data on biology and life history parameters of *S. obliqua* on six host plant leaves were analyzed using one-way analysis of variance. The significance of differences among host plants were compared by F-test at P = 0.05. Life tables and its parameters were constructed based on Birch (1948) and Southwood and Henderson (2000). For adults, the survival rate from birth to age x (l_x), fecundity (Total number of offspring produced at age *x*), and m_x (female offspring produced at age x) were also measured. The 'k' value indicating the effectiveness of a mortality factor was worked according to Varley and Gradwell's (1960).

RESULTS AND DISCUSSION

The egg incubation period, total larval and pupal period, adult male and female longevity, fecundity and host plant preference of S. *obliqua* were studied in the laboratory on six different bast fibre crops (Table 1). The larval and pupal period, adult longevity and fecundity was varied significantly among the test plants except egg incubation period (Table 1). The egg incubation period of *S. obliqua* was minimum (4.10 ± 0.42 days) and maximum (5.70 ± 0.27 days) on *C. olitorius* and *H. sabdariffa* crop, respectively. The total larval period was highest (28.1 ± 1.25 days) on *H. sabdariffa* host followed by *H. cannabinus*, *B. nivea*, *C. capsularis*, *C. juncea* and lowest (24.00 ± 0.65 days) on *C. olitorius.* It was evident that total larval period was significantly ($P<0.05$) influenced by the different bast fibre crops. The quickest larval development observed on *C. olitorius* (24.00 ± 0.65 days) being at par ($P=0.05$) with *C. juncea* (24.98 days). The variation in the duration of different larval instars on different hosts were reported by several workers (Taleb *et al.*, 1998; Varatharajan *et al.*, 1998; Begum *et al.*, 2000; Gotyal *et al.*, 2013) and reported that the duration of the later instars varied from 4-6 days (4th instar), 5.33-10.00 days (5th instar) when reared on different host plants. These findings were partially similar to the findings of the present study. However, some variations were observed which might be due to the variations in the quality of food plants and biochemical content of the host plant. The mean pupal period was longest (11.5 ± 0.844 days) on *H. sabdariffa* and it was shorter (8.62 ± 0.46 days) when it was reared on the *C. olitorius.* The *C. olitorius* host appeared to be most suitable food source of *S. obliqua* for pupation as the larvae fed on this leaves completed their pupation within shorter duration. However these results are not in consistency with the results of Idris and Emelia, 2001. These differences might be because of different host plants or different plant parts consumed by the larvae, which may be very different in primary and secondary biochemicals. The pupal period was varied from 10.25-11.75 days when reared on different bast fibre crops.

The male longevity varied significantly ($P>0.05$) from 4.06 ± 0.16 days in *B. nivea* to 4.30 ± 0.14 days in *H. sabdariffa*. The female longevity was slightly more than the male which was significantly ($P>0.05$) maximum (5.34 ± 0.24 days on *C. olitorius* and least in *H. sabdariffa* (4.34 ± 0.53 days). Similar range was also recorded (Taleb *et al.*, 1998; Varatharajan *et al*., 1998; Roy and Barik, 2013). Fecundity of herbivorous insects also depends on host-plant quality, which influences growth rates, digestibility, utilization efficiency and developmental time of herbivores (Shobana *et al.*, 2010). The number of eggs laid by individual female ranged from 268.00 ± 21.68 - 477.00 ± 24.12 eggs/female. Adult fecundity was significantly ($P<0.05$) highest on *C. olitorius* and the lowest on *H. sabdariffa.* The role of host plants, especially food limitation, is an important factor in regulating insect population as the life cycle characteristics of herbivores may be affected by variation in host traits. The insect life history parameters such as fecundity, longevity and survival may be influenced by the variation in host plant quality (Awmack and Leather, 2002). In regard to insect-plant interaction, it is useful to determine the effect of the different host plants or cultivars on the performance of herbivorous (Saeed *et al.*, 2009).

The early larval instar after the emergence from egg were much delicate than the later instars and hence showed higher mortality upto pupal stage which indicates that *C. olitorius* is the most suitable host for the *S. obliqua* (Fig. 1). On the other hand in *C. capsularis*, *H. sabdariffa, C. juncea, B. nivea,* the survivality rapidly declined before pupal stage and then showed decreased mortality. Survivorship curves of *S. obliqua* on all the bast fibre crops were type-III.

Table 1. Biology of *Spilarctia obliqua* on different bastfibre crops.

Lifecycle (days)	*C. olitorius*	*C. capsularis*	*H. cannabinus*	*H. sabdariffa*	*C. juncea*	*B. nivea*	LSD (P=0.05)
Incubation period	4.10 ± 0.42	4.50 ± 0.35	4.80 ± 0.27	5.70 ± 0.27	4.31 ± 0.34	4.45 ± 0.21	0.42
Larval duration	24.00 ± 0.65	25.62 ± 0.83	27.06 ± 0.93	28.64 ± 1.15	24.98 ± 0.66	26.10 ± 0.80	1.10
Pupal duration	8.62 ± 0.46	9.90 ± 0.74	10.22 ± 0.97	11.54 ± 0.84	8.94 ± 0.47	9.16 ± 0.29	0.89
Male longevity	4.06 ± 0.19	4.08 ± 0.17	4.30 ± 0.14	4.22 ± 0.16	4.30 ± 0.22	4.04 ± 0.16	0.25
Female longevity	5.34 ± 0.24	4.62 ± 0.13	4.44 ± 0.46	4.34 ± 0.53	4.78 ± 0.19	4.52 ± 0.26	0.43
Larval survival (%)	78.68 ± 1.41	65.44 ± 1.58	67.65 ± 1.03	53.92 ± 1.20	73.02 ± 1.96	70.21 ± 1.27	1.80
Fecundity (eggs/ female)	477.00 ± 21.12	268.00 ± 19.68	271.00 ± 16.47	260.00 ± 21.41	383.00 ± 15.35	357.00 ± 20.74	34.81

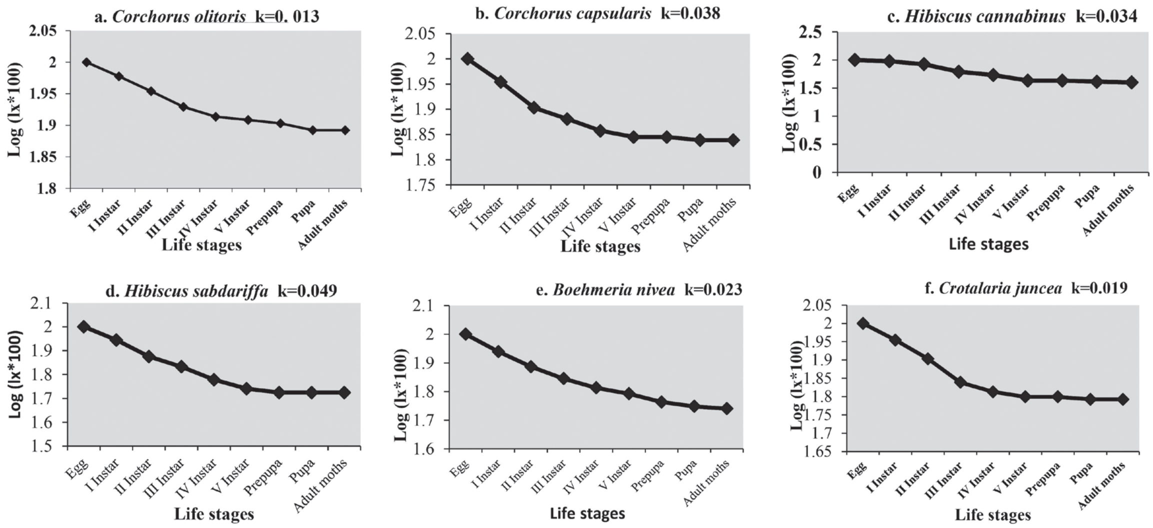

Fig. 1. Survivorship curve and key mortality value of *S. obliqua* on different bast fibre crops

Roy (2015) reported the average alive population of *D. casignetum* in each stage was gradually decreased in the developmental stages from egg to adult stage in jute leaves. But during pupation, the killing power was highest relative to all stages, even, in the egg stage for the jute leaves. The survival increased rate of mortality during initial developmental stages and then it relatively decreased in the advanced stages except pupation stage and reflecting type-III curve. During present study, the larval survivality was greater ($P<0.05$) in insects that were fed on *C. olitorius* (78.68 ± 1.41) and it was lowest (53.92 ± 1.20) on *H. sabdariffa*. The key mortality factor (k value) is primarily responsible for increase or decrease in number from one generation to another. It was computed as the difference between the successive values for log l_x, however, the total generation mortality was calculated by adding the k-values of different developmental stages of the insect. The total generation mortality 'k' was recorded maximum (0.049) on *H. sabdariffa* and minimum (0.013) on *C. olitorius* which has been proven as most suitable hosts for superior development, maximum survival and minimum mortality (Fig 1). The age-specific fecundity life table revealed that the death of the last female (maximum age) occurred in the age of 40.4, 44.5, 46.0, 49.0, 44.0 and 43.0 days for female on *C. olitorius, C. capsularis, H. cannabinus*, *H. sabdariffa*, *B. nivea* and *C. juncea*, respectively (Fig. 2). The mated female began oviposition 3-4 days after emergence in the age of 32.5, 35.5, 37.0, 40.0, 35.0, 34.0 days on *C. olitorius*, *C. capsularis*, *H. cannabinus*, *H. sabdariffa*, *B. nivea* and *C. juncea*, respectively (Fig. 2). The maximum life span from egg to the death of the adults was 43-49 days for the three cohorts reared on different kind of jute leaves (Roy, 2015).

Host plants had a profound effects on all growth parameters, i.e., net reproductive rate (R_0), intrinsic rate of increase (r_m), population doubling time (T_d), mean generation time (T), finite rate of increase (**λ**) and approximate generation time (Tc) (Table 2). The

Table 2. Population growth parameters (mean ± SE) of *Spilarctia obliqua* on different bast crops.

Life table parameters	Different bast fibre crops						LSD (P=0.05)
	C.olitorius	*C. capsularis*	*H. cannabinus*	*H. sabdariffa*	*C. juncea*	*B. nivea*	
Net reproduction rate (R_o)	384.84 ± 21.56	225.12 ± 11.88	200.54 ± 14.21	163.80 ± 14.65	302.57 ± 14.28	282.03 ± 27.83	18.54
Approximate generation time (Tc) (days)	44.77 ± 1.71	50.54 ± 0.52	49.97 ± 1.22	54.73 ± 0.63	46.34 ± 0.43	47.17 ± 1.49	2.37
Capacity for increase (rc)	0.15 ± 0.00	0.13 ± 0.00	0.13 ± 0.00	0.11 ± 0.00	0.14 ± 0.002	0.13 ± 001	0.005
Intrinsic rate of natural increase (rm)	0.15 ± 0.00	0.13 ± 0.00	0.12 ± 0.00	0.12 ± 0.00	0.14 ± 0.008	0.13 ± 0.001	0.009
Finite rate of increase (λ)	1.16 ± 0.00	1.23 ± 0.12	1.13 ± 0.00	1.12 ± 0.00	1.15 ± 0.005	1.14 ± 0.002	0.11
Mean generation time (T) (days)	45.06 ± 0.89	48.98 ± 0.52	49.42 ± 0.72	54.93 ± 0.19	46.23 ± 0.36	47.74 ± 1.04	1.45
Population doubling time (Td)	4.70 ± 0.10	5.59 ± 0.16	5.40 ± 0.01	6.15 ± 0.10	5.30 ± 0.24	5.73 ± 0.20	0.33

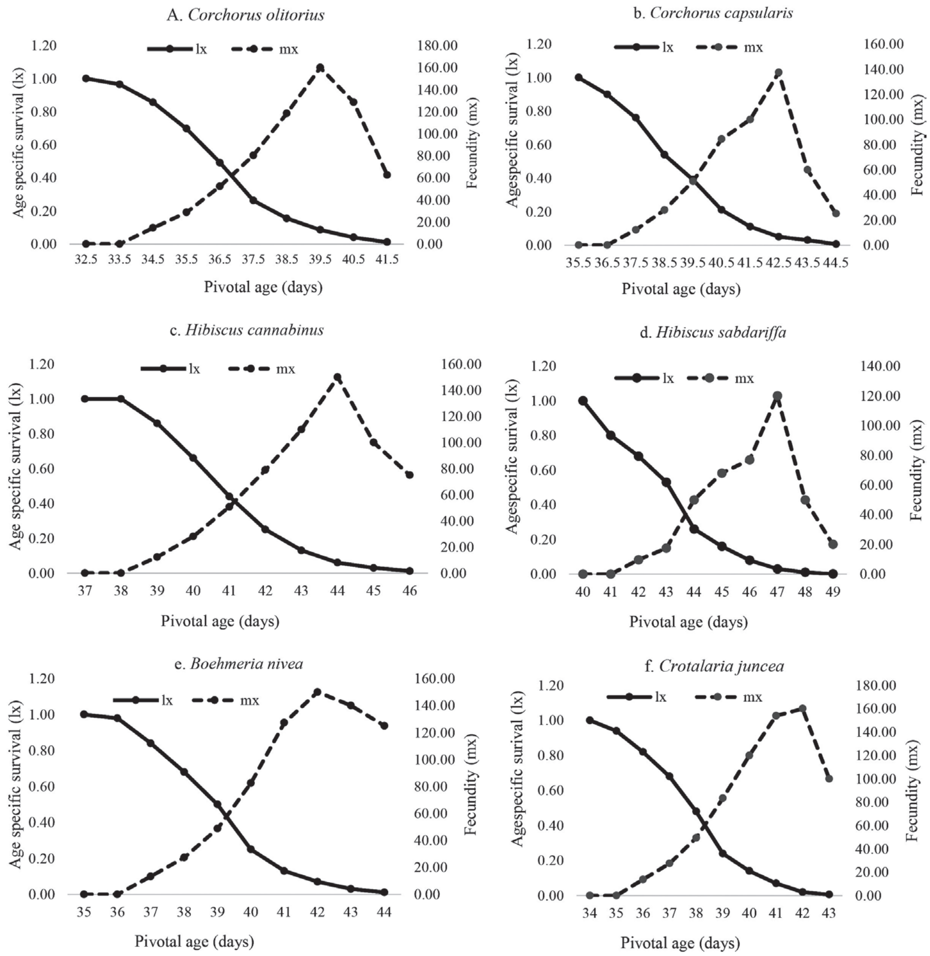

Fig. 2. Age-specific survivorship (lx) and age-specific fecundity (mx) of Bihar hairy caterpillar, *S. obliqua* on various bast fibre crops

net reproductive rate (R_o) was significantly higher on *C. olitorius* (384.84 ± 21.56 females/female/ generation) and minimum (163.80 ± 14.65 females/ female/generation) on *H. sabdariffa.* The intrinsic rate of natural increase (rm) was higher on *C. olitorius* (0.15 ± 0.00 females/ female/day) and the population was expected to double in 4.70 ± 0.10 days. The lowest (rm) (0.12 ± 0.00 females/female/day) was recorded on *H. cannabinus* and *H. sabdariffa* with a doubling time of 5.40 ± 0.01 days and 6.15 ± 0.10 days, respectively. Roy (2015) studies revealed the average gross reproductive rate and net reproductive rate of *D. casignetum* was significantly higher in mature jute leaves. During the present studies, the intrinsic rate of increase (rm) is a key life table parameter useful for predicting the population growth potential of an organism under a given environmental condition such as climatic and food (Southwood and Henderson, 2000). The *S. obliqua* developmental period was faster especially the immature stages (shorter generation time) on *C. olitorius* hence, the higher intrinsic rate of increase (rm), higher survivorship (%) and higher fecundity than other bast fibre crops. High value of rm indicates the susceptibility of a host plant to insect feeding, while a low value indicates that the host plant species is resistant to the pest.

The *C. olitorius* recorded the lowest mean generation time (T) of 45.06 ± 0.89 days and the highest duration (54.93 ± 0.19 days) observed in *H. sabdariffa*. The finite rate of increase was highest on *C. capsularis* (1.23 ± 0.12 individuals day^{-1}) and lowest (1.12 ± 0.00 individuals day^{-1}) on *H. sabdariffa*. The capacity for increase (rc) was found to be highest on *C. olitorius* (0.15 ± 0.00) and the approximate generation time (Tc) was highest on *H. sabdariffa* (54.73 ± 0.63 days) and lowest on *C. olitorius* (44.77 ± 1.71 days). These results are in close agreement with Roy (2015) who studied the life table parameters of *D. casignetum* on jute. The increase in growth rate, shorter developmental time and higher fecundity, point out that increased feeding and higher assimilation rate, both of which may be the results of an increased concentration of digestive enzymes (Farahani *et al.*, 2012). In addition, the finite rate of increase (λ) was comparatively higher on *C. olitorius* and populations of *S. obliqua* were double in the minimum duration on the same crops. In contrary to this, longer development time on *H. sabdariffa* did not increase the value of rc which may be attributed to poor nutritional status and reduced survival of cohort, resulting in low net reproductive rate. Thus, the population growth parameters of *S. obliqua* were significantly affected by the different developmental stages of bast fibre crops due to variation in their phytochemical regime.

In the interaction between adult preference and progeny performance on specific host plants is modified by maternal feeding experience and host plant quality. In the present study, *C. olitorius* with a shorter developmental time, mortality and higher survival rate, was most susceptible. The shorter developmental time and greater reproduction potential of insects on a host plant indicate greater suitability of that plant. HPR increased the developmental time and becomes a cause of high mortality. Therefore appropriate inter-specific crosses may provide platform for developing the resistance in these crops for *S. obliqua.*

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