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Naznin Kamar
a) Department of Zoology, Bolpur College, Birbhum, West Bengal, India
b) Research Scholar, Ecology Research Unit, M. U. C. Women's College, Department of Zoology, Burdwan, West Bengal, India

Neha Chowdhury
Research Scholar, Ecology Research Unit, M. U. C. Women's College, Department of Zoology, Burdwan, West Bengal, India

Bratatee Sardar
Research Scholar, Ecology Research Unit, M. U. C. Women's College, Department of Zoology, Burdwan, West Bengal, India

Biplab Kahar
Department of Zoology, Panchakot Mahavidyalaya, Purulia, West Bengal, India

Biplob Kumar Modak
Department of Zoology, Sidho Kanho Birsha University, Purulia, West Bengal, India

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

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

Life table and population growth of a generalist semilooper, *Anomis sabulifera*, Guenée 1852 (Lepidoptera: erebidae) on four fabaceous plants

Naznin Kamar, Neha Chowdhury, Bratatee Sardar, Biplab Kahar, Biplob Kumar Modak and Nayan Roy

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Abstract
Basic information on insect pest population growth is necessary before deciding on any strategy to combat the pest. The generalist semilooper pest, *Anomis sabulifera*, Guenée 1852 (Lepidoptera: Erebidae), is one of the major pests affecting economic crops worldwide. The stage-specific life table and population growth of *A. sabulifera* on four fabaceous crops, cowpea (*Vigna unguiculata*), black gram (*Vigna mungo*), pigeon pea (*Cajanus cajan*) and peanut (*Arachis hypogaea*), were observed during their growing season from 2023 to 2025. The influence of phytochemicals on the host preference of the generalist semilooper, *A. sabulifera* (cowpea > black gram > pigeon pea > peanut), was represented through population growth and developmental patterns. It also provided information about the vulnerability of the developmental stages of *A. sabulifera* on the selected fabaceous crops. This study suggested the use of trap crops (cowpea> black gram) in a specific pattern with peanut and/or pigeon pea as the main crop for enhanced production, without relying on pesticide-treated monocultures. Multi-trap cropping using the most preferred crops (cowpea > black gram) cultivated as a companion crop in a defined pattern with peanut and or pigeon pea as the main crop will lead to less infestation of *A. sabulifera* or other such pests in the field than their sole cropping. Such studies will also inform about the susceptibility and/or severity of host cultivars towards *A. sabulifera* for their judicious management by using a defined trap cropping system with higher production to promote IPM of peanut and pigeon pea or other such crops.

Keywords: Life table, population growth, *Anomis sabulifera*, fabaceous crops, *Vigna unguiculata*, *Vigna mungo*, *Cajanus cajan*, *Arachis hypogaea*, trap crops, IPM

Introduction
Cowpea (*Vigna unguiculata*), Black gram (*Vigna mungo*), Pigeon pea (*Cajanus cajan*) and Peanut (*Arachis hypogaea*) are economically important fabaceous crops worldwide [1-3]. Cowpea (*Vigna unguiculata* L.) is one of the most important pulse crops, native to central Africa [4]. Cowpea is known as vegetable meat due to its high protein content. The major cowpea-growing countries are Africa, Nigeria, Brazil, Haiti, India, Myanmar, Sri Lanka and Australia. In India, a larger portion of cowpea is cultivated in Tamil Nadu, Andhra Pradesh and Karnataka. Black gram (*Vigna mungo* L.), commonly known as urad bean in India, is a rich source of proteins (20.8 to 30.5%) and carbohydrates (56.5 to 63.7%) [2]. It contributes about 10% to national pulse production [5, 6]. Pigeon pea (*Cajanus cajan*) is an important legume crop in semi-arid tropical and subtropical areas of the world [7]. In terms of global grain legume production, it is sixth after Phaseolus beans, peas, chickpeas, broad beans, and lentils [8]. In Asia, pigeon pea is the third most important pulse crop, where India, Myanmar, and Nepal are the largest producers [9]. It is cultivated as an annual or semi-perennial crop, usually in mixed cropping systems [8]. Peanut (*Arachis hypogaea* L.) is another important crop that significantly contributes to economy and food security worldwide [10, 3].
Despite their importance in nutrition, it is considered too risky because of the numerous pest problems associated with it. Insect pests damage these crops from seedling emergence to storage [11-13, 10]. Different insect pests limit the yield potential of economic crops worldwide [14, 15]. The poor productivity of these crops in India has been attributed to many factors, but among them, insect pests' infestation is a major limiting factor [16].

Among the insect pests, whitefly (*Bemisia tabaci* Gennadius), aphid (*Aphis craccivora* Koch), Jassid (*Empoasca spp*.) and green leaf hopper (*Nephotettix spp*. Stal.) are recognised as important sucking pests. Whereas, grasshopper (*Atractomorpha spp*. Saussure), leaf webber (*Grapholita critica* Meyr.), grey weevil (*Myllocerus spp*. Marshall), tobacco caterpillar (*Spodoptera litura* Fabricius), Bihar hairy caterpillar (*Spilosoma obliqua* Walker), jute semilooper, *Anomis sabulifera* (Guenée 1852), corn earworm (*Helicoverpa zea*), fall armyworm (*Spodoptera frugiperda*), and other Lepidopteran species are foliage feeders [17]. The protection of these crops against pest damage is important in optimising their yield [7]. The deployment of improved cultivars and the adoption of cultural practices, including fertilisers, can increase yield. However, these inputs can be expensive or unavailable in some areas of their production [13, 6].

Among the pest complex, jute semilooper, *Anomis sabulifera* (Guenée 1852) [Lepidoptera: Erebidae], is the most destructive holometabolic insect pest in South-East Asian countries [18-16]. Its wide host range supports the uninterrupted succession of generations. The life cycle of the jute semilooper, *A. sabulifera*, is completed within 28-34 days [20, 21]. They complete their life cycle through four metamorphic stages (egg, larva (up to 5th instar), pupa and adult), and several generations are completed in a year [22, 23]. Pupation occurs in plant debris or the soil, with adults emerging at the beginning of crop growing season. The larvae camouflage but are easily noticed when they crawl, producing a loop in the middle. Several management strategies, namely physical, chemical and biological modes, are commonly deployed [24]. Unfortunately, management of this notorious pest is conducted indiscriminately, heedless to pest density or pest population growth [25]. These result in secondary pest outbreaks, pest resurgence and development of pesticide resistance [26].

The basic information on the bioecology of an insect pest is necessary before deciding on any strategy to combat the pest [27]. Host plant quality influences larval growth and development of insect pests, which are key determinants of their adult longevity, fertility, fecundity and survivability [28, 29]. Host primary metabolites (PMs) are used only for general vitality, growth and reproduction of the herbivores [30, 31], whereas most of the secondary metabolites (SMs) have a defensive role [32, 33]. Morphological and chemical characters of plant surface waxes (alkanes, free fatty acids, alcohols, etc.) also serve an important role in insect–plant interactions [34, 35]. Even environmental factors influence the growth, reproduction, longevity and survival of that population [15]. Therefore, understanding the fundamental life history parameters of *A. sabulifera* on their host plants will enhance effective strategies to control this economically important pest. On the other hand, the life table is a powerful tool for analysing and understanding the effects of different hosts on feeding, growth, survival and reproduction of an insect pest [36]. Thus, bioecology and population dynamics of pests are crucial for their sustainable management [37, 38]. But, to date, none of the studies has been performed with *A. sabulifera* on those fabaceous crops using a stage-specific life table. Thus, the present research was undertaken to investigate the effects of different host phytochemicals on the life table and population growth of the major pest, *A. sabulifera*, for the sustainable management. Therefore, attempts were made to understand the relationships between pest population growth and host phytochemicals.

Materials and methods:

A series of laboratory experiments was conducted from 2023 to 2025 to study the life table and population growth of *A. sabulifera* on four fabaceous crops, cowpea (*Vigna unguiculata*), black gram (*Vigna mungo*), pigeon pea (*Cajanus cajan*) and peanut (*Arachis hypogaea*).

Host plants cultivation and field work: The selected fabaceous crops (cowpea, black gram, pigeon pea, and peanut) were cultivated in a field situated near Chinsurah Rice Research Centre (CRRC), Chinsurah, 22°53' N, 88°23' E, 13m above sea level, Hooghly, West Bengal, India, in their growing season in 2023-2025. Total 24 [4 crop× (3 treated+3 control) =24] plots [each plot 10m× 10m; soil organic matter 5.3 ± 0.2%, pH 7.7, average photoperiod of about 13:11 (L:D) at 30–32°C] were prepared for cultivation of the four fabaceous crops with an average plant density of 18±4 plants/m^2. Fieldwork was conducted by growing the crops in a randomised block design (RBD), separating adjacent plots by 1 m. The growth of the selected crops was observed twice, after application of a traditional synthetic pesticide, Quinalphos 25 EC (@ 15 gm a.i/ha), along with a control (without pesticide). The crops were naturally infested by *A. sabulifera* in the field, and they were collected for mass culturing. Intact mature leaves from 3-4-week-old crops from the respective control plots were collected separately for phytochemical analysis, as well as to provide as food for the semiloopers.

Insect mass culture: The initial populations of *A. sabulifera* larvae were collected from each crop (cowpea, black gram, pigeon pea, and peanut) separately from the cultivated fields near CRRC, Chinsurah, Hooghly, West Bengal, India, from 2023 to 2025. The larvae were incubated in the laboratory at 26±1°C, 60±5% RH, and a photoperiod of 12:12 (L: D) on intact mature leaves of the selected crops in glass jars (20 cm dia. × 30 cm ht.) until their pupation. After the emergence of adults from the reared pupae, six pairs of newly emerged males and females were placed in an oviposition cage (25×25×25 cm) of fine nylon net containing a small cotton ball soaked with 10% honey solution for their feeding. The paired moths (male and female) were kept with their respective fresh foliage separately for their oviposition. The stock culture of *A. sabulifera* was initiated with the F_1 eggs on the selected crop cultivars with three replications under the same conditions in a growth chamber [ten eggs in a glass jar (20 cm dia. × 30 cm ht.)] up to three generations. Newly laid eggs from the F_3 females on each crop were collected to obtain the eggs of a defined cohort (n=100) for life table and population growth studies. Three replicates were maintained. Mature leaf petioles of each crop were inserted into a moist piece of cotton, which was wrapped with aluminium foil to prevent moisture loss and replaced daily with fresh ones. The larvae were placed in a glass jar (20 cm dia. × 30 cm ht.) containing mature fresh leaves of the selected fabaceous crops in the same condition up to their last instar (5th instar) for pupation. The pupae obtained from each glass jar were placed in separate glass jars (6 cm dia. × 10 cm ht.) covered with fine mesh nylon net in the same condition up to their adult emergence on the respective crops. Mortality and developmental durations from egg to adult, along with newly emerged females' fecundity, were recorded separately for each host plant.

Life table study: The data on survival, developmental duration and oviposition of *A. sabulifera* on the selected four fabaceous crops (Cowpea, Black gram, Pigeon pea, and Peanut) were analysed separately based on age-stage life table. It includes several parameters, which were calculated with the formulae of Carey (1993) [37], Krebs (1994) [39], Price (1997) [40] and Southwood (1978) [41]. These parameters include the probability of survival from birth to age x (l_x), the proportion dying (d_x), the mortality rate (q_x) and the survival rate (s_x) per day per age class from egg to adult stages. Using these parameters, the following statistics like total individuals at age x and beyond k (T_x), average population alive in each stage (L_x), life expectancy (e_x), gross reproductive rate (GRR or m_x), net reproductive rate (NRR or R_0), mean generation time (T_c), doubling time (DT), intrinsic rate of population increase (r_m), and finite rate of population increase (λ), weekly multiplication rate (λ^7), increase rate per generation (λ^{Tc}) were also computed, using Carey's formulae (1993) [37]. Some other population parameters like potential fecundity (P_f), the total fertility rate (F_x), effective population size (N_e), mortality coefficient (MC), population growth rate (PGR), population momentum factor of increase (PMF), expected population size in 2nd generation (PF_2), Hypothetical females in 2nd generation (HFF_2), expected females in 2nd generation (EFF_2), general fertility rate (GFR), crude birth rate (CBR), reproductive value (RV), vital index (VI) and trend index (TI) were also determined by using well defined formulae [41, 37, 42, 43].

Phytochemical analysis: Freshly collected intact leaves (cowpea, black gram, pigeon pea, and peanut) were initially rinsed with distilled water and dried by paper towelling separately for different phytochemical analysis such as total carbohydrates [44], total proteins [45], total lipids [46], total amino acids [47], total nitrogen [48], moisture [49], ash content [49], total phenols [50], total flavonoids [51], Tannins [52], saponins [52], alkaloids [53], phytates [54] and oxalates [55]. Total alkanes [56], free fatty acids [57], as well as free and bound amino acids [58] were also determined as in [59]. Determination of each biochemical analysis was repeated three times and expressed on a dry or fresh weight basis accordingly [31, 42, 43].

Statistical Analysis: Experimental data of different phytoconstituents of the selected fabaceous crops (cowpea, black gram, pigeon pea, and peanut) and *A. sabulifera* population parameters were homogeneous among treatments as confirmed by Levene's homogeneity test. All the data were normally distributed as determined by Shapiro–Wilk tests and thus the data were analysed with one-way ANOVA [60]. Means associated with all the data were separated using Tukey's (HSD) test when significant values were obtained [60]. All the statistical analyses were performed using SPSS, version 16.0.

Results

Population dynamics: The stage-specific life tables of *A. sabulifera* were investigated on four selected fabaceous crops (cowpea, black gram, pigeon pea, and peanut) in the laboratory. It showed four distinct stages (i.e., egg, larva, pupa and adult) with four larval instars (Table 1). The l_x, L_x, T_x and e_x of *A. sabulifera* gradually decreased throughout the developmental stages, except egg stage for e_x on the selected fabaceous crops (Table 1), and they also produced a type-III survivorship curve, like most of the insects. Whereas, q_x varied in different developmental stages and was comparatively higher in the pupa and adult stages, followed by the egg stage (Table 1). The primary life table parameters of the pest on the selected crop cultivars showed a similar pattern with no significant variations ($F_{3,8} \geq 0.413$; $P \leq 0.748$), due to similar metabolic utility of the respective host phytoconstituents (Figures 1 and 2). The values of all primary life table parameters (l_x, s_x, L_x, T_x and e_x) on the selected crop cultivars could be arranged in the order of black gram > pigeon pea > cowpea > peanut, except q_x and k_x, which were in reverse order (Table 1).

Secondary population parameters exhibited significant variations ($F_{3,8} \geq 3.543$; $P \leq 0.068$), with few exceptions, due to differences in the host phytoconstituents (Table 2). The average P_f (eggs/female) of *A. sabulifera* was in the order of cowpea (153.333±5.925) > black gram (127.333±3.528) > pigeon pea (113.000±5.508) > and peanut (80.333±8.452) with significant ($F_{3,8} \geq 24.807$; $P < 0.001$) variations (Table 2). The F_x, GRR or m_x, NRR or R_0 of *A. sabulifera* were in the same order as cowpea > black gram > pigeon pea > peanut, like the P_f values with significant ($F_{3,8} \geq 5.155$; $P \leq 0.0.028$) variations (Table 2). The r_m (individuals/female/day) of *A. sabulifera* was in the same order as cowpea (0.092±0.004) > black gram (0.086±0.002) > pigeon pea (0.085±0.002) > and peanut (0.077±0.004), like the P_f with significant ($F_{3,8}$=4.193; P=0.047) variations (Table 2). Average T_c of *A. sabulifera* for the fabaceous crops (black gram > pigeon pea > cowpea > peanut) were without any significant ($F_{3,8}$=1.034; P=0.428) variations (Table 2). Whereas, the average DT (days) of *A. sabulifera* were in the reverse order of P_f, i.e., cowpea (7.577±0.337) < black gram (8.026±0.211) < pigeon pea (8.151±0.183) < peanut (9.097±0.403) with significant ($F_{3,8}$=4.613; P=0.037) variations (Table 2). The λ, PMF, GRF, CBR, RV and TI of *A. sabulifera* were in the same order as cowpea > black gram > pigeon pea > peanut, like the P_f values with significant variations ($F_{3,8} \geq 4.172$; $P \leq 0.047$) (Table 2). The N_e and GM values of *A. sabulifera* were in the same and reverse order of T_c values, respectively, without any significant ($F_{3,8} \leq 1.128$; $P \geq 0.0.394$) variations (Table 2). The population growth and reproductive parameters of *A. sabulifera* were significantly affected by the respective host phytoconstituents (Figures 1 and 2) and by their specific population growth patterns (Table 2). Thus, overall population growth of *A. sabulifera* showed the highest preference for cowpea, followed by black gram, pigeon pea and peanut.

Table 1: Population parameters (Mean ± SE of 3 observations) of *A. sabulifera* Guenée (1852) on four plants like, cowpea (*Vigna unguiculata*), black gram (*Vigna mungo*), pigeon pea (*Cajanus cajan*) and peanut (*Arachis hypogaea*) observed during their growing season in 2023-2025.

Stages	Cowpea	Black gram	Pigeon pea	Peanut	$F_{3,8}$	*p*
			l_x			
Egg-0	1.000±0.000^{a}	1.000±0.000^{a}	1.000±0.000^{a}	1.000±0.000^{a}	0.000	1.000
lnst- I -1	0.487±0.028^{ab}	0.530±0.025^{a}	0.500±0.025^{c}	0.470±0.025^{d}	0.951	0.461
lnst- II-2	0.417±0.024^{a}	0.470±0.025^{b}	0.440±0.025^{c}	0.410±0.025^{a}	1.188	0.373
lnst- III-3	0.380±0.021^{a}	0.440±0.025^{b}	0.410±0.025^{c}	0.380±0.025^{a}	1.414	0.308
lnst- IV-4	0.330±0.015^{a}	0.380±0.025^{b}	0.350±0.025^{c}	0.320±0.025^{d}	1.313	0.336
lnst- V-5	0.277±0.017^{a}	0.330±0.025^{b}	0.300±0.025^{c}	0.270±0.025^{a}	1.352	0.325
Pup-6	0.243±0.015^{a}	0.290±0.025^{b}	0.260±0.025^{c}	0.230±0.025^{d}	1.268	0.349
Adult-7	0.200±0.010^{a}	0.233±0.032^{b}	0.210±0.025^{a}	0.180±0.025^{c}	0.827	0.515
			q_x			
Egg-0	0.513±0.028^{a}	0.470±0.025^{b}	0.500±0.025^{c}	0.530±0.025^{d}	0.951	0.461
lnst- I -1	0.143±0.016^{a}	0.114±0.006^{b}	0.121±0.006^{c}	0.128±0.007^{c}	1.687	0.246
lnst- II-2	0.087±0.027^{a}	0.064±0.004^{b}	0.069±0.004^{b}	0.074±0.005^{c}	0.498	0.694
lnst- III-3	0.131±0.009^{a}	0.137±0.008^{a}	0.148±0.010^{b}	0.159±0.011^{d}	1.731	0.238
lnst- IV-4	0.163±0.014^{a}	0.133±0.009^{b}	0.144±0.011^{c}	0.158±0.013^{a}	1.247	0.355
lnst- V-5	0.120±0.023^{a}	0.123±0.010^{a}	0.135±0.012^{b}	0.151±0.015^{c}	0.800	0.528
Pup-6	1.000±0.000^{a}	1.000±0.000^{a}	1.000±0.000^{a}	1.000±0.000^{a}	0.000	1.000
Adult-7	1.000±0.000^{a}	1.000±0.000^{a}	1.000±0.000^{a}	1.000±0.000^{a}	0.000	1.000
			s_x			
Egg-0	0.487±0.028^{a}	0.530±0.025^{b}	0.500±0.025^{c}	0.470±0.025^{d}	0.951	0.528
lnst- I -1	0.857±0.016^{a}	0.886±0.006^{b}	0.879±0.006^{b}	0.872±0.007^{b}	1.687	0.246
lnst- II-2	0.913±0.027^{a}	0.936±0.004^{b}	0.931±0.004^{b}	0.926±0.005^{d}	0.498	0.694
lnst- III-3	0.869±0.009^{a}	0.863±0.008^{a}	0.852±0.010^{b}	0.841±0.011^{d}	1.731	0.238
lnst- IV-4	0.837±0.014^{a}	0.867±0.009^{b}	0.856±0.011^{c}	0.842±0.013^{a}	1.247	0.355
lnst- V-5	0.880±0.023^{a}	0.877±0.010^{a}	0.865±0.012^{c}	0.849±0.015^{d}	0.800	0.528
Pup-6	0.823±0.021^{a}	0.797±0.044^{b}	0.804±0.021^{b}	0.777±0.027^{c}	0.413	0.748
Adult-7	0.630±0.000^{a}	0.630±0.000^{a}	0.630±0.000^{a}	0.630±0.000^{a}	0.000	1.000
			L_x			
Egg-0	0.743±0.014^{a}	0.765±0.013^{b}	0.750±0.013^{c}	0.735±0.013^{d}	0.951	0.461
lnst- I -1	0.452±0.026^{a}	0.500±0.025^{b}	0.470±0.025^{c}	0.440±0.025^{d}	1.065	0.416
lnst- II-2	0.398±0.022^{a}	0.455±0.025^{b}	0.425±0.025^{c}	0.395±0.025^{a}	1.313	0.336
lnst- III-3	0.355±0.018^{a}	0.410±0.025^{b}	0.380±0.025^{c}	0.350±0.025^{a}	1.360	0.323
lnst- IV-4	0.303±0.016^{a}	0.355±0.025^{b}	0.325±0.025^{c}	0.295±0.025^{a}	1.333	0.330
lnst- V-5	0.260±0.015^{a}	0.310±0.025^{b}	0.280±0.025^{c}	0.250±0.025^{a}	1.313	0.336
Pup-6	0.122±0.007^{a}	0.145±0.013^{b}	0.130±0.013^{c}	0.115±0.013^{a}	1.268	0.349
Adult-7	0.100±0.005^{a}	0.117±0.016^{b}	0.105±0.013^{a}	0.090±0.013^{a}	0.827	0.515
			T_x			
Egg-0	2.512±0.103^{a}	2.795±0.138^{b}	2.630±0.138^{c}	2.465±0.138^{d}	1.274	0.347
lnst- I -1	1.890±0.098^{a}	2.175±0.138^{b}	2.010±0.138^{c}	1.845±0.138^{d}	1.296	0.341
lnst- II-2	1.438±0.077^{a}	1.675±0.113^{b}	1.540±0.113^{c}	1.405±0.113^{d}	1.328	0.331
lnst- III-3	1.040±0.056^{a}	1.220±0.088^{b}	1.115±0.088^{c}	1.010±0.088^{d}	1.325	0.332
lnst- IV-4	0.685±0.038^{a}	0.810±0.063^{b}	0.735±0.063^{c}	0.660±0.063^{d}	1.313	0.336
lnst- V-5	0.382±0.022^{a}	0.455±0.038^{b}	0.410±0.038^{c}	0.365±0.038^{d}	1.298	0.340
Pup-6	0.122±0.007^{a}	0.145±0.013^{b}	0.130±0.013^{a}	0.115±0.013^{a}	1.268	1.268
Adult-7	0.100±0.005^{a}	0.117±0.016^{a}	0.105±0.013^{a}	0.090±0.013^{a}	0.827	0.515
			e_x			
Egg-0	2.512±0.103^{a}	2.795±0.138^{b}	2.630±0.138^{c}	2.465±0.138^{d}	1.274	0.347
lnst- I -1	3.892±0.139^{a}	4.097±0.070^{b}	4.012±0.079^{c}	3.916±0.089^{d}	0.926	0.471
lnst- II-2	3.457±0.096^{a}	3.558±0.053^{b}	3.493±0.061^{c}	3.418±0.071^{d}	0.682	0.587
lnst- III-3	2.737±0.012^{a}	2.768±0.044^{b}	2.713±0.051^{c}	2.650±0.060^{d}	1.196	0.371
lnst- IV-4	2.074±0.019^{a}	2.128±0.026^{b}	2.096±0.031^{c}	2.057±0.038^{d}	1.101	0.403
lnst- V-5	1.380±0.023^{a}	1.377±0.010^{b}	1.365±0.012^{c}	1.349±0.015^{d}	0.800	0.528
Pup-6	0.500±0.000^{a}	0.500±0.000^{a}	0.500±0.000^{a}	0.500±0.000^{a}	0.000	1.000
Adult-7	0.500±0.000^{a}	0.500±0.000^{a}	0.500±0.000^{a}	0.500±0.000^{a}	0.000	1.000
			k_x			
Egg-0	0.314±0.026^{a}	0.277±0.021^{b}	0.302±0.022^{c}	0.329±0.024^{d}	0.892	0.486
lnst- I -1	0.067±0.008^{a}	0.052±0.003^{b}	0.056±0.003^{b}	0.060±0.004^{c}	1.677	0.248
lnst- II-2	0.040±0.013^{a}	0.029±0.002^{b}	0.031±0.002^{c}	0.033±0.002^{c}	0.511	0.686
lnst- III-3	0.061±0.004^{a}	0.064±0.004^{b}	0.069±0.005^{c}	0.075±0.006^{c}	1.721	0.240
lnst- IV-4	0.077±0.007^{a}	0.062±0.005^{b}	0.068±0.006^{c}	0.075±0.007^{a}	1.231	0.360
lnst- V-5	0.056±0.011^{a}	0.057±0.005^{a}	0.063±0.006^{b}	0.071±0.008^{c}	0.804	0.526
Pup-6	0.085±0.011^{a}	0.100±0.025^{b}	0.095±0.011^{b}	0.110±0.016^{c}	0.406	0.753
Adult-7	0.201±0.000^{a}	0.201±0.000^{b}	0.201±0.000^{b}	0.201±0.000^{b}	0.000	1.000

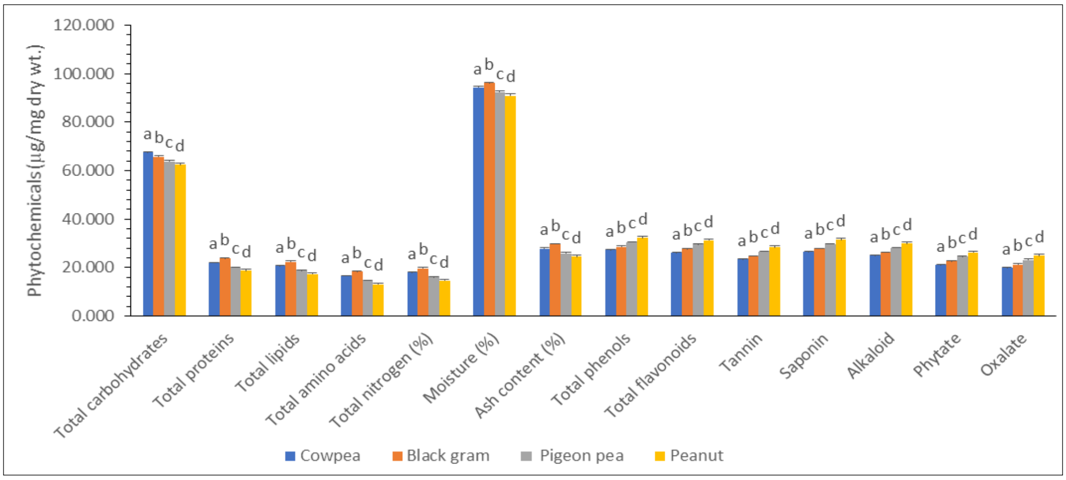
Note: Different alphabets with in the rows indicate the means (Mean ± SE of 3 observations) are significantly different (P< 0.05, Tukey's HSD) with *F* and *P* values (ANOVA) while comparing one type of host plant with the other.

Table 2: Population parameters (Mean ± SE of 3 observations) of *A. sabulifera* Guenée (1852) on four plants like, cowpea (*Vigna unguiculata*), black gram (*Vigna mungo*), pigeon pea (*Cajanus cajan*) and peanut (*Arachis hypogaea*) observed during their growing season in 2023-2025.

Population parameters of Semilooper	Cowpea	Black gram	Pigeon pea	Peanut	$F_{3,8}$	*p*
Potential fecundity (P_f)	153.333±5.925^{a}	127.333±3.528^{b}	113.000±5.508^{c}	80.333±8.452^{d}	24.807	<0.001
Total fertility rate (F_x)	1924.860±29.96^{a}	1873.200±264.140^{b}	1508.010±231.27^{c}	930.090±197.45^{d}	5.155	0.028
Gross reproductive rate (GRR or m_x)	96.600±3.733^{a}	80.220±2.222^{b}	71.190±3.470^{c}	50.610±5.325^{d}	24.807	<0.001
Net reproductive rate (NRR or R_0)	26.607±0.630^{a}	26.481±2.195^{a}	21.487±2.591^{b}	13.856±2.423^{c}	8.078	0.008
Generation time (T_c)	35.857±1.531^{a}	37.873±1.631^{b}	35.873±1.631^{a}	33.873±1.631^{c}	1.034	0.428
Doubling time (DT)	7.577±0.337^{a}	8.026±0.211^{b}	8.151±0.183^{b}	9.097±0.403^{c}	4.613	0.037
Intrinsic rate of increase (r_m)	0.092±0.004^{a}	0.086±0.002^{b}	0.085±0.002^{b}	0.077±0.004^{c}	4.193	0.047
Euler's corrected r (r_c)	0.165±0.007^{a}	0.146±0.019^{b}	0.148±0.013^{b}	0.147±0.012^{b}	0.449	0.725
Finite rate of increase (λ)	1.096±0.005^{a}	1.090±0.002^{a}	1.089±0.002^{a}	1.080±0.004^{b}	4.172	0.047
Weekly multiplication rate (λ^7)	1.904±0.056^{a}	1.832±0.028^{b}	1.815±0.024^{b}	1.709±0.043^{c}	4.041	0.051
Increase rate per generation (λ^{Tc})	26.607±0.630^{a}	26.481±2.195^{a}	21.487±2.591^{b}	13.856±2.423^{c}	8.078	0.008
Effective Population size (Ne)	18.648±0.932^{a}	21.756±2.965^{b}	19.580±2.346^{c}	16.783±2.346^{d}	0.827	0.515
Generation mortality (GM)	0.615±0.026^{a}	0.541±0.040^{b}	0.589±0.044^{b}	0.644±0.051^{a}	1.128	0.394
Mortality coefficient (MC)	0.083±0.007^{a}	0.116±0.016^{b}	0.117±0.011^{b}	0.141±0.015^{c}	3.543	0.068
Generation survival (GS)	0.571±0.035^{a}	0.621±0.019^{b}	0.598±0.021^{c}	0.572±0.024^{a}	0.861	0.500
Population growth rate (PGR)	1.835±0.107^{a}	2.009±0.249^{b}	1.787±0.214^{a}	1.386±0.226^{c}	1.624	0.259
Population momentum factor of increase (PMF)	35.023±2.232^{a}	28.598±1.022^{b}	27.343±0.681^{c}	22.589±1.199^{d}	13.252	0.002
Population size in 2nd generation (PF_2)	696.864±25.215^{a}	662.087±75.786^{a}	573.379±67.008^{b}	408.842±66.709^{c}	4.319	0.044
Hypothetical F_2 females (HFF_2)	708.727±33.608^{a}	710.882±112.781^{a}	475.123±105.517^{b}	203.728±64.270^{c}	7.969	0.009
Realised F_2 females (RFF_2)	439.024±15.885^{a}	417.115±47.745^{a}	361.229±42.215^{b}	257.570±42.026^{c}	4.319	0.044
General fertility rate (GFR)	12.271±1.023^{a}	9.039±1.393^{b}	8.738±0.849^{c}	7.232±0.687^{d}	4.299	0.044
Crude birth rate (CBR)	4.072±0.346^{a}	2.913±0.183^{b}	2.765±0.110^{c}	2.111±0.149^{d}	14.175	0.001
Reproductive value (RV)	193.200±7.466^{a}	160.440±4.445^{b}	142.380±6.940^{c}	101.220±10.650^{d}	24.807	<0.001
Vital Index (VI)	0.131±0.012^{a}	0.183±0.025^{b}	0.185±0.017^{b}	0.224±0.023^{c}	3.543	0.068
Trend index (TI)	82.791±9.171^{a}	65.768±4.043^{b}	59.322±4.111^{c}	40.921±5.566^{d}	8.069	0.008

Note: Different alphabets with in the rows indicate the means (Mean ± SE of 3 observations) are significantly different ($P < 0.05$, Tukey's HSD) with *F* and *P* values (ANOVA) while comparing one type of host plant with the other.

Host Phytochemicals: The chemical constituents of the selected fabaceous crops (cowpea, black gram, pigeon pea, and peanut) were presented in Figures 1 and 2 and Supplementary Table 1. The PMs and SMs varied significantly ($F_{3,8} \geq 47.339$, $P \leq 0.001$) among the crop cultivars, and the concentrations followed almost reverse orders (Figure 1, Supplementary Table 1). Among the PMs, total carbohydrate (µg/mg dry weight) was in the order of cowpea (67.567±0.349) > black gram (65.787±0.276)> pigeon pea (63.857±0.276) > and peanut (62.447±0.679) (Figure 1, Supplementary Table 1). Whereas, total protein (µg/mg dry weight) was in the order of black gram (23.767±0.269) > cowpea (21.987±0.196) > pigeon pea (20.057±0.196) > peanut (18.647±0.599) (Figure 1). Similarly, total lipids, amino acids, nitrogen (%) and moisture (%) content were highest in black gram, followed by cowpea, Pigeon pea, and peanut, respectively (Figure 1, Supplementary Table 1). All the SMs were in the reverse order (cowpea < black gram < pigeon pea < peanut) of carbohydrate as well as other PMs, except black gram followed by cowpea (Figure 1). Among the SMs, total phenol and tannin in cowpea, black gram, pigeon pea, and peanut were 27.167±0.629, 28.577±0.226, 30.507±0.226, 32.287±0.299 and 23.307±0.589, 24.717±0.186, 26.647±0.186, 28.427±0.259 µg/mg dry weight, respectively (Figure 1, Supplementary Table 1). Similarly, alkanes, free fatty acids, free and bound amino acids were highest in black gram, followed by cowpea, pigeon pea, and peanut (Figure 2, Supplementary Table 1). Ultimately, the ratio of PMs to SMs varied significantly ($F_{3,8} \geq 47.236$, $P < 0.001$) among the selected crops.



Figu 1: Phytochemical (primary and secondary) variations (Mean ± SE of 3 observations) in four fabaceous crops like, cowpea (*Vigna unguiculata*), black gram (*Vigna mungo*), pigeon pea (*Cajanus cajan*) and peanut (*Arachis hypogaea*) observed during their growing season in 2023-2025. Means followed by same alphabets above the error bars are not significantly different ($P \geq 0.05$) by Tukey's HSD test.

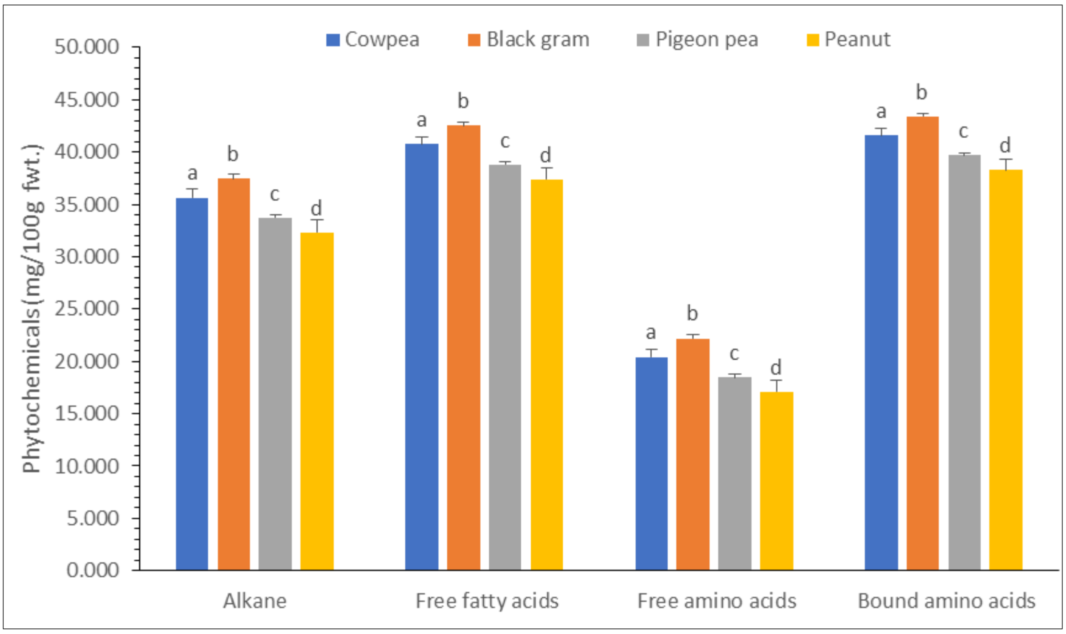


Fig 2: Cuticular wax chemicals (alkanes and free fatty acids) and amino acids (free and bound) variations (Mean ± SE of 3 observations) in four fabaceous crops like, cowpea (*Vigna unguiculata*), black gram (*Vigna mungo*), pigeon pea (*Cajanus cajan*) and peanut (*Arachis hypogaea*) observed during their growing season in 2023-2025. Means followed by same alphabets above the error bars are not significantly different ($P \geq 0.05$) by Tukey's HSD test.

Discussions

Insect-plant interactions and the interrelationship between these two are indispensable for the survival of both, having evolved from a long run of the evolutionary arms race. Insects search for a healthy host plant for oviposition and proper nutrition for themselves and their offspring [61, 30]. On the other hand, plants have evolved a regulatory mechanism to maintain a balance between growth and defence responses [62]. Plant structural traits (leaf surface wax, trichomes, etc.) form the first physical barrier, and the SMs form the next barrier against the herbivores [63, 64]. Whereas, herbivores also use volatiles and/or non-volatile compounds for host finding and oviposition [65, 66]. Basic information on population growth of an insect pest, concerning host phytoconstituents, is necessary for combating the pest [67, 42]. The population growth of pests is regulated by host phytoconstituents [29, 31]. Host PMs (carbohydrates, proteins, lipids, amino acids), including moisture content, are utilised by herbivores for general vitality, growth and reproduction [28, 68]. Whereas, host SMs have defensive roles and pose adverse effects on them [69, 33] due to higher metabolic costs [70]. Among the SMs, plant phenols, flavonoids, tannins, terpenoids, alkaloids, etc., constitute the most common and cosmopolitan group of defensive compounds against insect herbivores [14, 71]. The defensive SMs (alkaloids, phenolics, oxidative enzymes, etc.) of tomato, tobacco and maize act in a synergistic manner on different insects, including *Spodoptera spp.* and *Helicoverpa spp.*, during ingestion, digestion and metabolism [72, 73]. Quinones formed by oxidation of phenols bind covalently to leaf proteins and inhibit the protein digestion in herbivores [74, 32]. Flavonoids defend plants against various insect pests like *H. armigera*, *S. littoralis*, etc., by acting as feeding deterrents and by influencing their growth and development [75, 71]. Tannins are bitter polyphenols that act as feeding deterrents by binding to the proteins, reducing nutrient absorption efficiency, chelating metal ions and causing midgut lesions [76]. The complex mixture of other SMs in many plants may provide effects in defence against a range of pests [77].

The effect of different food sources on population growth was observed in *D. casignetum* [59], *S. obliqua* [78], *S. litura* [70], *H. armigera* [79], *P. xylostella* [80], *Papilio polytes* [29], *Podontia quatuordecimpunctata* [81], *Epilachna vigintioctopunctata* [82], *Leptocorisa acuta* [83] and many more. In all cases, the population parameters, primarily survival, developmental durations and fecundity, were in good agreement with our findings on the generalist semilooper, *A. sabulifera* [84, 85, 78]. Phytochemical analyses of the selected fabaceous crops had revealed that Cowpea and Black gram leaves had good nutritional (PMs) quality compared to other crops (Pigeon pea> peanut), and anti-nutritional factors (SMs) were in reverse order (cowpea< black gram< pigeon pea< peanut). Such variations in host phytochemicals directly affected the development and growth of *A. sabulifera*, as with other insects [67, 17]. Ultimately, host utilisation efficiencies were reflected in the fecundity, larval survival and adult emergence of *A. sabulifera*. They were in the order of cowpea > black gram > pigeon pea > peanut, with reproductive parameters that are similar to various insects [31, 86]. Pest ecology and population dynamics are widely useful techniques in their management [36]. The P_f, GRR or m_x, NRR or R_0, r_m, λ, etc., are fundamental ecological parameters that predict pest population growth, evaluate the performance of an insect on different host plants, and thus assess their resistance or susceptibility [38]. In this finding, all these fundamental parameters were almost higher in cowpea, followed by the black gram, pigeon pea and peanut based on the respective host preference of *A. sabulifera*, like most of the insects [31, 42]. Modern agriculture incorporates integrated crop management (ICM) and integrated pest management (IPM) to establish eco-friendly, sustainable and smart agriculture [87]. Despite this, it also relies primarily on habitat manipulation through farm scaping, trap cropping and other biological control practices to avoid detrimental effects of chemical insecticides on the environment [88]. Trap cropping through habitat manipulation is an attractive remedy for biological control by natural enemies, more so than artificial biocontrol or other conventional means of pest control through vegetative diversification [89, 90, 91]. It reduces pest dispersal to the main crop [92]. Moreover, different trap crops can release different volatiles, which can attract and enhance the foraging efficacy of natural enemies in an agroecosystem [93]. Considerable research has been conducted on various trap crops to develop improved pest management strategies for a substantial reduction in pesticide use worldwide [94]. Egg plants act as trap crops and field corn as a barrier crop for the management of *Bemisia argentifolii* on common bean [95]. Moreover, nectar and pollen-producing plants are interplanted as trap crops for the management of broccoli against the cabbage worm (*Pieris rapae*), the diamondback moth (*P. xylostella*) and the cabbage looper (*Trichoplusia ni*) by [96]. Thus, trap crops can attract and divert pests from the main crop by exploiting their sensory modalities [93, 94]. The relatively low food quality of peanut and/or pigeon pea made it a less preferred host for the generalist semilooper, *A. sabulifera*, than black gram and cowpea. This finding will support the use of cowpea or black gram as a trap crop for the sustainable production of peanut and pigeon pea as main crops against the generalist semiloopers, for their sustainable cultivation.

Conclusions

The influence of phytochemicals on the host preference of the generalist semilooper, *A. sabulifera* (cowpea > black gram > pigeon pea > peanut), was represented through population growth and developmental patterns. It also provided information about the vulnerability of the developmental stages of *A. sabulifera* on the selected fabaceous crops. The host preference of *A. sabulifera* on the selected fabaceous crops suggested the use of trap crops (cowpea> black gram) in a specific pattern with peanut and or pigeon pea as the main crop for enhanced production, without relying on pesticide-treated monocultures. Multi-trap cropping by using the most preferred crops (cowpea> black gram) was cultivated as a companion crop in a defined pattern with peanut and or pigeon pea as the main crop, which will lead to less infestation of *A. sabulifera* or other such pests in the field than their sole cropping. Even trap cropping systems for different agronomic situations will be greatly enhanced if further research is conducted on cropping patterns, along with other ecological concepts. This study will also inform about the susceptibility and/or severity of host cultivars towards *A. sabulifera* for their judicious management, by using a defined trap cropping system with higher production to promote IPM of peanut and pigeon pea or other such crops.

Statements and Declarations

Competing Interests: The authors declare that there is no competing interest other than the publication of this paper.

Author's contributions: NK, NC, BS, BK, BKM and NR designed the whole study, including sample collection, chemical analysis, index calculation, data analysis and drafted the manuscript with the help of institutional support.

Disclosure: The author declares that there is no conflict of interest other than publication of this paper.

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Supplementary Table 1. Phytochemical variations (Mean ± SE of 3 observations) in four plants like, cowpea (*Vigna unguiculata*), black gram (*Vigna mungo*), pigeon pea (*Cajanus cajan*) and peanut (*Arachis hypogaea*) observed during their growing season in 2023-2025. All the estimated chemicals significantly differed within the host plants at P<0.05 by Tukey's (HSD) test.

Phytochemicals (µg/mg dry wt)	Cowpea	Black gram	Pigeon pea	Peanut	$F_{3,8}$	p
Total Carbohydrate	67.567±0.349[a]	65.787±0.276[b]	63.857±0.276[c]	62.447±0.679[d]	48.612	<0.001
Total protein	21.987±0.196[a]	23.767±0.269[b]	20.057±0.196[c]	18.647±0.599[d]	48.932	<0.001
Total Lipid	20.587±0.226[a]	22.367±0.299[b]	18.657±0.226[c]	17.247±0.629[d]	49.042	<0.001
Total Amino acids	16.467±0.186[a]	18.247±0.259[b]	14.537±0.186[c]	13.127±0.589[d]	47.452	<0.001
Total Nitrogen (%)	17.907±0.196[a]	19.687±0.269[b]	15.977±0.196[c]	14.567±0.599[d]	47.532	<0.001
Moisture (%)	94.347±0.386[a]	96.127±0.459[b]	92.417±0.386[c]	91.007±0.789[d]	47.742	<0.001
Ash content (%)	27.867±0.236[a]	29.647±0.309[b]	25.937±0.236[c]	24.527±0.639[d]	47.352	<0.001
Total phenol	27.167±0.629[a]	28.577±0.226[b]	30.507±0.226[c]	32.287±0.299[d]	49.352	<0.001
Total Flavonoid	26.127±0.609[a]	27.537±0.206[b]	29.467±0.206[c]	31.247±0.279[d]	49.042	<0.001
Tannin	23.307±0.589[a]	24.717±0.186[b]	26.647±0.186[c]	28.427±0.259[d]	49.312	<0.001
Saponin	26.407±0.569[a]	27.817±0.166[b]	29.747±0.166[c]	31.527±0.239[d]	49.052	<0.001
Alkaloid	24.807±0.619[a]	26.217±0.216[b]	28.147±0.216[c]	29.927±0.289[d]	49.332	<0.001
Phytate	21.107±0.579[a]	22.517±0.176[b]	24.447±0.176[c]	26.227±0.249[d]	47.376	<0.001
Oxalate	19.847±0.649[a]	21.257±0.246[b]	23.187±0.246[c]	24.967±0.319[d]	47.339	<0.001
Phytochemicals (mg/100g fwt)						
Alkane	35.647±0.266[a]	37.427±0.339[b]	33.717±0.266[c]	32.307±0.669[d]	49.479	<0.001
Free fatty Acids	40.727±0.236[a]	42.507±0.309[b]	38.797±0.236[c]	37.387±0.639[d]	49.515	<0.001
Free AA	20.417±0.206[a]	22.197±0.279[b]	18.487±0.206[c]	17.077±0.609[d]	49.552	<0.001
Bound AA	41.607±0.176[a]	43.387±0.249[b]	39.677±0.176[c]	38.267±0.579[d]	49.588	<0.001

Note: Different alphabets with in the rows indicate the means (Mean ± SE of 3 observations) are significantly different (P< 0.05, Tukey's HSD) with *F* and *P* values (ANOVA) while comparing one type of host plant with the other.