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Biology and morphometric study of *Callosobruchus chinensis* on seeds of *Flemingia* spp.: A host plant of lac insect

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Abstract
An experiment was conducted to study the comparative biology and morphometric study of *Callosobruchus chinenesis* on *Flemingia macrophylla, Flemingia semialata*, *Vigna radiata* and *Cicer arietinum* seeds in the Insect Physiology Laboratory of Department of Entomology, Assam Agricultural University, Jorhat during 2018-19. The study revealed that incubation period, larval period, pupal period, total developmental period, adult longevity, fecundity and rate of oviposition varied significantly among different stored seeds. The developmental parameters during the months of June-July and Nov-Dec showed that the total developmental period was highest in *F. semialata* (32.60±0.50 days, 46.4±0.50 days) and lowest in *V. radiata* (25.40±0.24 days, 39.2±0.37 days) in both the seasons, respectively. The morphometric measurement revealed that females were larger in size than males. The maximum body length of adult was recorded on *V. radiata* (3.86±0.05 mm, 4.13±0.08 mm) in male and female, respectively.

Keywords: Biology, *Callosobruchus chinensis*, *Flemingia macrophylla*, *Flemingia semialata*, morphometric measurement

Introduction
Flemingia macrophylla (Willd.) and *Flemingia semialata* (Roxb.) (Leguminosae), two perennial woody shrubs, are extensively utilized for commercial lac *Kerria lacca* (Kerr) (Hemiptera: Kerridae) cultivation in different parts of the country. Plants are propagated through seeds and generally one-year old plants are utilized for inoculation of winter season *kusmi* lac cultivation [11]. In the field, *Flemingia* spp. are attacked by as many as 32 insect-pests [7]. Seeds are harvested in the month of March-April, sun-dried and stored inside room for sowing next year as well as to supply to farmers.
Hazarika *et al*. (2017) [7] reported 15 species of insect pests of different orders *viz.*, Lepidoptera, Coleoptera, Hemiptera associated with *Flemingia* spp. under Jorhat condition of Assam. The stored grain pest reported in *Flemingia macrophylla* and *Flemingia semialata* is *Callosobruchus chinensis* (L.) (Coleoptera: Bruchidae), which is considered as the major stored grain pest of pulses. It is mostly destructive for chickpea, mung, cowpea, lentil and pigeonpea. In case of severe infestation, the damage caused is up to 100% during storage [6]. It causes reduction in germination potential and commercial value of the seed [13]. The infestation begins in the field and continues in the storehouses causing heavy losses. Both grub and adult cause damage. It is a holometabolic insect with the egg and adult stage found on the grain and the larval and pupal stages living inside the grain [5]. Such infested grains are not only unfit for consumption but also useless as seed [12]. High temperature, high relative humidity and high precipitation during the monsoon period favour the rapid growth and development of stored pests. In order to initiate a perfect pest management strategy, it is very much essential to have a thorough knowledge of the biology of the insect pest.

Materials and methods
The experiment was carried out in the Insect Physiology Laboratory of Department of Entomology, Assam Agricultural University, Jorhat during season I (June –July) and season II (Nov-Dec). Biology of *C. chinensis* was carried out on *Flemingia macrophylla* and *Flemingia semialata*, and to have a comparison green gram, *Vigna radiata* (L.) and chickpea, *Cicer Cicer arietinum* were used as check.

For mass rearing, the seeds were washed with distilled water and sieved to remove the traces of other insects and microorganisms. Seed samples of 500 g of each was placed in plastic jars (5 l capacity) and released 5 pairs of adult male and female in 1:1 ratio.

Larvae and pupae of different age groups were isolated by following the method as suggested by Hazarika and Farooquie (1978)[8]. The seeds were soaked in water for a period of time and then larvae or pupae of different age groups were isolated by simple dissection of soaked seeds under the compound microscope. In order to count the total development period, the life cycle of *C. chinensis* was recorded daily from egg to adult.

To observe the fecundity and rate of oviposition, single mated pair of freshly emerged adults were collected from stock culture and introduced into plastic containers (5 cm × 5 cm) containing 20 g of each of the seed sample. Adults were removed from these containers after death and total no. of eggs laid on the seed surface by a single female were counted with the help of a magnifying lens.

By using the method of Credland and Dick (1987) [4], weight loss due to feeding by a larva was estimated. The dry weight of the seeds prior to hatching was taken and the infested seeds were maintained at the room temperature till the emergence of adults. After removing the adults, the infested seeds were weighed again. The difference between the two was the amount of food consumed by a larva in its whole life and it was expressed in percentage as:

$$\%\ \text{food consumption} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

The per cent seed infestation was recorded by selecting 100 seeds randomly and recorded the number of seeds with emergence holes in each sample. Average data of five such samples were taken to calculate the per cent damaged seeds by the following formula:

$$\%\ \text{damaged seeds} = \frac{\text{Number of seeds with emergence holes}}{\text{Total number of seeds}} \times 100$$

For morphometric study five freshly emerging male and female adults from different seed sample were collected separately in small vials and the weight of the adults were measured by means of a “Mettler H5 IAR” electric balance. Weight of insects was recorded individually and mean weights of male and female emerging from each pulse were worked out. Similarly, body length/width, antennal length/width and elytral length/width were measured by means of stage micrometer in conjugation with ocular micrometer.

Statistical analysis was carried out by following CRD (Completely randomized design). Each treatment was replicated five times. The experimental data in percentage were subjected to angular transformation before analysis. Statistical analysis of the angular transform data was done using Fisher’s method of Analysis of Variance (ANOVA) with Completely Randomized Design (CRD).

Results and discussion

Incubation period

Incubation period varied significantly on different host seeds during season I and season II. During season I, maximum duration of incubation period was recorded in *F. semialata* (5.20±0.374 days), followed by *F. macrophylla* (5.00±0.63 days) and *C. arietinum* (4.80±0.37 days) and minimum on *V. radiata* (4.40±0.40 days). However, incubation period of *C. chinensis* on *F. semialata* was statistically at par with *F. macrophylla*. The results (table 2) showed that during season II, incubation period was found to be maximum (8.2±0.20 days) on *F. semialata* which was statistically at par with *F. macrophylla* (8±0.31 days). Whereas, the shortest incubation period (7±0.31 days) was recorded on *V. radiata* which was also at par with *C. arietinum* (7.2±0.44 days).

The result of the present investigation was in consonance with the results obtained by Chakraborty and Mandal (2016)[2], they found that the incubation period of *C. chinensis* on *V. radiata* varied from 6-8 days during winter and 4-5 days during summer.Variation in incubation period among different stored seeds might be due to seed texture and climatic condition [9].

Grub period

It is apparent from the study that hosts significantly affected the grub period of *C. chinensis*. During season I, the maximum grub period (19.80±1.12 days) was found on *F. semialata* which did not differ significantly from *F. macrophylla* (18.40±0.40 days). Whereas minimum grub period was recorded on *V. radiata* (15.00±1.39 days), which was statistically at par with *C. arietinum* (16.40±0.92 days) but differed significantly from other hosts. The data revealed that during season II, the maximum grub period (26.8±0.20 days) was found on *F. semialata* which did not differ significantly from *F. macrophylla* (26.0±0.63 days). Whereas minimum grub period was recorded on *V. radiata* (23.2±0.37 days), which was statistically at par with *C. arietinum* (24.2±0.37 days) but differed significantly from other hosts.

The result of the present investigation was in consonance with the results obtained by Bhargava *et al.* (2008) [1], they reported that grub period varied from 14.8-26.2 days. It was also noted that with decreasing temperature, larval period increased [2]. The slight variation of the results with the findings of the present investigation might be due to the presence of thick seed coat and biochemical constituents present in *Flemingia* seeds.

Pupal period

The longest pupal period was recorded on *F. Semialata* (7.60±0.51 days, 11.4±0.40 days) followed by *F. macrophylla* (7.40±0.40 days, 11.2±0.37 days) and *V. radiata* (6.00±0.44 days, 9.0±0.70 days) accounted for shortest pupal period during season I and season II respectively. However, there was no significant difference between *V. radiata* and *C. arietinum*.

Bhargava *et al.* (2008) [1] noted that the pupal period varied from 5.4-11.4 days on different stored seeds. Observations made by Devi and Devi (2014) [5], Hosamani *et al*. (2018) [9] and Jaiswal *et al.* (2018) [10] had been in agreement with the findings.

Total developmental period

It is evident from the data presented in table 1 that host seeds had significant effect on total developmental period of *C. chinensis*. Total developmental period during season I was maximum in case of *F. semialata* (32.60±0.50 days) followed by *F. macrophylla* (30.80±0.37 days) and *C. arietinum* (27.60±0.24 days) and minimum on *V. radiata* (25.40±0.24

days). During season II, total developmental period was maximum in case of *F. semialata* (46.4±0.50 days) followed by *F. macrophylla* (45.2±0.37 days), *C. arietinum* (41.0±0.31 days) and *V. radiata* (39.2±0.37 days).
Chakraborty *et al.* (2015) [3] reported that total developmental period of *C. chinensis* ranged from 29-49 days in *V. radiata*. Similar results were observed by Chakraborty and Mandal (2016) [2], Sharma *et al.* (2016) [16] and Hosamani *et al.* (2018) [9] on different stored seeds. The possible reason for maximum duration of *F. semialata* seed may be due to temperature, presence of thick seed coat and biochemical constituent of the seed.

Adult longevity
During season I, adult males lived longer when reared on *F. semialata* (10.00±0.54 days) which differed significantly from other hosts. In case of *V. radiata* (7.60±0.24 days), the longevity was observed to be the shortest. In case of adult females, the longevity was observed to be the longest (9.00±0.44 days) on *F. semialata* while it was shortest (6.40±0.51days) on *V. radiata* which did not differ significantly from *C. arietinum*. The data presented in table 2 shows that during season II, adult males lived longer when reared on *F. semialata* (13.2±0.37 days) which differed significantly from other hosts. In case of *V. radiata* (11.4±0.50 days), the longevity was observed to be the shortest. In case of adult females, the adult longevity was longest (11.2±0.66 days) on *F. semialata* and shortest on *V. radiata* (9.4±0.24 days). The adult males of *C. chinensis* lived longer than the females. The present findings were supported by Chakraborty and Mandal (2016)[2] and Singh *et al*. (2016)[17].

Table 1: Life cycle duration (mean± SE) of *Callosobruchus chinensis* on different stored seeds during June-July, 2018 (Season I)

Host seeds	Incubation period (days)	Grub period (days)	Pupal period (days)	Total developmental period	Adult longevity Male (days)	Adult longevity Female (days)
Flemingia macrophylla	5.00±0.63	18.40±0.40	7.40±0.40	30.80±0.37	9.20±0.20	8.00±0.54
Flemingiasemialata	5.20±0.37	19.80±1.12	7.60±0.51	32.60±0.50	10.00±0.54	9.00±0.44
Vigna radiata	4.40±0.40	15.00±1.39	6.00±0.44	25.40±0.24	7.60±0.24	6.40±0.51
Cicer arietinum	4.80±0.37	16.40±0.92	6.40±0.24	27.60±0.24	8.00±0.31	7.20±0.86
SEd±	0.264	1.453	0.583	0.509	0.500	0.866
CD (P=0.05)	0.560	3.106	1.236	1.08	1.059	1.852

*Data presented are the mean of five replications

Table 2: Life cycle duration (mean± SE) of *Callosobruchus chinensis* on different stored seeds during Nov-Dec, 2018 (Season II)

Host seeds	Incubation period (days)	Larval period (days)	Pupal period (days)	Total developmental period (days)	Adult longevity male (days)	Adult longevity female (days)
Flemingia macrophylla	8±0.31	26.0±0.63	11.2±0.37	45.2±0.37	12.0±0.31	10.8±0.20
Flemingia semialata	8.2±0.20	26.8±0.20	11.4±0.40	46.4±0.50	13.2±0.37	11.2±0.66
Vigna radiata	7±0.31	23.2±0.37	9.0±0.70	39.2±0.37	11.4±0.50	9.4±0.24
Cicer arietinum	7.2±0.44	24.2±0.37	9.6±0.24	41.0±0.31	11.8±0.20	9.6±0.51
SEd±	0.374	0.6	0.656	0.565	0.519	0.632
CD (P=0.05)	0.793	1.27	1.402	1.199	1.101	1.352

*Data presented are the mean of five replications

Fecundity and Rate of oviposition
The maximum fecundity was recorded on *C. arietinum* (84.2±1.28 eggs/ female) followed by *V. radiata* (77.4±1.43 days) and *F. macrophylla* (70.2±0.73 eggs/female) and minimum on *F. semialata* (67.6±0.51 eggs/ female).
The rate of oviposition on *C. arietinum* (9.12±0.33 eggs/ day/ female) was found to be the highest among the hosts. Whereas, in *F. semialata* minimum rate of oviposition (6.24±0.32 eggs/day/female) was recorded which was statistically at par with *F. macrophylla* (7.42±0.32 eggs/day/female) but differ significantly from other hosts.
This may be due to the various physical characters of the seeds like size, the thickness of the seed coat, colour etc. The present finding was in conformity with Raina (1970) [14], Satyavir (1980) [15] and Sharma *et al.* (2016) [16] who have pointed out that the seed size positively influenced the ovipositional preference of *C. chinensis.*

Per cent food consumption per cent seed infestation
Per cent food consumption computed for *C. chinensis* revealed that in case of *V. radiata*, grub consumed 57.82% of the seed during its entire grub period followed by *C. arietinum* (55.47%), *F. macrophylla* (52.54%) and *F. semialata* (50.98%). It is apparent from the data that host seeds significantly affected the food consumption percentage of *C. chinensis.*
The per cent seed infestation on *V. radiata* (76.81%) was found to be the highest among all the seeds which was at par with *C. arietinum* (74.84%). The minimum infestation percentage was recorded on *F. semialata* (65.30%) which did not differ significantly from *F. macrophylla* (67.98%).

Table 3: Fecundity, rate of oviposition, per cent food consumption and per cent infestation (mean±SE) by *Callosobruchus chinensis* on different stored seeds

Host seeds	Fecundity (no. of eggs/ female)	Rate of oviposition (no. of eggs/day/female)	Percentage food consumption	Percentage infestation
Flemingia macrophylla	70.2±0.73	7.42±0.320	52.54±1.08 (46.44)	67.98±0.75 (55.52)
Flemingiasemialata	67.6±0.51	6.24±0.323	50.98±0.55 (45.54)	65.30±3.21 (53.60)
Vigna radiata	77.4±1.43	8.04±0.474	57.82±0.28 (49.48)	76.81±0.88 (61.20)

Cicer arietinum	84.2±1.28	9.12±0.331	55.47±0.57 (48.12)	74.84±1.09 (59.89)
SEd±	1.5	0.520	0.561	1.610
CD (P=0.05)	3.17	1.112	1.200	3.443

*Data presented are the mean of five replications

The different morphological parameters studied for both male and female adult of *C. chinensis* were body weight, body length, body width, antennal length, elytral length and elytral width. Table 4 shows the data on relevant aspects.

Weight of adults of *C. chinensis*
It is evident from the data presented in table 4 that females are heavier than males. Moreover, host seeds had significant effect on the weights of adults of *C. chinensis*. The mean body weights of both the sexes of *C. chinensis* on different host seeds were presented in table 4. From the table it has been found that the weight of adult males of *C. chinensis* was found to be highest (5.06±0.05mg) when reared on *V. radiata*. The lowest body weight of adult male was 4.39±0.14 mg when reared on *F. macrophylla* which was statistically at par with *F. semialata*.
Similarly, the weight of adult females of *C. chinensis* was found to be highest on *V. radiata* (6.13±0.04 mg) followed by *C. arietinum* (5.43±0.03mg), *F. semialata* (5.25±0.01 mg) and *F. macrophylla* (5.11±0.03 mg). All the host seeds exhibited significant influence on female weight of *C. chinensis*.

Body length and width of *C. chinensis*
It is apparent from the data presented in table 4 that females of *C. chinensis* were larger in size than males. The maximum body length of male was recorded on *V. radiata* (3.86±0.05 mm) followed by *C. arietinum* (3.59±0.04 mm), *F. semialata* (3.48±0.01mm) and minimum on *F. macrophylla* (3.27±0.01mm). The body length of female *C. chinensis* on *V. radiata* (4.13±0.08 mm) was found to be significantly higher than other hosts. The shortest body length of female was recorded on *F. macrophylla* (3.68±0.02 mm) which was statistically at par with *F. semialata* (3.79±0.01 mm).
In respect of body width of male *C. chinensis*, the highest record (1.94±0.02mm) was obtained on *V. radiata*. The lowest body width (1.58±0.01mm) of male was found when insect was reared on *F. macrophylla*. The maximum body width of female was observed on *V. radiata* (2.14±0.01 mm) and minimum on *F. macrophylla* (1.77±0.01 mm). All the host seeds had significant effect on body width of both male and female adults.Observations made by Devi and Devi (2014) [5] on *V. radiata* seed had been in agreement with the findings.

Antennal length of *C. chinensis*
It is apparent from the table that antennal size of male adult is larger than female adult. Moreover, male antennae were of pectinate while in female it was serrated. The highest antennal length in case of male *C. chinensis* was recorded on *V. radiata* (3.43±0.01 mm), while shortest was found on *F. macrophylla* (3.02±0.01mm). In case of female, antennal length was maximum on *V. radiata* (2.45±0.01mm) and shortest antennal length was found on *F. macrophylla* (2.17±0.05 mm).

Elytral length and width of *C. chinensis*
Elytral length computed for male *C. chinensis* revealed that on *V. radiata* (2.21±0.01mm) insect exhibited maximum length. Whereas, it was found to be minimum (1.92±0.02 mm) on *F. macrophylla*. The maximum elytral length of female *C. chinensis* was recorded on *V. radiata* (2.65±0.02 mm). Whereas, it was recorded to be minimum on *F. macrophylla* (2.45±0.01mm).
Similarly, elytral width of male *C. chinensis* was maximum on *V. radiata* (1.21±0.01mm). The minimum elytral width of male insect was noticed on *F. macrophylla* (0.93±0.01 mm). In case of female, elytral width observed on *V. radiata* (1.38±0.01 mm) was maximum and *F. macrophylla* (1.22±0.01mm) accounted for minimum elytral width in female. All the host seeds exhibited significant influence on elytral length and width of both male and female adult of *C. chinensis.*
Studies on the developmental and reproductive parameters of *C. chinensis* on different stored seeds revealed that *V. radiata* is the most preferable host followed by *C. arietinum*, *F. macrophylla* and *F. semialata.* The infestation of the pest started from field to storage and it is essential to have the thorough knowledge on the biology of the pest.

Table 4: Morphometric study (mean±SE) of *Callosobruchus chinensis* on different stored seeds

Host seeds	Body weight (mg)		Body length (mm)		Body width (mm)		Antennal length (mm)		Elytral length (mm)		Elytral width (mm)	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Flemingia macrophylla	4.39±0.14	5.11±0.03	3.27±0.01	3.68±0.02	1.58±0.01	1.77±0.01	3.02±0.01	2.17±0.05	1.92±0.02	2.45±0.01	0.93±0.01	1.22±0.01
Flemingiasemialata	4.58±0.02	5.25±0.01	3.48±0.01	3.79±0.01	1.61±0.01	1.86±0.01	3.10±0.03	2.22±0.01	1.95±0.01	2.43±0.01	1.02±0.03	1.27±0.05
Vigna radiata	5.06±0.05	6.13±0.04	3.86±0.05	4.13±0.08	1.94±0.02	2.14±0.01	3.43±0.01	2.45±0.01	2.21±0.01	2.65±0.02	1.21±0.01	1.38±0.01
Cicer arietinum	4.78±0.04	5.43±0.03	3.59±0.04	3.94±0.05	1.77±0.01	1.98±0.03	3.37±0.02	2.34±0.01	2.15±0.01	2.52±0.01	1.14±0.01	1.30±0.07
SEd±	0.114	0.048	0.049	0.074	0.026	0.027	0.034	0.018	0.024	0.023	0.032	0.016
CD (P=0.05)	0.243	0.102	0.104	0.158	0.055	0.058	0.073	0.041	0.045	0.050	0.068	0.035

*Data presented are the mean of five replications

Conclusion
Studies on developmental and reproductive parameters of *C. chinensis* on different stored seeds revealed that *F. semialata* and *F. macrophylla* are less preferable host than *V. radiata* and *C. arietinum*. The infestation of the pest started from field to storage and it is essential to have the thorough knowledge on the biology of the pest.

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