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Research Article

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Age Specific and Female Fecundity Life Table of *Callosobruchus chinensis* Linn. on Green gram

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ABSTRACT

The cowpea weevil, Callosobruchus chinensis Linn. is reported to be the most damaging pest of stored legume seeds in the tropics and subtropics. In this study, biology and life table parameters of the pest were investigated on green gram under laboratory condition at temperature of 25±3˚C and 78±5% relative humidity. The experiments began from eggs and continued to the end of adult longevity. The result showed that mean length of generation (T) were 44.87 days in first generation and 42.68 days in second generation net reproductive rates (R_0) were 11.64 females per female in first generation and 13.74 females per female in second generation. The approximate rate of increase (r_{approx}) was recorded slightly lower than the actual rate of natural increase ($r_{accurate}$) and those were 0.547 females per female per day and 0.061 females per female per day respectively in first generation while in second generation those were similar i.e. 1.056 females per female per day and 0.061 females per female per day respectively. Finite rate of increase was 1.056 females per female per day in first generation and 1.063 females per female per day in second generation. Potential fecundity in first generation 27.50 females per female, and in second generation 28.50 females per female. Doubling time (DT) and weekly rate of increase (WRI) was 12.66 days and 1.46 females per female respectively in first generation and decreased to 11.28 days in second generation followed by the increasement of weekly rate of increase to 1.53 females per female in second generation.

Key words: *Callosobruchus , Green gram , Age specific life table, Female fecundity table, Doubling time.*

INTRODUCTION

The green gram, *Vigna radiata* is economically most important pulse crop. It is an important pulse crop in almost all states of the country. Seeds of green gram are highly nutritious containing 24.6% protein, 1.0% fat, 57.5% carbohydrate, Ca 0.08g, P 0.045g, Fe 5.7 mg, vitamin 750 IU, thiamin 0.525mg, riboflavin 300mg and fiber 2.2 gm per 100 gm and provide 234 cal energy[16].

Green gram is attacked by a number of insect pests which causes huge losses during storage[1]. Among the various pests the pulse beetle *Callosobruchus chinensis* L. is one of the most destructive. *C. chinensis* is a cosmopolitan polyphagous pest in the most tropics and subtropics[15].This weevil is reported to be the most damaging pest of legume seeds. Eggs are laid on the seeds surface in stored or pods in the fields and larvae develop within seeds causing weight loss, decreased germination potential and reduction in commercial value[4]. Beetle populations built rapidly in storage. The seeds may be almost completely hollowed out by feeding activities of the larvae, and characteristic emergence hole are evident after the adult leaves the seeds[8].

Because of the economic importance and wide spread distribution, the development of suitable control measures for this pest is essential. As it is difficult to find suitable, cheap methods of control, emphasis should be placed on developing new plant varieties that have a natural resistance to bruchids as well as high yield[8]. Several studies, mainly in the Indian subcontinent, report on the biology of *Callosobruchus* on various pulses[3,11,12,13]. The knowledge on pest resistance characteristics of seeds and the biology of the pest is therefore very important to achieve this goal.

In ecological study, life table is a most important analytical tool, which provides detailed information of population dynamics to generate simple but more informative statistics. It also gives a comprehensive description of the survivorship, development and expectation of life[2]. The collection of data on life-table at particular temperature and humidity gives an important task for pest management in different environmental conditions. Therefore, in present investigation age and female fecundity life table of *C. chinensis* were evaluated on most preferred legume seeds of green gram under laboratory condition.

MATERIALS AND METHODS

At the beginning of experiments, to synchronize the age of eggs, ten pairs of *C. chinensis* were transferred from the stock culture on 100 gram of green gram seeds. After 12 hrs 100 laid eggs on seeds were collected for further investigation. The collected eggs were transferred into containers (10 cm diameter and 4.5 cm height)which was covered with white cloth. The collected eggs were checked daily until the emergence of adults. Incubation and larval periods and their mortality were recorded. As the larvae were internal feeder it is very difficult to record exact data on larval and pupal period i.e. the developmental period of the insect. Seeds were splitted out to observe the stage of development of insect after certain intervals. Duration of adult longevity was also recorded daily until death of last female. After emergence of adults, each females with one male was placed into each plastic case (10 cm diameter and 4.5 cm height) containing green gram. The duration of oviposition and post-oviposition periods as well as longevity, daily fecundity (eggs per reproduction day) and total fecundity (eggs during reproduction period) were recorded of two successive generations. After the end of the life table experiment the insects which failed to come out from the seeds were observed minutely by splitting the seeds under the binocular microscope and the stages of the dead insects were also recorded.

Age-specific survival (lx) and mortility (dx) were used to construct the age-specific survivorship life table. Age-specific survival (lx) and average number of female offspring (mx) for each age interval (x) were used to construct age-specific female fertility life tables. Using survivorship and fertility schedules, the demographic parameters of *C. chinensis* including net reproductive rate (R_0), mean length of generation (T), approximate rate of increase (r_{approx}), actual rate of natural increase ($r_{accurate}$), finite rate of increase(λ), potential fecundity (Pf), doubling time (DT), weekly rate of increase (λ^7) were calculated.

RESULTS

The details of the Table 1 and 2 revealed that the age specific survival (lx) of *C. chinensis* decreases at a regular interval from the day after laying of egg on green gram. Where, 100 eggs have been taken as a initial cohort on the grains. A sharp decline in survival was recorded from the very beginning of its starting of life. After a period of interval the population again decreases due to adult mortality. The sharp decrease of survivorship was noticed from 36rd days and 37th days during first and second generations respectively. These trends were maintained for next few days till the mortality of all the adults. The survival pattern of these insect was more or less similar in two generations. However, a slight deviation in early period of life can be observed.

Life expectancy (ex) of *C. chinensis* was recorded. A gradual decrease in 'ex' was found with the advancement of age of the insect. The expectancy of life was quite high at early age and it was recorded from the beginning of the life to 12th day on green gram. Survival of the insects dropped quickly after 36th day in first generation while in the second generation it was 35th day. This finding indicates that the diet was more or less equally suitable for every generation. Expectancy (ex) of remaining individuals increased initially in green gram due to constant egg mortality in each generation. Expectancy gradually decreased as the larvae grew older. Sharp decrease in the mean length of the generations from the beginning of pupation and subsequent adult mortality (Fig 1 and 2). The increase in expectancy was common to any population which suffered heavy loss at any stage of its development. Generally after 4 to

5 days these rate decrease sharply due to ageing of the female. At the middle age, expectancy was within 16 to 23 days where as on cessation it was 0.5 days.

Perusal of Tables 3 and 4 depicted that the pre-reproductive period of *C. chinensis* was very short in both the generations. The female adults were recorded to start lay egg within 24 h after emergence from the pupal case in the pulse seeds during each generation.

The reproductive period of the insect in green gram was recorded from 42.5 days to 47.5 days in first generation while it was 40.5 days to 44.5 days in second generation. In the first generation, at the beginning of the egg laying the survival of female (lx) or proportional survival of female at age 'x' was 0.53 and 0.54 in second generation for green gram. Afterwards, these proportion decrease steadily due to death of female. Natality rate (mx) i.e. the number of female offspring produced per female at the age 'x' was not similar during the whole length of reproductive period. Natality rate was higher in second generation (3.00) than the first generation (4.50).

Table 1. Age Specific survivorship of *C. chinensis* on green gram (First generation)

x	lx	dx	100*qx	Lx	Tx(=∑Lx)	ex
0	100.00	4.00	4.00	98.00	3076.00	30.76
1	96.00	4.00	4.17	94.00	2978.00	31.02
2	92.00	4.00	4.35	90.00	2884.00	31.35
3	88.00	4.00	4.55	86.00	2794.00	31.75
4	84.00	4.00	4.76	82.00	2708.00	32.24
5	80.00	4.00	5.00	78.00	2626.00	32.83
6	76.00	0.00	0.00	76.00	2548.00	33.53
7	76.00	1.00	1.32	75.50	2472.00	32.53
8	75.00	1.00	1.33	74.50	2396.50	31.95
9	74.00	1.00	1.35	73.50	2322.00	31.38
10	73.00	1.00	1.37	72.50	2248.50	30.80
11	72.00	1.00	1.39	71.50	2176.00	30.22
12	71.00	1.00	1.41	70.50	2104.50	29.64
13	70.00	1.00	1.43	69.50	2034.00	29.06
14	69.00	0.00	0.00	69.00	1964.50	28.47
15	69.00	0.00	0.00	69.00	1895.50	27.47
16	69.00	0.00	0.00	69.00	1826.50	26.47
17	69.00	0.00	0.00	69.00	1757.50	25.47
18	69.00	0.00	0.00	69.00	1688.50	24.47
19	69.00	0.00	0.00	69.00	1619.50	23.47
20	69.00	0.00	0.00	69.00	1550.50	22.47
21	69.00	1.00	1.45	68.50	1481.50	21.47
22	68.00	1.00	1.47	67.50	1413.00	20.78
23	67.00	1.00	1.49	66.50	1345.50	20.08
24	66.00	1.00	1.52	65.50	1279.00	19.38
25	65.00	1.00	1.54	64.50	1213.50	18.67
26	64.00	1.00	1.56	63.50	1149.00	17.95
27	63.00	1.00	1.59	62.50	1085.50	17.23
28	62.00	1.00	1.61	61.50	1023.00	16.50
29	61.00	1.00	1.64	60.50	961.50	15.76
30	60.00	1.00	1.67	59.50	901.00	15.02
31	59.00	1.00	1.69	58.50	841.50	14.26
32	58.00	1.00	1.72	57.50	783.00	13.50
33	57.00	1.00	1.75	56.50	725.50	12.73
34	56.00	1.00	1.79	55.50	669.00	11.95
35	55.00	1.00	1.82	54.50	613.50	11.15
36	54.00	1.00	1.85	53.50	559.00	10.35
37	53.00	0.00	0.00	53.00	505.50	9.54
38	53.00	0.00	0.00	53.00	452.50	8.54
39	53.00	0.00	0.00	53.00	399.50	7.54
40	53.00	0.00	0.00	53.00	346.50	6.54
41	53.00	0.00	0.00	53.00	293.50	5.54
42	53.00	2.00	3.77	52.00	240.50	4.54
43	51.00	4.00	7.84	49.00	188.50	3.70
44	47.00	6.00	12.77	44.00	139.50	2.97
45	41.00	6.00	14.63	38.00	95.50	2.33

46	35.00	10.00	28.57	30.00	57.50	1.64
47	25.00	11.00	44.00	19.50	27.50	1.10
48	14.00	13.00	92.86	7.50	8.00	0.57
49	1.00	1.00	100.00	0.50	0.50	0.50

X: age of the insect in days; lx: no. of surviving at the beginning of each age interval x; dx: no. of dying within age interval x to x+1; 100qx: mortality rate at the age interval x to x+1; Lx: average no. survives at the age interval x to x+1; ex; expectation of life at the beginning of each age interval x.

Table 2. Age Specific survivorship of *C. chinensis* on green gram (Second generation)

x	lx	dx	100*qx	Lx	Tx(=∑Lx)	ex
0	100.00	3.00	3.00	98.00	3046.00	30.46
1	96.00	3.00	3.13	94.00	2948.00	30.71
2	92.00	3.00	3.26	90.00	2854.00	31.02
3	88.00	3.00	3.41	86.00	2764.00	31.41
4	84.00	3.00	3.57	82.00	2678.00	31.88
5	80.00	3.00	3.75	78.00	2596.00	32.45
6	76.00	1.00	1.32	76.00	2518.00	33.13
7	76.00	0.00	0.00	75.50	2442.00	32.13
8	75.00	1.00	1.33	74.50	2366.50	31.55
9	74.00	1.00	1.35	73.50	2292.00	30.97
10	73.00	1.00	1.37	72.50	2218.50	30.39
11	72.00	1.00	1.39	71.50	2146.00	29.81
12	71.00	1.00	1.41	70.50	2074.50	29.22
13	70.00	1.00	1.43	69.50	2004.00	28.63
14	69.00	1.00	1.45	69.00	1934.50	28.04
15	69.00	0.00	0.00	69.00	1865.50	27.04
16	69.00	0.00	0.00	69.00	1796.50	26.04
17	69.00	0.00	0.00	69.00	1727.50	25.04
18	69.00	0.00	0.00	69.00	1658.50	24.04
19	69.00	1.00	1.45	69.00	1589.50	23.04
20	69.00	1.00	1.45	69.00	1520.50	22.04
21	69.00	1.00	1.45	68.50	1451.50	21.04
22	68.00	1.00	1.47	67.50	1383.00	20.34
23	67.00	1.00	1.49	66.50	1315.50	19.63
24	66.00	1.00	1.52	65.50	1249.00	18.92
25	65.00	1.00	1.54	64.50	1183.50	18.21
26	64.00	1.00	1.56	63.50	1119.00	17.48
27	63.00	1.00	1.59	62.50	1055.50	16.75
28	62.00	1.00	1.61	61.50	993.00	16.02
29	61.00	1.00	1.64	60.50	931.50	15.27
30	60.00	1.00	1.67	59.50	871.00	14.52
31	59.00	1.00	1.69	58.50	811.50	13.75
32	58.00	1.00	1.72	57.50	753.00	12.98
33	57.00	1.00	1.75	56.50	695.50	12.20
34	56.00	1.00	1.79	55.50	639.00	11.41
35	55.00	1.00	1.82	54.50	583.50	10.61
36	54.00	1.00	1.85	53.50	529.00	9.80
37	53.00	1.00	1.89	53.00	475.50	8.97
38	53.00	1.00	1.89	53.50	422.50	7.97
39	54.00	0.00	0.00	54.00	369.00	6.83
40	54.00	0.00	0.00	54.00	315.00	5.83
41	54.00	1.00	1.85	53.50	261.00	4.83
42	53.00	2.00	3.77	52.00	207.50	3.92
43	51.00	3.00	5.88	49.50	155.50	3.05
44	48.00	5.00	10.42	45.50	106.00	2.21
45	43.00	14.00	32.56	36.00	60.50	1.41
46	29.00	19.00	65.52	19.50	24.50	0.84
47	10.00	10.00	100.00	5.00	5.00	0.50

X: age of the insect in days; lx: no. of surviving at the beginning of each age interval x; dx: no. of dying within age interval x to x+1; 100qx: mortality rate at the age interval x to x+1; Lx: average no. survives at the age interval x to x+1; ex; expectation of life at the beginning of each age interval x.

The net reproductive rate (R_o) estimated as 11.64 females per female in first generation and 13.74 females per female in second generation in green gram. While mean length of generation (T) were 44.87 days in first generation and 42.68 days in second generation in green gram. The approximate rate of increase (r_{approx}) was recorded slightly lower than the actual rate of natural increase ($r_{accurate}$) and those were 0.547 females per female per day and 0.055 females per female per day respectively in first generation while in second generation those were similar i.e. 0.061 females per female per day. Finite rate of increase was 1.056 females per female per day in first generation and 1.063 females per female per day in second generation. Potential fecundity slightly lower in first generation (27.50 females per female) than in second generation (28.50 females per female). Doubling time and weekly rate of increase was 12.66 days and 1.46 females per female respectively in first generation while doubling time was decreased to 11.28 days in second generation followed by the increasement of weekly rate of increase to 1.53 females per female in second generation.

DISCUSSION

Perusal of Tables 1 and 2 reveal that the age specific survival (lx) of *C. chinensis* decreased at a regular interval for in first few days both in green gram due to egg mortality and subsequent reduction in survival was observed due to the mortality of the last instar larvae. Generally after 4 to 5 days these rate decrease sharply due to ageing of the female[14].Survival of the insects dropped quickly after 35th days in average in both two generations. This finding indicates that the diet was more or less equally suitable for every generation. Expectancy (ex) of remaining individuals increased initially in green gram due to constant egg mortality in each generation. Expectancy gradually decreased as the larvae grew older. Sharp decrease in the mean length of the generations from the beginning of pupation and subsequent adult mortality (Fig 1 - 2). The increase in expectancy was common to any population which suffered heavy loss at any stage of its development[6,9]. Moreover, at the middle age, expectancy was within 16 to 23 days where as on cessation it was 0.5 days on green gram[14].

Perusal of Table 3 and 4 revealed that the survival fraction of *C. chinensis* at the beginning of the egg laying was 0.53 in first generation and 0.54 in second generation in green gram. The natality rate (mx) fluctuated in all the two consecutive generations in green gram. These findings showed that each group did not contribute equally towards intrinsic rate of increase of the insect[5].

To understand the population growth of this insects, various life parameters viz, mean length of generation (T), net reproductive rate (R_0), potential fecundity (Pf), intrinsic rate of increase (r), finite rate of increase (λ), doubling time (DT) and weekly rate of increase (WRI) were also computed. Mean length in first generation was slightly higher than that of second generation in both the pulses. However, R_0 was lesser in first generation than second generation in green gram. In green gram DT was recorded 12.66 and 11.28 respectively in two successive generations. The result revealed that the rate of population increase was accelerated in second generation then in the first[10].Comparing the R_0 values of *C. chinensis* on two successive generations , it can be concluded that the R_0 value was increasing and thus the bruchid can multiply faster on green gram [10]. These results revealed that on the same diet the insect could complete its life cycle within shorter time period in the second generation and multiply comparatively more in number. The approximate rate of increase (r_{approx}) was slightly lower than the actual rate of natural increase ($r_{accurtae}$) in each generation which indicated the population trend towards overlapping generation. However, these rate of increase gradually increases in the subsequent generation in green gram. Similarly, population multiplication in a unit time (λ) also increase with continuous rearing. Doubling time (DT) i.e. time required for population to be doubled, was decreased during successive generation while potential fecundity (Pf) of second generation was higher. Weekly rate of increase (WRI) indicated gradual increase in the population upon continuous rearing beyond first generation. These life parameters suggest that the efficiency of green gram to support the population development of *C. chinensis* increased gradually from one generation to the other generation. Moreover, general comparison of biological parameters of *C. chinensis* between two consecutive generations, it can be concluded that green gram is the adapted host for the bruchid .Therefore, *C. chinensis* able to produce higher population on green gram and causes considerable damage on it[10].

Table 3. Age specific female fertility life table of *C. chinensis* on green gram (First generation)

x	lx	mx	lx.mx	x.lx.mx
Immature stages and pre-reproductive period = 0.5 to 41.5 days				
42.50	0.53	2.50	1.325	56.31250
43.50	0.51	3.00	1.530	66.55500
44.50	0.47	6.50	3.055	135.94750
45.50	0.41	8.50	3.485	158.56750
46.50	0.35	5.00	1.750	81.37500
47.50	0.25	2.00	0.500	23.75000
r(approx)=.0547112		**Σmx=27.50**	**Σlx.mx=11.6450**	**Σx.lx.mx=522.5075**

$e^{-rx.lx.mx}$ **(r = 0.0547659)**	**Cal(k)**	**%Contribution***	**%Contribution(k)**
0.1292326	1.519418	12.92121	12.92121
0.1412743	1.660995	14.12519	14.12519
0.2670536	3.139811	26.70112	26.70113
0.2884068	3.390865	28.83610	28.83610
0.1371059	1.611986	13.70842	13.70842
0.0370854	0.436022	3.707957	3.707957
sum=1.000159	**∑Cal(k)=11.75909**	**∑%Contr. =99.9**	**∑%Contr.(k) =100**

∑x.lx.mx	: 522.5075
Net reproductive rate (R_0) = ∑lx.mx	: 11.64 females / female
Mean length of generation(T)= ∑x.lx.mx/∑lx.mx	: 44.87 days
Approximate rate of increase(r_{approx})=$\log_e R_0$/T	: 0.547 females/♀/day
Actual rate of natural increase ($r_{accurtae}$)=	: 0.055 females/♀/day
Finite rate of increase (λ) =$e^{r(accurate)}$)	: 1.056 females/♀/day
Potential fecundity (Pf)= ∑mx	: 27.50 females/female
Doubling time (DT) = $\log_e 2/\log_e \lambda$	: 12.66 days
Weekly rate of increase(WRI) = λ^7	: 1.46 females/female

X: pivotal age in days; lx: survival fraction of females; mx: natality rate;
* : % contribution of each group towards 'r'

Table 4. Age specific female fertility life table of *C. chinensis* on green gram (Second generation)

x	lx	mx	lx.mx	x.lx.mx
Immature stages and pre-reproductive period = 0.5 to 39.5 days				
40.50	0.54	3.00	1.620	65.6100
41.50	0.54	4.50	2.430	100.8450
42.50	0.53	7.00	3.710	157.6750
43.50	0.51	7.50	3.825	166.3875
44.50	0.48	4.50	2.160	96.1200
r(approx)=0.061403		**Σmx=26.50**	**Σlx.mx=13.74**	**Σx.lx.mx=586.6375**

$e^{-rx.lx.mx}$ **(r = 0.0614642)**	**Cal(k)**	**%Contribution***	**%Contribution(k)**
0.1344082	1.831901	13.43719	13.43719
0.1895936	2.584043	18.95423	18.95423
0.2722059	3.709999	27.21324	27.21324
0.2639135	3.596978	26.38421	26.38422
0.1401491	1.910146	14.01112	14.01112
∑ $e^{-rx.lx.mx}$ =1.00027	**∑Cal(k)=13.63307**	**∑%Contr =100**	**∑%Contr.(k)=100**

∑x.lx.mx	: 586.6375
Net reproductive rate (R_0) = ∑lx.mx	: 13.74 females / female
Mean length of generation(T)= ∑x.lx.mx/∑lx.mx	: 42.68 days
Approximate rate of increase(r_{approx})=$log_e R_0$/T	: 0.061 females/♀/day
Actual rate of natural increase ($r_{accurtae}$)	: 0.061 females/♀/day
Finite rate of increase (λ) =$e^{r(accurate)}$	: 1.063 females/♀/day
Potential fecundity (Pf)= ∑mx	: 28.50 females/female
Doubling time (DT) = $log_e 2/log_e λ$	: 11.28 days
Weekly rate of increase(WRI) = $λ^7$	: 1.53 females/female

X: pivotal age in days; lx: survival fraction of females; mx: natality rate;
* : % contribution of each group towards 'r'

Fig. 1: Age specific survivorship (lx) and life expectancy (ex) of *C. chinensis* on green gram during life period (First generation)

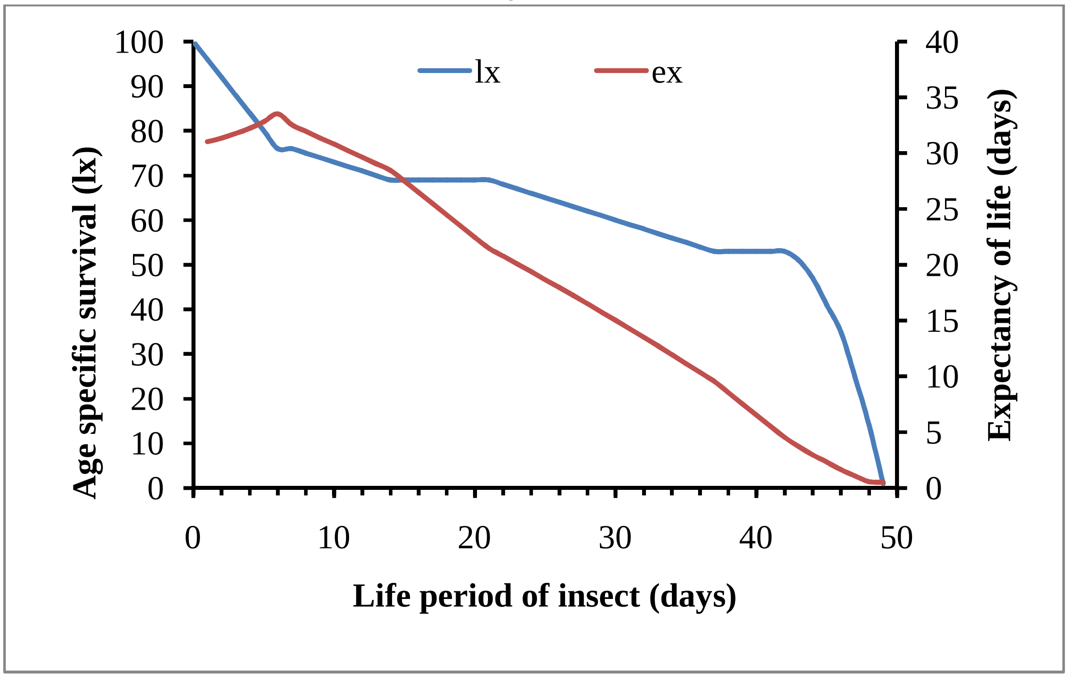
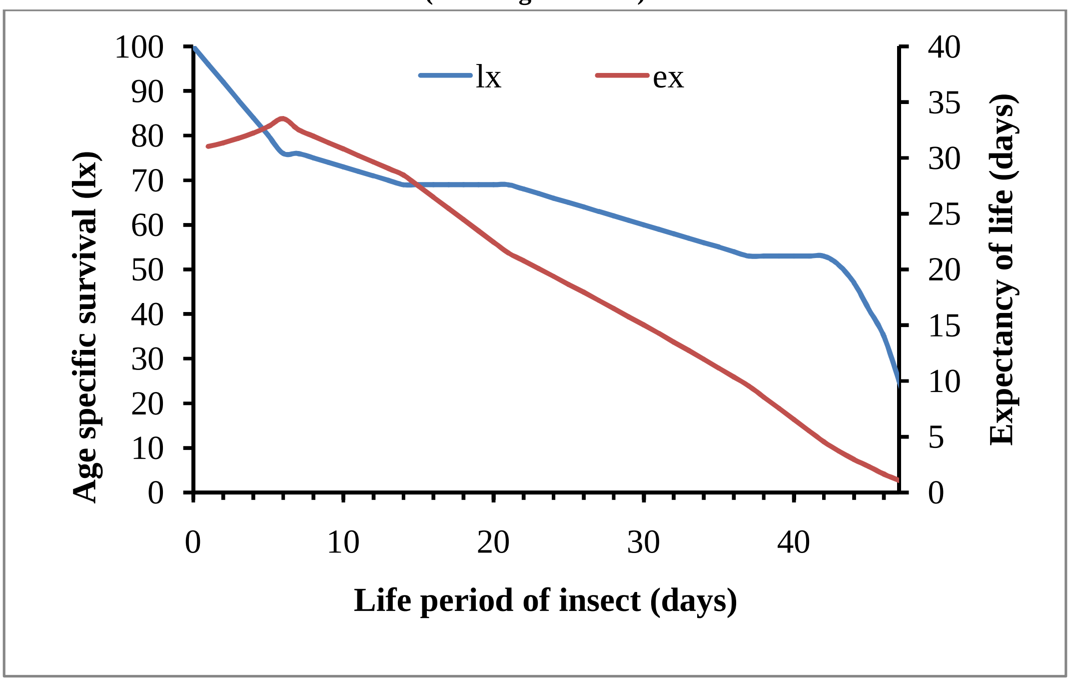


Fig. 2: Age specific survivorship (lx) and life expectancy (ex) of *C. chinensis* on green gram during life period (Second generation)



CONCLUSION

A life table is a kind of book-keeping system that ecologists often used to keep track of stage specific mortality in the population they study. A life describes for successive age intervals, the number of deaths, the survivors, the rate of mortality and the expectation of further life. It is an especially useful approach in entomology, where developmental stages are discrete and mortality rates may vary widely from one life stage to another. The construction of several life tables may be possible to prepare a predictive model which can be tested against natural population fluctuations**. Thorough understanding of the biology and ecology of the pest on different pulse seeds of different cultivar needs to be worked out for proper management of the insect. So the insect can not cause damage to a large amount of pulses in storage.**

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