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AGE SPECIFIC SURVIVORSHIP, FEMALE FECUNDITY LIFE TABLE, POPULATION GROWTH PARAMETERS AND STAGE SPECIFIC LIFE TABLE OF *Callosobruchus chinensis* Linn. ON COWPEA (*Vigna Unguiculata* L.) UNDER LABORATORY CONDITIONS

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ABSTRACT

The cowpea weevil, *Callosobruchus chinensis* Linn., is reported to be one of the most damaging pests of stored legume seeds in tropical and subtropical regions. In the present investigation, age-specific survivorship and female fecundity life table parameters of the pest were studied on cowpea (*Vigna unguiculata* L.) variety CPD-119 under laboratory conditions at temperature of 29 ± 1.5^{0}C and 75 ± 5 per cent relative humidity. The experiment was initiated from freshly laid eggs and continued until the end of adult longevity. The results revealed that the net reproductive rate (R_0) was recorded as 3.72 females per female and the mean length of generation (T) was 26.34 days. The intrinsic rate of natural increase (rm) and finite rate of increase (λ) were observed as 0.0498 females per female per day and 1.05 females per female per day, respectively. Potential fecundity was recorded as 21.50 females per female. Doubling time (DT) and weekly rate of increase (WRI) were 13.92 days and 1.42 times, respectively. The stable age distribution revealed maximum contribution of larval stage (58.30%) followed by egg (21.11%), pupal (10.33%) and adult stage (10.27%). The stage-specific life table indicated maximum apparent mortality during larval stage (25.77%) followed by pupal stage (15.28%) and egg stage (3.00%) with total generation mortality (K-value) of 0.21. The findings provide information on the survival, reproduction and population growth potential of *C. chinensis* on cowpea under storage conditions.
Keywords **:** *Callosobruchus chinensis*, Cowpea, Age specific life table, Female fecundity table, Stable age distribution.

Introduction

Cowpea, *Vigna unguiculata* (L.) Walp., is an important food legume grown extensively in tropical and subtropical regions. It is valued for its nutritional composition and serves as a rich source of plant-based protein, carbohydrates, vitamins and essential minerals. Due to its adaptability and nutritional importance, cowpea plays a significant role in food and nutritional security, particularly in developing countries (Singh *et al*., 2003).

Despite of its importance, stored cowpea seeds are highly vulnerable to infestation by bruchid beetles, which cause substantial losses during storage. Among them, the pulse beetle, *Callosobruchus chinensis* Linn. (Coleoptera: Chrysomelidae), is regarded as a serious pest of stored pulses. Adult females deposit eggs on the seed coat and the newly hatched larvae penetrate into the seeds, where internal feeding causes seed damage. Infestation results in loss of seed weight, reduction in germination capacity, deterioration of seed quality and decreased economic value (Southgate, 1979; Rees, 2004).

The reproductive ability and population development of storage pests are strongly influenced by host characteristics and environmental conditions. Knowledge of survival, mortality and reproductive potential of *C. chinensis* on different host seeds is essential for understanding its population growth

pattern and developing suitable management approaches. Life table analysis is a valuable ecological method used to study insect population dynamics. It provides information on survival rate, mortality pattern, reproductive capacity and population growth of insects under specific environmental conditions. Parameters such as net reproductive rate, intrinsic rate of increase, finite rate of increase and generation time help in assessing the ability of an insect population to multiply on a particular host (Birch, 1948; Southwood, 1978).

Considering the importance of life table studies in predicting pest population growth, the present investigation was undertaken to determine the age-specific survivorship, female fecundity life table, stable age distribution and stage-specific life table parameters of *C. chinensis* on cowpea variety CPD-119 under laboratory conditions.

Materials and Methods

The present investigation was carried out in the Storage Laboratory, Department of Entomology, S.K.N. College of Agriculture, Jobner to study the age-specific survivorship and female fecundity life table of *C. chinensis* on cowpea variety CPD-119. The experiment was conducted under laboratory conditions at 29 ± 1.5°C temperature and 75 ± 5 per cent relative humidity. Healthy cowpea seeds were cleaned, washed, sun dried and sterilized in a hot air oven at 55°C for five hours to eliminate any hidden insect infestation. The sterilized seeds were conditioned for 48 hours under laboratory conditions before being used for the experiment. The initial culture of *C. chinensis* was obtained from the stock culture maintained in the Storage Laboratory, Department of Entomology, S.K.N. College of Agriculture, Jobner. Freshly emerged adults (0–24 hours old) were used for maintaining the culture. The insect culture was maintained by releasing 20 pairs of freshly emerged adults into glass jars (18 × 10 cm) containing 500 g cowpea seeds for oviposition. The subsequent generations obtained from the culture were utilized for conducting the experiment. At the beginning of the experiment, to synchronize the age of eggs, freshly emerged adults (0–24 hours old) of *C. chinensis* were released on cowpea variety CPD-119 seeds for oviposition. After obtaining freshly laid eggs of uniform age, the adults were removed and 100 eggs were selected for initiating the life table study. The selected eggs were observed regularly and observations on survivorship and mortality were recorded from the egg stage until the death of the last emerged adult under laboratory conditions of 29 ± 1.5°C temperature and 75 ± 5 per cent relative humidity.

The age-specific life table was constructed by recording age interval (x), number of individuals surviving at the beginning of each age interval (lx), number of individuals dying during each age interval (dx), mortality rate (100qx), average number of individuals alive between ages x and x+1 (Lx), total number of individuals of x age units and beyond (Tx) and expectation of further life (ex).

For the determination of female fecundity life table, newly emerged females of *C. chinensis* were paired with males and observed throughout their reproductive period. Daily egg laying was recorded to calculate the age-specific female survivorship (lx), age-specific fecundity (mx), number of female births at each age interval (lxmx) and age-specific birth schedule (x.lxmx). The data obtained were utilized for estimating different population growth parameters such as net reproductive rate (R_0), mean length of generation (T), intrinsic rate of natural increase (rm), finite rate of increase (λ), doubling time (DT) and weekly rate of increase (WRI). The stable age distribution and stage-specific life table were also prepared to determine the age structure, stage-wise survival and mortality pattern of *C. chinensis* on cowpea (Southwood (1968), Birch (1948), Howe (1953) and Atwal and Bains (1974)).

Results and Discussion

Age-specific life table and survivorship of *C. chinensis* on cowpea

The data presented in Table 1 and Fig. 1 revealed observations recorded from egg stage until the death of the last adult. The egg stage extended from 0–2 days, larval stage from 3–15 days, pupal stage from 16–20 days and adult stage from 21–33 days. The life table was initiated with 100 freshly laid eggs. The number of surviving individuals (lx) decreased gradually with advancement of age. The survived population remained 100 individuals during the initial egg period and declined to 97 individuals at the end of egg stage. During larval stage, survivorship decreased from 97 individuals to 72 individuals, whereas in the pupal stage it declined from 72 to 61 individuals. In the adult stage, continuous reduction in survivorship was recorded from 61 individuals on day 21 to one individual on day 33. The mortality rate (100qx) varied during different developmental stages. The egg stage recorded 3.00 per cent mortality. During larval stage, mortality ranged from 0.00 to 7.69 per cent, while in pupal stage it varied from 0.00 to 6.94 per cent. The expectation of further life (ex) was maximum at the beginning of the life cycle (22.19 days) and gradually decreased with advancement of age, reaching 0.50 days

at the end of adult life. The results indicated that survivorship and life expectancy of *C. chinensis* decreased gradually with increase in age. Similar observations were recorded by Chakraborty and Mondal (2015), who studied the age-specific life table of *C. chinensis* on green gram and reported a gradual decline in survivorship (lx) and life expectancy (ex) with advancement of age. The findings of Kamble (2008), Kale (2017) and Ravivarman (2021) also coincide with the present results, where reduction in survival of *C. chinensis* was observed on different leguminous hosts.

Age-specific survivorship and fecundity of female *C. chinensis* on cowpea

The age-specific survivorship (lx) and fecundity (mx) of female *C. chinensis* on cowpea are presented in Table 2 and Fig. 2. The first oviposition was recorded on the 25th day of the life cycle. Maximum age-specific fecundity (mx) was observed on the 25th day with 6.90 eggs per female. Thereafter, fecundity gradually decreased and was recorded as 4.00, 4.30, 2.40, 1.60, 1.10, 0.80 and 0.40 eggs per female from the 26th to 32nd day, respectively. No egg laying was observed on the 33rd day. The total female births (lxmx) were maximum on the 25th day (1.38) and declined gradually during the succeeding age intervals. The total age-specific fecundity (Σmx), total female births (Σlxmx) and total age-specific birth schedule (Σx.lxmx) were recorded as 21.50, 3.72 and 98.00, respectively. Chakraborty and Mondal (2015) recorded potential fecundity of 27.50–28.50 females/female in *C. chinensis* on green gram. Similar observations were reported by Chudasama *et al.* (2016) and Singh *et al.* (2022), who observed variation in fecundity and reproductive performance of bruchids on different pulse hosts and tshe variation in fecundity might be due to differences in host suitability and nutritional characteristics of seeds.

Table 1 : Age specific life table and survivorship of *Callosobruchus chinensis* on cowpea under laboratory conditions

x		lx	dx	100qx	Lx	Tx= ΣLx	ex	
0	Egg	100	0	0.00	100.00	2219.00	22.19	Gradual decrease of ex
1		100	0	0.00	100.00	2119.00	21.19	
2		100	3	3.00	98.50	2019.00	20.19	
3	Larva	97	2	2.06	96.00	1920.50	19.80	
4		95	0	0.00	95.00	1824.50	19.21	
5		95	0	0.00	95.00	1729.50	18.21	
6		95	0	0.00	95.00	1634.50	17.21	
7		95	0	0.00	95.00	1539.50	16.21	
8		95	0	0.00	95.00	1444.50	15.21	
9		95	0	0.00	95.00	1349.50	14.21	
10		95	0	0.00	95.00	1254.50	13.21	
11		95	5	5.26	92.50	1159.50	12.21	
12		90	6	6.67	87.00	1067.00	11.86	
13		84	0	0.00	84.00	980.00	11.67	
14		84	6	7.14	81.00	896.00	10.67	
15		78	6	7.69	75.00	815.00	10.45	
16	Pupa	72	5	6.94	69.50	740.00	10.28	
17		67	2	2.99	66.00	670.50	10.01	
18		65	0	0.00	65.00	604.50	9.30	
19		65	0	0.00	65.00	539.50	8.30	
20		65	4	6.15	63.00	474.50	7.30	
21	Adult	61	5	8.20	58.50	411.50	6.75	
22		56	3	5.36	54.50	353.00	6.30	
23		53	1	1.89	52.50	298.50	5.63	
24		52	0	0.00	52.00	246.00	4.73	
25		52	0	0.00	52.00	194.00	3.73	
26		52	10	19.23	47.00	142.00	2.73	
27		42	10	23.81	37.00	95.00	2.26	
28		32	12	37.50	26.00	58.00	1.81	
29		20	8	40.00	16.00	32.00	1.60	
30		12	5	41.67	9.50	16.00	1.33	

31		7	5	71.43	4.50	6.50	0.93	
32		2	1	50.00	1.50	2.00	1.00	
33		1	1	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.

Population growth parameters of *C. chinensis* on cowpea

The population growth parameters of *C. chinensis* on cowpea are presented in Table 3. The net reproductive rate (R_0) was recorded as 3.72 females per female and the mean length of generation (Tc) was 26.34 days. The intrinsic rate of natural increase (rm) was observed as 0.0498 females/female/day, while the corrected rm was 0.05 females/female/day. The finite rate of increase (λ) was recorded as 1.05 females/female/day. The doubling time (DT), corrected generation time (T) and weekly rate of increase (WRI) were recorded as 13.92 days, 26.38 days and 1.42 times, respectively. The hypothetical F_2 female population was 13.84 and annual rate of increase (ARI) was 7.86×10^7. The positive values of R_0, rm and λ indicated an increasing population trend of the pest. The present findings are in close agreement with Chakraborty and Mondal (2015), who reported net reproductive rate (R_0), intrinsic rate of increase (rm) and finite rate of increase (λ) of *C. chinensis* on green gram as 11.64–13.74 females/female, 0.055–0.061 females/female/day and 1.056–1.063 females/female/day, respectively. Similar population growth trends were also recorded by Ravivarman (2021), Kale (2017) and Khedkar *et al*. (2023) on different pulse hosts.

Stable age distribution of *C. chinensis* on cowpea

The stable age distribution of *C. chinensis* on cowpea presented in Table 4 and Fig. 3 showed the contribution of different developmental stages in the population. The highest contribution was recorded in larval stage (58.30%) followed by egg stage (21.11%), pupal stage (10.33%) and adult stage (10.27%). The total birth rate (β) was recorded as 12.87362, while the stable age distribution value (px) was calculated as 0.07767. The instantaneous birth rate (b) and instantaneous death rate (d) were recorded as 2.55 and 2.50, respectively. The result suggested that immature stages constituted the major proportion of the stable population of *C. chinensis*, with larval stage showing maximum contribution. The higher proportion of larval stage might be due to its longer developmental duration compared to other stages. Similar findings were reported by Thite *et al*. (2025), who observed variation in stable age distribution of *C. chinensis* on green gram varieties, where immature stages contributed a major proportion of the population.

Table 2 : Age specific survivorship (lx) and fecundity (mx) of female of *Callosobruchus chinensis* on cowpea under laboratory conditions

x	lx	mx	lxmx	x.lxmx
25	0.20	6.90	1.38	34.50
26	0.20	4.00	0.80	20.80
27	0.20	4.30	0.86	23.22
28	0.13	2.40	0.31	8.74
29	0.13	1.60	0.21	6.03
30	0.09	1.10	0.10	2.97
31	0.06	0.80	0.05	1.49
32	0.02	0.40	0.01	0.26
33	0.01	0.00	0.00	0.00
		Σmx= 21.50	**Σlxmx= 3.72**	**Σx.lxlmx= 98.00**

x: pivotal age in days; lx: survival fraction of females; mx: natality rate

Table 3 : Life parameters of *C. chinensis* on cowpea under laboratory conditions

S. No.	Population growth parameters	Population growth parameters (statistical values)
1.	Net reproductive rate (R_0)	3.72 individuals /female
2.	Mean length of generation (Tc)	26.34 days
3.	Intrinsic rate of increase (rm)	0.0498 individuals/♀ /day
4.	Fluctuating rm (rc)	0.04 - 0.05
5.	Corrected rm	0.05 individuals/♀ /day
6.	Finite rate of increase (λ)	1.05 females/ ♀ /day
7.	Doubling time (DT)	13.92
8.	Corrected generation time (T)	26.38 days
9.	Weekly rate of increase (WRI)	1.42 times
10.	Hypothetical F_2 females	13.84
11.	Annual Rate of Increase (ARI)	7.86×10^7

Table 4 : Stable age distribution of *Callosobruchus chinensis* on cowpea (rm= 0.0499) under laboratory conditions

X	Lx	x+1	rm	rm (x+1)	e-rm (x+1)	Lx. e-rm (x+1)	Px. e-rm(x+1)	Px.100	Per cent contribution
0	1	1	0.04990	0.04990	0.95132	0.95132	0.07390	7.38969	Egg (21.11%)
1	1	2	0.04990	0.09980	0.90502	0.90502	0.07030	7.03004	
2	1	3	0.04990	0.14970	0.86097	0.86097	0.06688	6.68786	
3	0.99	4	0.04990	0.19960	0.81906	0.81087	0.06299	6.29869	Larva (58.30%)
4	0.96	5	0.04990	0.24950	0.77919	0.74802	0.05811	5.81051	
5	0.95	6	0.04990	0.29940	0.74126	0.70420	0.05470	5.47008	
6	0.95	7	0.04990	0.34930	0.70518	0.66992	0.05204	5.20383	
7	0.95	8	0.04990	0.39920	0.67086	0.63732	0.04951	4.95057	
8	0.95	9	0.04990	0.44910	0.6382	0.60629	0.04710	4.70955	
9	0.95	10	0.04990	0.49900	0.60714	0.57678	0.04480	4.48035	
10	0.95	11	0.04990	0.54890	0.57758	0.54870	0.04262	4.26221	
11	0.95	12	0.04990	0.59880	0.54947	0.52200	0.04055	4.05478	
12	0.93	13	0.04990	0.64870	0.52272	0.48613	0.03776	3.77617	
13	0.87	14	0.04990	0.69860	0.49728	0.43263	0.03361	3.36062	
14	0.84	15	0.04990	0.74850	0.47308	0.39739	0.03087	3.08683	
15	0.81	16	0.04990	0.79840	0.45005	0.36454	0.02832	2.83169	
16	0.75	17	0.04990	0.84830	0.42814	0.32111	0.02494	2.49429	Pupa (10.33%)
17	0.70	18	0.04990	0.89820	0.4073	0.28511	0.02215	2.21468	
18	0.66	19	0.04990	0.94810	0.38748	0.25574	0.01987	1.98652	
19	0.65	20	0.04990	0.99800	0.36862	0.23960	0.01861	1.86119	
20	0.65	21	0.04990	1.04790	0.35067	0.22794	0.01771	1.77056	
21	0.63	22	0.04990	1.09780	0.3336	0.21017	0.01633	1.63255	Adult (10.27%)
22	0.59	23	0.04990	1.14770	0.31737	0.18725	0.01455	1.45451	
23	0.55	24	0.04990	1.19760	0.30192	0.16606	0.01290	1.28989	
24	0.53	25	0.04990	1.24750	0.28722	0.15223	0.01182	1.18247	
25	0.52	26	0.04990	1.29740	0.27324	0.14208	0.01104	1.10369	
26	0.52	27	0.04990	1.34730	0.25994	0.13517	0.01050	1.04997	
27	0.47	28	0.04990	1.39720	0.24729	0.11623	0.00903	0.90283	
28	0.37	29	0.04990	1.44710	0.23525	0.08704	0.00676	0.67613	
29	0.26	30	0.04990	1.49700	0.2238	0.05819	0.00452	0.45199	
30	0.16	31	0.04990	1.54690	0.21291	0.03407	0.00265	0.26462	
31	0.10	32	0.04990	1.59680	0.20254	0.02025	0.00157	0.15733	
32	0.05	33	0.04990	1.64670	0.19268	0.00963	0.00075	0.07484	
33	0.02	34	0.04990	1.69660	0.18331	0.00367	0.00028	0.02848	
						12.87362			

Birth rate (β) = 12.87362

px= 1/ β= 0.07767

Instantaneous birth rate (b) = ln (β)= 2.55

Instantaneous death rate(d) = d-r = 2.50

X: Age in days; Lx: proportion of individuals survive at x and rm: intrinsic rate of increase

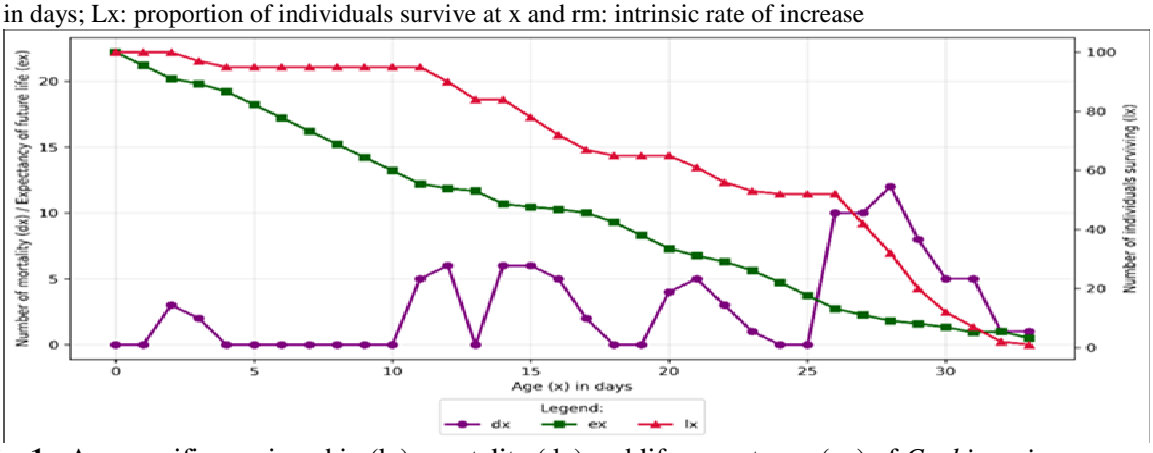

Fig. 1 : Age specific survivorship (lx), mortality (dx) and life expectancy (ex) of *C. chinensis* on cowpea

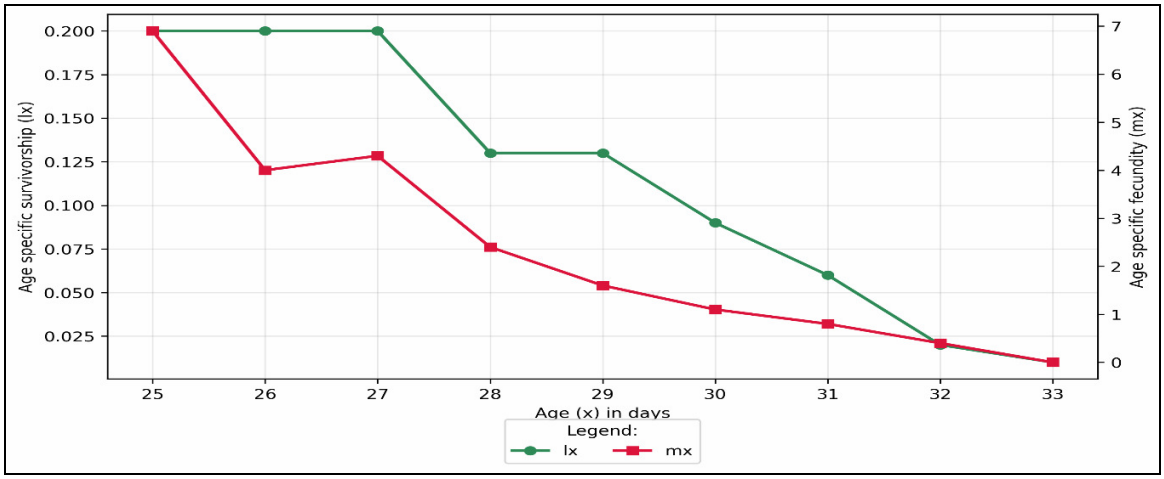

Fig. 2 : Age specific survivorship of female (lx) and fecundity (mx) of *C. chinensis* on cowpea

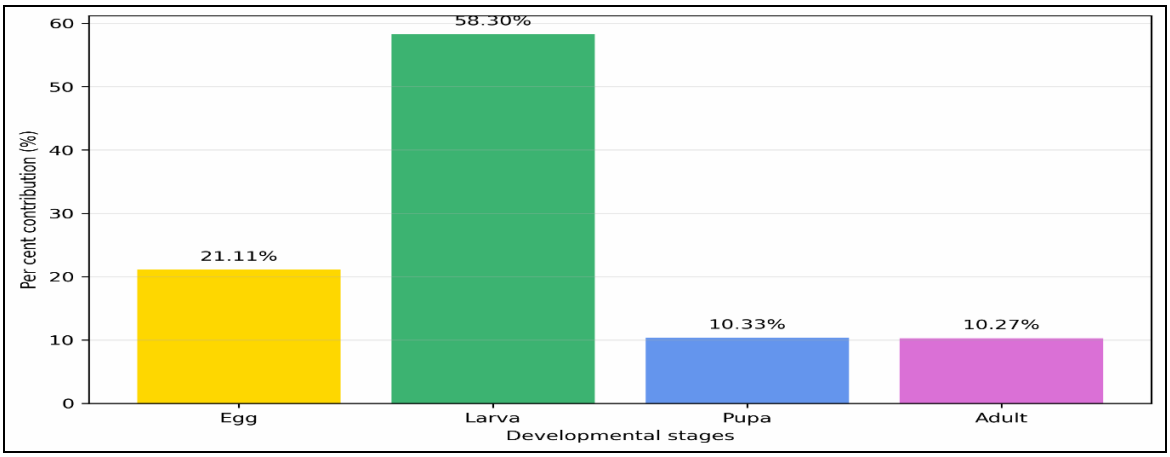

Fig. 3 : Per cent contribution of developmental stages of *C. chinensis* on cowpea

Table 5 : Stage specific life table of *Callosobruchus chinensis* on cowpea

Stage of insect	Lx	Dx	qx=dx/lx	100qx	Sx = 1-qx	MSR	IM	Log lx	Log lx+1	K value (log lx-log lx+1)
Egg	100	3	0.03	3.00	0.97	0.03	6.81	2	1.99	0.01
Larva	97	25	0.26	25.77	0.74	0.35	58.51	1.99	1.86	0.13
Pupa	72	11	0.15	15.28	0.85	0.18	34.68	1.86	1.79	0.07
Adult	61	61	1.00	100.00	0.00	-	-	1.79	-	-
				44.05	-	-	-	-	-	-
Total mortality K = $k_{Egg} + k_{Larva} + k_{Pupa}$										0.21

Lx: no. of individuals survive; dx: no. of individuals dying; qx: mortality; 100qx: apparent mortality; Sx: survival fraction; MSR: mortality/survivor ratio; IM: indispensable mortality; log lx: logarithmic survivorship values and K: total mortality

Stage specific life table of *C. chinensis* on cowpea

The stage-specific life table of *C. chinensis* on cowpea presented in Table 5 showed that out of 100 eggs, 3 individuals died during egg stage with apparent mortality of 3.00 per cent. During larval stage, 25 individuals died with apparent mortality of 25.77 per cent, whereas pupal stage recorded 15.28 per cent mortality. The survival fraction (Sx) was recorded 0.97, 0.74 and 0.85 during egg, larval and pupal stages, respectively. The K-values of egg, larval and pupal stages were 0.01, 0.13 and 0.07, respectively. The total generation mortality (K-value) was recorded as 0.21, indicated the highest contribution of larval stage towards mortality. Similar observations were recorded by Ravivarman (2021), who reported stage-specific mortality of *C. chinensis* on mung bean with total generation mortality (K-value) of 0.2291. The findings of Yadav (2025) also coincide with the present results, where differences in survival and mortality among developmental stages of *C. chinensis* were observed.

Conclusion

In the present investigation age-specific life table showed a gradual decline in survivorship and life expectancy with advancement of age. The positive values of population growth parameters including net reproductive rate (R_0), intrinsic rate of natural increase (rm) and finite rate of increase (λ) indicated successful establishment and reproductive potential of the pest on cowpea. Stable age distribution showed maximum contribution in the larval stage, while stage-specific life table indicated that the larval stage contributed the highest mortality during the course of investigation. The information generated from the present study may be useful for understanding the population dynamics of *C. chinensis* which can be utilised for strategic management to reduce storage losses in cowpea against pulse beetle.

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