AGE SPECIFIC AND FEMALE FECUNDITY LIFE TABLE OF *CALLOSOBRUCHUS CHINENSIS* LINN. ON COWPEA

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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 cowpea 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 40.25 days in first generation and 39.37 days in second generation net reproductive rates (R_0) were 25.63 females per female in first generation and 26.39 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 0.0805 females per female per day and 0.0806 females per female per day respectively in first generation while in second generation those were similar i.e. 0.0831 females per female per day and 0.0832 females per female per day respectively. Finite rate of increase was 1.084 females per female per day in first generation and 1.086 females per female per day in second generation. Potential fecundity in first generation 37.00 females per female,and in second generation 38.00 females per female. Doubling time (DT) and weekly rate of increase (WRI) was 8.59 days and 1.76 females per female respectively in first generation and decreased to 8.33 days in second generation followed by the increasement of weekly rate of increase to 1.78 females per female in second generation.

Keywords: Callosobruchus, Cowpea, Life table, Age-specific survival, Doubling time.

INTRODUCTION

The cowpea weevil, *Callosobruchus chinensis* is a cosmopolitan polyphagous pest in the most tropics and subtropics (Southgate,1979).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 (Caswell, 1980). 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 (Giga and Smith, 1983). 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 (Giga and Smith, 1981). 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 (Ali and Rizvi , 2007). 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 cowpea 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 cowpea 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 cowpea. 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

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

x	lx	dx	100*qx	Lx	Tx(=∑Lx)	ex
0	100.00	1.00	1.00	99.50	3704.00	37.04
1	99.00	1.00	1.01	98.50	3604.50	36.41
2	98.00	1.00	1.02	97.50	3506.00	35.78
3	97.00	1.00	1.03	96.50	3408.50	35.14
4	96.00	1.00	1.04	95.50	3312.00	34.50
5	95.00	1.00	1.05	94.50	3216.50	33.86
6	94.00	1.00	1.06	93.50	3122.00	33.21
7	93.00	1.00	1.08	92.50	3028.50	32.56
8	92.00	1.00	1.09	91.50	2936.00	31.91
9	91.00	1.00	1.10	90.50	2844.50	31.26
10	90.00	1.00	1.11	89.50	2754.00	30.60
11	89.00	1.00	1.12	88.50	2664.50	29.94
12	88.00	1.00	1.14	87.50	2576.00	29.27
13	87.00	1.00	1.15	86.50	2488.50	28.60
14	86.00	0.00	0.00	86.00	2402.00	27.93
15	86.00	0.00	0.00	86.00	2316.00	26.93
16	86.00	0.00	0.00	86.00	2230.00	25.93
17	86.00	0.00	0.00	86.00	2144.00	24.93
18	86.00	0.00	0.00	86.00	2058.00	23.93
19	86.00	0.00	0.00	86.00	1972.00	22.93
20	86.00	0.00	0.00	86.00	1886.00	21.93
21	86.00	0.00	0.00	86.00	1800.00	20.93
22	86.00	1.00	1.16	85.50	1714.00	19.93
23	85.00	1.00	1.18	84.50	1628.50	19.16
24	84.00	1.00	1.19	83.50	1544.00	18.38
25	83.00	1.00	1.20	82.50	1460.50	17.60
26	82.00	1.00	1.22	81.50	1378.00	16.80
27	81.00	1.00	1.23	80.50	1296.50	16.01
28	80.00	1.00	1.25	79.50	1216.00	15.20
29	79.00	1.00	1.27	78.50	1136.50	14.39
30	78.00	1.00	1.28	77.50	1058.00	13.56
31	77.00	1.00	1.30	76.50	980.50	12.73
32	76.00	1.00	1.32	75.50	904.00	11.89
33	75.00	1.00	1.33	74.50	828.50	11.05
34	74.00	1.00	1.35	73.50	754.00	10.19
35	73.00	1.00	1.37	72.50	680.50	9.32
36	72.00	1.00	1.39	71.50	608.00	8.44
37	71.00	1.00	1.41	70.50	536.50	7.56
38	70.00	0.00	0.00	70.00	466.00	6.66
39	70.00	0.00	0.00	70.00	396.00	5.66
40	70.00	3.00	4.29	68.50	326.00	4.66
41	67.00	3.00	4.48	65.50	257.50	3.84
42	64.00	5.00	7.81	61.50	192.00	3.00
43	59.00	11.00	18.64	53.50	130.50	2.21
44	48.00	12.00	25.00	42.00	77.00	1.60
45	36.00	19.00	52.78	26.50	35.00	0.97
46	17.00	17.00	100.00	8.50	8.50	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 cowpea (Second generation)

x	lx	dx	100*qx	Lx	Tx(=∑Lx)	ex
0	100.00	1.00	1.00	99.50	3648.00	36.48
1	99.00	1.00	1.01	98.50	3548.50	35.84
2	98.00	1.00	1.02	97.50	3450.00	35.20
3	97.00	1.00	1.03	96.50	3352.50	34.56
4	96.00	0.00	0.00	96.00	3256.00	33.92
5	96.00	0.00	0.00	96.00	3160.00	32.92
6	96.00	0.00	0.00	96.00	3064.00	31.92
7	96.00	1.00	1.04	95.50	2968.00	30.92
8	95.00	1.00	1.05	94.50	2872.50	30.24
9	94.00	1.00	1.06	93.50	2778.00	29.55
10	93.00	1.00	1.08	92.50	2684.50	28.87
11	92.00	1.00	1.09	91.50	2592.00	28.17
12	91.00	1.00	1.10	90.50	2500.50	27.48
13	90.00	0.00	0.00	90.00	2410.00	26.78
14	90.00	0.00	0.00	90.00	2320.00	25.78
15	90.00	0.00	0.00	90.00	2230.00	24.78
16	90.00	0.00	0.00	90.00	2140.00	23.78
17	90.00	0.00	0.00	90.00	2050.00	22.78
18	90.00	0.00	0.00	90.00	1960.00	21.78
19	90.00	1.00	1.11	89.50	1870.00	20.78
20	89.00	1.00	1.12	88.50	1780.50	20.01
21	88.00	1.00	1.14	87.50	1692.00	19.23
22	87.00	1.00	1.15	86.50	1604.50	18.44
23	86.00	1.00	1.16	85.50	1518.00	17.65
24	85.00	1.00	1.18	84.50	1432.50	16.85
25	84.00	1.00	1.19	83.50	1348.00	16.05
26	83.00	1.00	1.20	82.50	1264.50	15.23
27	82.00	1.00	1.22	81.50	1182.00	14.41
28	81.00	1.00	1.23	80.50	1100.50	13.59
29	80.00	1.00	1.25	79.50	1020.00	12.75
30	79.00	1.00	1.27	78.50	940.50	11.91
31	78.00	1.00	1.28	77.50	862.00	11.05
32	77.00	1.00	1.30	76.50	784.50	10.19
33	76.00	1.00	1.32	75.50	708.00	9.32
34	75.00	1.00	1.33	74.50	632.50	8.43
35	74.00	1.00	1.35	73.50	558.00	7.54
36	73.00	0.00	0.00	73.00	484.50	6.64
37	73.00	0.00	0.00	73.00	411.50	5.64
38	73.00	2.00	2.74	72.00	338.50	4.64
39	71.00	4.00	5.63	69.00	266.50	3.75
40	67.00	13.00	19.40	60.50	197.50	2.95
41	54.00	9.00	16.67	49.50	137.00	2.54
42	45.00	7.00	15.56	41.50	87.50	1.94
43	38.00	15.00	39.47	30.50	46.00	1.21
44	23.00	19.00	82.61	13.50	15.50	0.67
45	4.00	4.00	100.00	2.00	2.00	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.

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

x	lx	mx	lx.mx	x.lx.mx
Immature stages and pre-reproductive period = 0.5 to 37.5 days				
38.50	0.70	3.50	2.45	94.3250
39.50	0.70	10.50	7.35	290.3250
40.50	0.70	15.50	10.85	439.4250
41.50	0.67	6.00	4.02	166.8300
42.50	0.64	1.50	0.96	40.8000
r(approx)=0.0805828		Σmx=37.00	Σlx.mx=25.63	Σx.lx.mx=1031.705

$e^{-rx.lx.mx}$ (r = 0.0806634)	Cal(k)	%Contribution*	%Contribution(k)
0.1097608	2.878918	10.97910	10.97910
0.3037645	7.967443	30.38480	30.38481
0.4136640	10.850000	41.37778	41.37778
0.1413880	3.708467	14.14269	14.14268
0.0311477	0.816973	3.11562	3.11562
sum=0.9997245	sum=26.22180	sum=99.99999	sum=99.99999

∑x.lx.mx : 1031.705

Net reproductive rate (R_0) = ∑lx.mx : 25.63 females / female

Mean length of generation(T)= ∑x.lx.mx/∑lx.mx : 40.25 days

Approximate rate of increase(r_{approx})=$\log_e R_0/T$: 0.0805 females/♀/day

Actual rate of natural increase ($r_{accurtae}$)= : 0.0806 females/♀/day

Finite rate of increase (λ) = $e^{r(accurate)}$: 1.084 females/♀/day

Potential fecundity (Pf)= ∑mx : 37.00 females/female

Doubling time (DT) = $\log_e 2/\log_e \lambda$: 8.59 days

Weekly rate of increase (WRI) = λ^7 : 1.76 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 cowpea (Second generation)

x	lx	mx	lx.mx	x.lx.mx
Immature stages and pre-reproductive period = 0.5 to 36.5 days				
37.5	0.730	2.50	1.825	68.4375
38.5	0.730	11.00	8.030	309.1550
39.5	0.710	14.00	9.940	392.6300
40.5	0.670	7.50	5.025	203.5125
41.5	0.540	2.50	1.350	56.0250
42.5	0.450	0.50	0.225	9.5625
r(approx)=0.0831267	Σmx=38.00 Σlx.mx=26.395		Σx.lx.mx=1039.323	

$e^{-rx.lx.mx}$ (r = 0.0806634)	Cal(k)	%Contribution*	%Contribution(k)
0.0805572	2.247019	8.05344	8.05344
0.3261514	9.097496	32.60594	32.60594
0.3714946	10.36227	37.13898	37.13898
0.1728083	4.820224	17.27596	17.27596
0.0427194	1.191591	4.27073	4.27073
0.0065514	0.182742	0.654958	0.65495
sum=1.000282	sum=27.90135	sum=100.0000	sum=100.0000

∑x.lx.mx : 1039.323

Net reproductive rate (R_0) = ∑lx.mx : 26.39 females / female

Mean length of generation(T)= ∑x.lx.mx/∑lx.mx : 39.37 days

Approximate rate of increase(r_{approx})=$\log_e R_0/T$: 0.0831 females/♀/day

Actual rate of natural increase ($r_{accurtae}$) : 0.0832 females/♀/day

Finite rate of increase (λ) = $e^{r(accurate)}$: 1.086 females/♀/day

Potential fecundity (Pf)= ∑mx : 38.00 females/female

Doubling time (DT) = $\log_e 2/\log_e \lambda$: 8.33 days

Weekly rate of increase(WRI) = λ^7 : 1.78 females/female

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

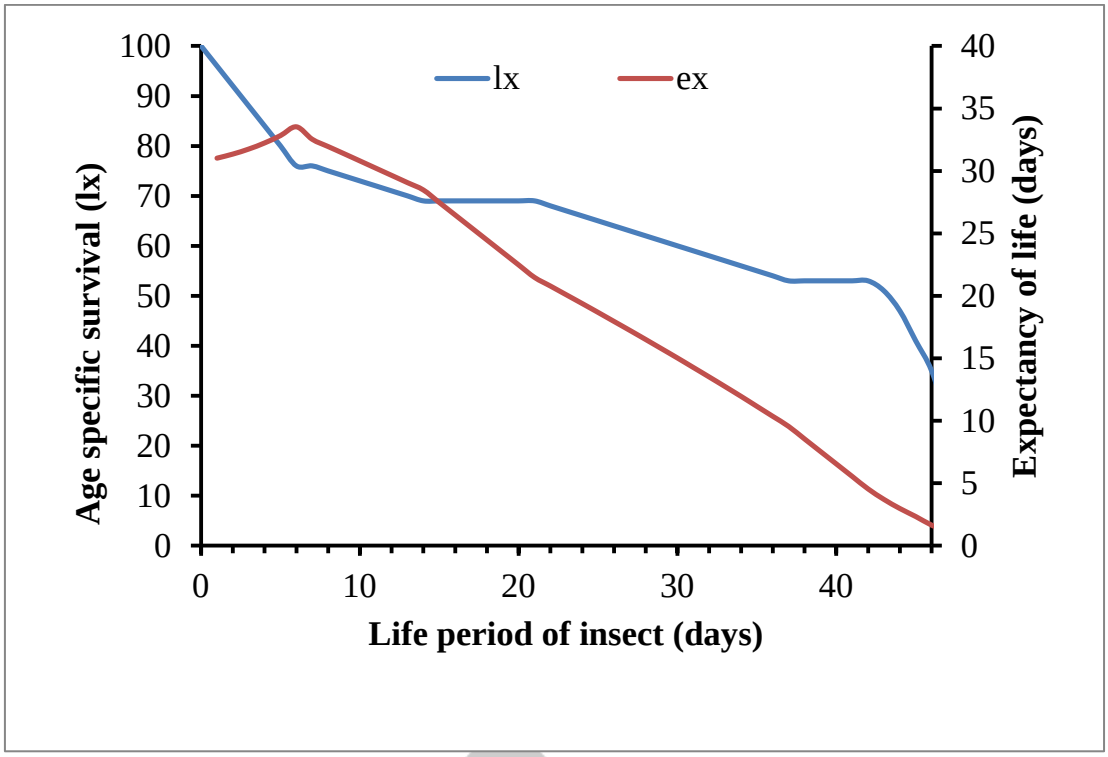

Fig. 1. Age specific survivorship (lx) and life expectancy (ex) of C. *chinensis* on cowpea during life period (First generation)

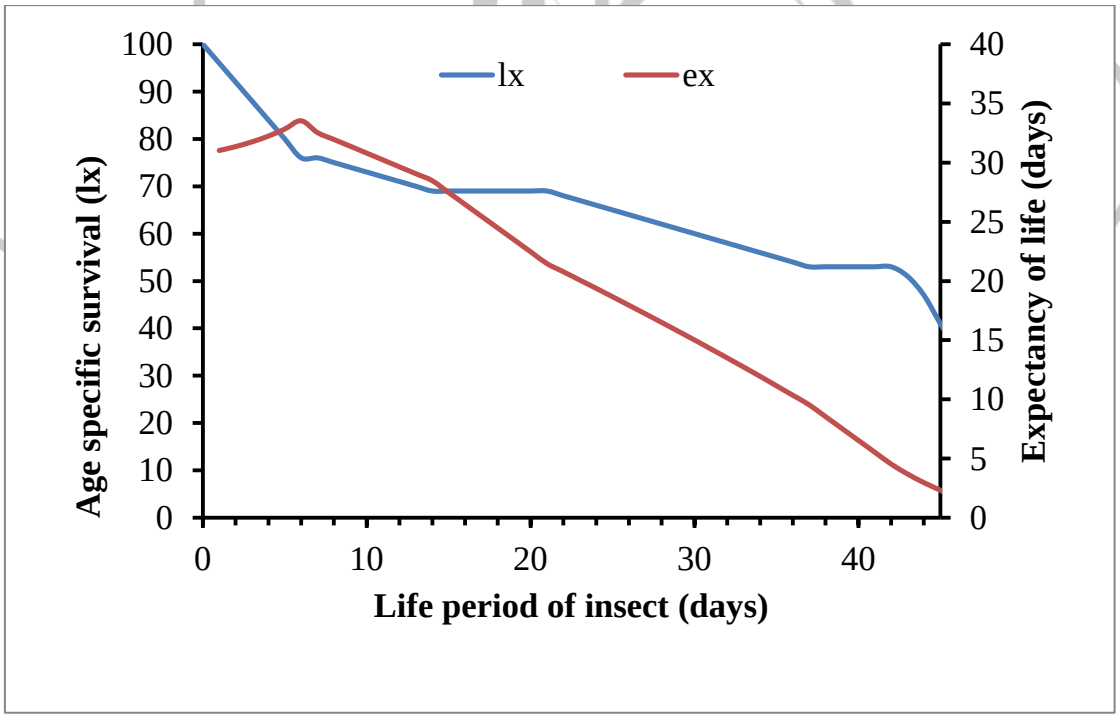

Fig. 2. Age specific survivorship (lx) and life expectancy (ex) of C. *chinensis* on cowpea during life period (Second generation)

RESULTS AND DISCUSSION

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 cowpea. 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 33rd days and 35th 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 cowpea. Survival of the insects dropped quickly after 41 days 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 and 2). The increase in expectancy was common to any population which suffered heavy loss at any stage of its development. The result of the study was in agreement with the experiments done by Deevey (1947) and Harcourt (1969). Generally after 4 to 5 days these rate decrease sharply due to ageing of the female. The finding also confirmed the report of Shah *et.al.*(2007). At the middle age, expectancy was within 16 to 23 days where as on cessation it was 0.5 days. These findings were corroborated with that of reported by Shah *et al.* (2007).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 cowpea was recorded from 38.5 days to 42.5 days in first generation while it was 37.5 days to 42.5 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 0.70 and 0.73 in second generation for cowpea. 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 (11.00) than the first generation (10.5) (Table 3 and 4). Thus, natality rate (mx) fluctuated in all the two consecutive generations. These findings showed that each group did not contribute equally towards intrinsic rate of increase of the insect. Similar fluctuations were also reported by Chenchaiah *et al.* (2007). 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. The net reproductive rate (R_o) estimated as 25.63 females per female in first generation and 26.39 females per female in second generation in cowpea. While mean length of generation (T) were 40.25 days in first generation and 39.37 days in second generation in cowpea. The approximate rate of increase (r_{approx}) was recorded slightly lower than the actual rate of natural increase ($r_{accurate}$) and those were 0.0805 females per female per day and 0.0806 females per female per day respectively in first generation while in second generation those were similar i.e. 0.0831 females per female per day and 0.0832 females per female per day respectively. Such findings indicated that the population trend towards overlapping generation. Finite rate of increase was 1.084 females per female per day in first generation and 1.086 females per female per day in second generation. Potential fecundity slightly lower in first generation (37.00 females per female) than in second generation (38.00 females per female). Doubling time and weekly rate of increase was 8.59 days and 1.76 females per female respectively in first generation. Doubling time was decreased to 8.33 days in second generation followed by the increasement of weekly rate of increase to 1.78 females per female in second generation (Table 3 and 4). The result was in association with Kazemi *et al*. (2009). Moreover, *C. chinensis* able to produce higher population on cowpea and causes considerable damage on it. The finding was corroborate with the results of Kazemi *et al*. (2009).

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