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Field life-tables and key mortality factors of *Achaea janata* Linn on castor*

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Abstract. Field life-tables and key mortality factors of castor semilooper *Achaea janata* L. were studied on castor for the year 1985–86 and 1986–87. There were 4 regular overlapping generations during both the years. The parasitization of *Achaea janata* larvae in early instars (I–III instar) by parasite *Microplitis maculipennis* (Sziepligetis) was 1·34, 4·41, 22·02 and 43·70% in first, second, third and fourth generation respectively during 1985–86. Similarly, the parasitization by same parasite was 44·12, 61·46 and 65·55% during second, third and fourth generation respectively in the year 1986–87. Key mortality factors and separate budget for each generations were prepared.

Keywords. Field life-tables; key mortality factors; *Achaea janata* L.

1. Introduction

Field life-tables and key mortality factors may be analysed to determine what stage in the life cycle contributes the most to the population trend when series of life-tables are available (Deevey 1947; Harcourt 1963, 1969; Atwal and Bains 1974). The use of field life-tables have been made recently for studying the natural population of insect pests. When the environmental parameters are related to several causes of mortality, the field life-tables form a budget of the successive process that operate in a given population. Field life-table studies indicate which age interval and independent variable should be studied in detail for the effective control of the pest. It is also important to grasp the real situation of seasonal prevalence of an insect pest for planning its successful control (Harcourt 1966, 1969; Morris and Millar 1954; Singh *et al* 1977).

2. Materials and methods

A non replicated trial was conducted in two trials comprising of 100 quadrates of 2·4 × 2·1 m size. The castor, VI-9 was raised during 'Kharif' season on main farm, College of Agriculture, Parbhani during the years 1985–86 and 1986–87. Frequent field visits were made in order to record the first incidence of (egg stage) *Achaea janata* on castor crop. The known number of eggs were collected and reared till pupation in laboratory and was continued till the cessation of pest in field. This culture was used as a check for further studies.

To decide the generations of pest regular sampling was taken based on the developmental stages of pest in check culture. Known number of sample quadrates

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were observed in early and late instar. The plants from sampled quadrates were observed for the presence of larvae and such 5 quadrates were observed per meteorological week. These collected larvae were reared in laboratory till pupation and observations were recorded on mortality of larvae and pupae due to different parasites and unknown reasons. An interval of 6 days was provided before next sampling for next generation after the emergence of previous adults. This period was considered as pre-oviposition act by moths. Known number of eggs were collected per generation and mortality owing to sterility and parasite was worked out.

The column headings used in preparation of field life-tables study were those proposed by Morris and Millar (1954) and Harcourt (1963, 1969).

x = The age interval, egg, larva, pupa and adult.
l_x = The number surviving at the beginning of stage noted in 'x'.
d_x = The number dying within the age interval stated in 'x'.
d_xF = The mortality factor responsible for 'd_x'.
100_{qx} = Percentage mortality.
S_x = Survival rate within the age mentioned in 'x'.

Separate budget for each generation was prepared to find out the key factor that influenced the population trend in different generation. The method for key factor analysis developed by Varley and Gradwell (1965), was used. By this method, the killing power (K) was estimated. As a series of mortality factor operated in succession during a generation of population, the total killing power of K was equal to the sum of the killing power of K's.

3. Results and discussion

The results obtained on the key mortality factors during the years 1985–86 and 1986–87 are presented in tables 1–8 and figure 1. It is evident from table 1 and

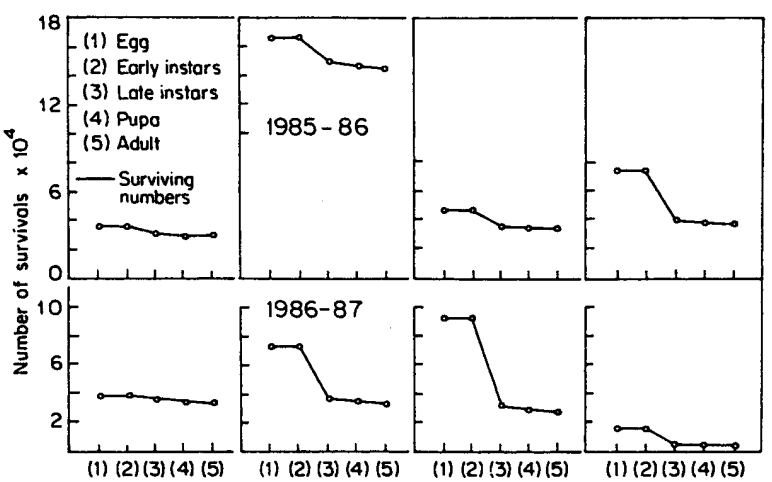

Figure 1. Survivorship curve of *A. janata* during 4 generations of castor (1985–86 and 1986–87).

Table 1. Key mortality factors for first generation of *A. janata* on castor during 1985–86 and 1986–87 population/ha.

Age interval (x)	No. alive at the beginning of x (l_x)	Factors responsible for d_x (d_xF)	No. dying during x (d_x)	d_x as a per cent of x (100_{qx})	Survival rate (S_x)
Expected eggs					
1985–86	43,823	Sterility/dead	6,573	14·99	0·85
1986–87	46,176		6,926	11·99	0·85
Viable eggs					
1985–86	37,250	—	—	—	—
1986–87	39,250	—	—	—	—
Larval instars					
Early instars					
1985–86 (I–III)N_1	37,250	*M. maculi-pennis*	500	1·34	0·87
1986–87	·39,250	–"–"	—	—	—
1985–86	—	Unknown causes	4,125	11·07	—
1986–87	—	–"–"	2,250	5·73	0·94
Late instars (IV–V)					
1985–86	32,625	–"–"	1,250	3·83	0·96
1986–87	37,000	–"–"	1,750	4·73	0·95
Pupae					
1985–86	31,375	–"–"	625	2·00	0·98
1986–87	35,250	–"–"	750	2·13	0·98
Moths					
1985–86	30,750	50% females	—	—	1·00
1986–87	34,500	–"–"	—	—	1·00
Females × 2 (N_3)					
1985–86	30,750	Reproducing females	15,375		
1986–87	34,500	–"–"	17,250		
Actual No. of younger larvae in next generation (N_2)					
1985–86	1,67,875				
1986–87	17,375				
Trend index (I)					
1985–86	4·506				
1986–87	1·869				
Generation survival (SG) N_3/N_1					
1985–86	0·82				
1986–87	0·87				

figure 1 that there was 14·38 and 11·99% mortality among the eggs owing sterility. The larval mortality because of parasite *Microplitis maculipennis* (szep) (Braconidae: Hymenoptera) was 1·34 and 0%, similarly larval mortality due to unknown causes was 11·07, 3·83 and 5·73, 4·73% in the first generation. The generation survival value (0·82 and 0·87) and the positive value of trend index (4·506 and 1·869) indicated that the mortality factors operated during first generation were not effective in causing a decline in population in the next generation. Table 2 indicates

Table 2. Budget of *A. janata* during first generation, 1985–86 and 1986–87.

	Number/ha		Log number/ha		*K's*	
Age interval	1985–86	1986–87	1985–86	1986–87	1985–86	1986–87
Expected eggs	43,823	46,176	4·6417	4·6644	—	—
Viable eggs	37,250	39,250	4·5711	4·5938	0·0706	0·0706
Actual early instar larvae after mortality due to parasite and unknown causes	37,250	39,250	4·5711	4·5938	0·0000	0·0000
Late instar after mortality due to unknown causes	32,650	37,000	4·5138	4·5682	0·0573	0·0256
Pupae after mortality due to unknown causes	31,375	35,250	4·4965	4·5471	0·0173	0·0211
Moths	30,750	34,500	4·4878	4·5378	0·0087	0·0093
Reproducing females	15,375	17,250	4·1868	4·2367	0·3010	0·3011
				Total K =	0·4549	0·4277

that the maximum mortality occurred in the early instar larvae of first generation with the highest K value (0·0573) and (0·0256). The number of reproducing females/hectare in first generation were 15375 and 17250 which actually contributed for population build up in the second generation.

It is evident from table 3 and figure 1 that there was 11·39 and 11·39% egg mortality due to sterility. The parasitization of larvae because of *M. maculipennis* was 4·91 and 44·12%. The generation survival values were 0·88 and 0·47. The negative value of trend index (0·301) indicated that the mortality factors operating during this period were effective in checking the population in the next generation for the year 1985–86 and it was vice versa for the year 1986–87. The early instar larvae had highest mortality ($K = 0·0435$) and ($K = 0·2988$) in the second generation (table 4, figure 1). The next important mortality factor was in pupal stage. At the end of second generation, 73875 and 17312 females were expected to contribute for population build up in the third generation.

It is observed from table 5 and figure 1 that the egg mortality due to sterility was 10·49 and 10·49 in the third generation. The mortality of early instar larvae by parasite was 22·02 and 61·46%. Total mortality in larval and pupal stages due to unknown causes was 4·05 and 16·14%. The generation survival value were 0·74 and 0·30. The trend index values (1·583 and 1·159) indicated that the mortality factors (major parasite) operating during this period were not effective in suppressing the pest population on castor. The age specific key mortality factors indicates that maximum contribution towards generation mortality came from the early instar larvae ($K = 0·1179$ and $K = 0·4753$) (table 6, figure 1). At the end of the third generation 17750 and 14250 females were expected to contribute for population build up in the fourth generation. The total *K's* for all the life stages was 0·4772 and 0·8793.

It is evident from table 7 and figure 1 that the mortality of eggs due to sterility was 13·99%. The parasite *M. maculipennis* parasitized the early instar larvae to the extent of 43·70 and 65·55% in fourth and last generation of the 1985–86 and 1986–87. The generation survival value was 0·52 and 0·26 and the trend index value remained zero in the last generation, hence the pest population was totally ceased. The

Table 3. Key mortality factors for second generation of *A. janata* on castor during 1985–86 and 1986–87 population/ha.

Age interval (x)	No. alive at the beginning of x (l_x)	Factors responsible for d_x (d_xF)	No. dying during x (d_x)	d_x as a per cent of x (100_{qx})	Survival rate (S_x)
Expected eggs					
1985–86	1,89,475	Sterility/dead	21,600	11·39	0·88
1986–87	82,816	–"–"–	9,441	11·39	0·36
Viable eggs					
1985–86	1,67,875	—	—	—	—
1986–87	73,375	—	—	—	—
Larval instar Early instars (I–III) N_1					
1985–86	1,67,875	*M. maculipennis*	8,250	4·91	0·90
		Unknown causes	7,750	4·61	—
1986–87	73,375	–"–"–	32,375	44·12	0·50
Late instar (IV–V)					
1985–86	1,51,875	–"–"–	3,125	2·05	0·98
1986–87	36,875	–"–"–	2,125	5·76	0·94
Pupae					
1985–86	1,48,750	–"–"–	1,000	0·67	0·99
1986–87	34,750	–"–"–	125	0·36	0·99
Moths					
1985–86	1,47,750	50% females	—	—	1·00
1986–87	34,625	–"–"–	—	—	1·00
Female × 2(N_3)					
1985–86	1,47,750	Reproducing females	73,875		
1986–87	34,625	–"–"–	17,312		
Actual No. of younger larvae in next generation (N_2)					
1985–86	4,766				
1986–87	3,833				
Trend index (I) = N_2/N_1					
1985–86	0·301				
1986–87	1·278				
Generation survival (SG) = N_3/N_1					
1985–86	0·88				
1986–87	0·47				

Table 4. Budget of *A. janata* during second generation, 1985–86 and 1986–87.

	Number/ha		Log number/ha		*K's*	
Age interval	1985–86	1986–87	1985–86	1986–87	1985–86	1986–87
Expected eggs	1,89,475	82,816	5·2775	4·9191	—	—
Viable eggs	1,67,875	73,375	5·2249	4·8655	0·0526	0·0526
Actual early instar larvae after mortality due to parasite and unknown causes	1,67,875	73,375	5·2249	4·8655	0·0000	0·0000
Late instars after mortality due to unknown causes	1,51,875	36,875	5·1814	4·5667	0·0435	0·2988
Pupae after mortality due to unknown causes	1,48,750	34,750	5·1724	4·5409	0·0090	0·0258
Moths	1,47,750	34,625	5·1695	4·5393	0·0029	0·0016
Reproducing females	73,875	17,312	4·8684	4·2383	0·3011	0·3010
				Total K =	0·4091	0·6798

Table 5. Key mortality factors for third generation of *A. janata* on castor during 1985–86 and 1986–87 population/h.

Age interval (x)	No. alive at the beginning of x (l_x)	Factors responsible for d_x (d_xF)	No. dying during x (d_x)	d_x as a per cent of x (100_{qx})	Survival rate (S_x)
Expected eggs					
1985–86	53,258	Sterility/dead	5,592	10·49	0·89
1986–87	1,04,841		11,008	10·49	0·89
Viable eggs					
1985–86	47,666	—	—	—	—
1986–87	93,833	—	—	—	—
Larval instars					
Early instars (I–III) (N_1)		*M. maculi-pennis*			
1985–86	47,666	Unknown	10,500	22·02	0·76
1986–87	93,833	causes	57,666	61·46	0·34
Late instars (IV–V)					
1985–86	36,333	–"–"–	333	0·92	0·99
1986–87	32,334	–"–"–	3,167	9·79	0·90
Pupae					
1985–86	36,000	–"–"–	500	1·39	0·99
1986–87	29,167	–"–"–	667	2·29	0·99
Moths					
1985–86	35,500	50% females	—	—	1·00
1986–87	28,500	–"–"–	—	—	1·00
Female × 2(N_3)					
1985–86	35,500	Reproducing	17,750		
1986–87	28,500	females	14,250		
Actual number of younger larvae in next generation (N_2)					
1985–86	75,500				
1986–87	15,000				

(*Contd.*)

Table 5. (*Contd.*)

Age interval (x)	No. alive at the begining of x (l_x)	Factors responsible for d_x (d_xF)	No. dying during x (d_x)	d_x as a per cent of x (100_{qx})	Survival rate (S_x)
Trend index (I) = N_2/N_1					
1985–86	1,583				
1986–87	1,159				
Generation survival (SG) = N_3/N_1					
1985–86	0·74				
1986–87	0·30				

Table 6. Budget of *A. janata* during third generation, 1985–86 and 1986–87.

	Number/ha		Log number/ha		*K's*	
Age interval	1985–86	1986–87	1985–86	1986–87	1985–86	1986–87
Expected eggs	53,258	1,04,841	4·7263	5·0205	—	—
Viable eggs	47,666	93,833	4·6782	4·9723	0·0481	0·0482
Actual egg early instar larvae after mortality due to parasite and unknown causes	47,666	93,833	4·6782	4·9723	0·0000	0·0000
Late instar after mortality due to unknown causes	36,333	32,334	4·5603	4·5096	0·1179	0·4753
Pupae after mortality due to unknown causes	36,000	29,167	4·5563	4·4648	0·0040	0·0448
Moths	35,500	28,500	4·5502	4·4548	0·0061	0·0100
Reproducing females	17,750	14,250	4·2491	4·1538	0·3011	0·3010
				Total K =	0·4772	0·8793

budget for fourth generation in which the mortality factor in larval stage was $K = 0{\cdot}2705$ and $K = 0{\cdot}5228$. The value of total K remained 0·6522 and 0·9405 for all the life stages (table 8, figure 1).

Khan (1946) reported 5 to 6 generations of *A. janata* on castor, the second instar larvae were attacked by *M. maculipennis* parasite in Andhra Pradesh. Five overlapping generations have been reported by Pandey *et al* (1967) on castor. According to Srivastava and Pande (1966), *Achaea* completed 3 generations in Bikaner–Barmer tract and 5 generations in Ajmer–Bharatpur tract of Rajasthan. Cherian and Basheer (1946) observed 56·2% parasitization of *A. janata* larvae by *M. maculipennis*. The larval parasitization was to the extent of 70–75% on castor in Karnataka (Rai and Jayaramaiah 1978). The results obtained in the present investigation in relation to generation and per cent parasitization are in agreement with the earlier workers with little variation (Khan 1946; Srivastava and Pande 1966; Pandey *et al* 1967; Rai and Jayaramaiah 1978).

From these studies it has been observed that the per cent parasitization of *M. maculipennis* exhibited an increasing trend in both the years and reached at its peak in the last generation. The high per cent parasitization resulted suppressing

Table 7. Key mortality factors for fourth generation of *A. janata* on castor during 1985–86 and 1986–87 population/ha.

Age interval (x)	No. alive at the beginning of x (l_x)	Factors responsible for d_x(d_xF)	No. dying during x (d_x)	d_x as a per cent of x (100_{qx})	Survival rate (S_x)
Expected eggs					
1985–86	87,790	Sterility/dead	12,290	13·99	0·86
1986–87	17,441		2,441	13·99	0·86
Viable eggs					
1985–86	75,500	—	—	—	—
1986–87	15,000	—	—	—	—
Larval instars					
Early instars (I–III) N_1		*M. maculipennis*	33,000	43·70	0·54
1985–86	75,500	Unknown causes	2,000	2·65	—
1986–87	15,000	–"–"–	9,833	65·55	0·30
Late instars (IV–V)					
1985–86	40,500	–"–"–	875	2·16	0·98
1986–87	4,500	–"–"–	167	3·71	0·98
Pupae					
1985–86	39,625	–"–"–	250	0·63	0·99
1986–87	4,333	–"–"–	333	7·76	0·92
Moths					
1985–86	39,375	50% females	—	—	1·00
1986–87	4,000	–"–"–	—	—	1·00
Females × 2(N_3)					
1985–86	39,375	Reproducing females	19,687·5		
1986–87	4,000	–"–"–	2,000		
Actual No. of younger larvae in next generation (N_2)					
1985–86	Nil				
1986–87	Nil				
Trend index (I) = N_2/N_1					
1985–86	Nil				
1986–87	Nil				
Generation survival (SG) = N_3/N_1					
1985–86	0·52				
1986–87	0·26				

Table 8. Budget of *A. janata* during fourth generation, 1985–86 and 1986–87.

	Number/ha		Log number/ha		*K's*	
Age interval	1985–86	1986–87	1985–86	1986–87	1985–86	1986–87
Expected eggs	87,750	17,441	4·9434	4·2415	—	—
Viable eggs	75,500	15,000	4·8750	4·1760	0·0684	0·0655
Actual early instar larvae after mortality due to parasite and unknown causes	75,500	15,000	4·8750	4·1760	0·0000	0·0000
Late instar after mortality due to unknown causes	40,500	4,500	4·6074	3·6532	0·2705	0·5228
Pupae after mortality due to unknown causes	39,625	4,333	4·5952	3·6367	0·0095	0·0165
Moths	39,375	4,000	4·5952	3·6020	0·0027	0·0347
Reproducing females	19,687	2,000	4·2941	3·3010	0·3011	0·3010
				Total K =	0·6522	0·9405

the pest population in the next generation, hence this parasite could be considered for the management programme of *A. janata* on castor.

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