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LABORATORY STUDIES ON THE LIFE HISTORY OF FOUR SPECIES OF COLLEMBOLA FROM N. E. INDIA

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INTRODUCTION

Work on the life history of collembola species under laboratory conditions in relation to various environmental factors is very meagre.

Maclagen (1932) was one of the earliest who showed that soil pH had a profound effect on the oviposition of *Sminthurus viridis*(L.) Davidson (1934) showed that pH 5.5-7.0 was favourable for oviposition in the same species. Milne (1960) suggested that quantity of food and moisture content rapidly changed the oviposition, fecundity and mortality in various species of Arthropleone collembola.

The earliest work on environmental factors affecting the development of collembola was that of Choudhuri (1960, 1963) who showed the effect of temperature on the development of three species of the genus *Onychiurus*. Marshall and Kevan (1962) also showed that an increase in temperature simultaneously increased the oviposition rate and reduced the time of hatching in *Folsomia candida* (Willam). Sharma and Kevan (1963a) recorded the influence of temperature on the development, mortality and fecundity of *Isotoma notabilis*.

Green (1964a, 1964b) revealed moisture as the one factor in reducing mortality while crowding as the other affecting fecundity, which was reciprocal to the density of the culture media. Vail (1965) showed that the pH of activated charcoal had an effect on the colonization *Hypogastrura manubrialis*. A linear relationship was shown between the reciprocal of egg-developmental time and temperature by Hale (1965a, 1965b). Ashraf (1969) while working on the fecundity of *Onychiurus bhattii* Yosii showed that they differed considerably with pH and that most indlviduals survived around slight alkaline pH but died at pH beyond 9.7. Studies on food and the speed of establishment of a population of *Folsomia candida* revealed that it was proportional to the rate at which the food was supplied (Usher et. al., 1971). Snider (1971) had shown in culture-experiments that the type and quality of diet can influence collembola growth and fecundity which is again attributed to pH.

The aim of the present study was to take up some important species of the dominant

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groups in N. E. India, to identify the reproductive strategies and to show their importance in the population-dynamics.

MATERIAL AND METHODS

The top surface layers of soil were taken for these experiments. The specimens from the soil samples were extracted in the usual way with the help of the modified Tullgren funnel series except that the collecting tubes contained triple distilled water. The species were then identified, removed and kept separately. All four species belonged to Family Entomobryidae. These were (1) *Seira indica* Yosii (2) *Seira lateralis* Yosii, (3) *Salina yosii* Salmon and (4) *Entomobrya kali* Imms.

The substrate preparation was done by the plaster-charcoal method after Hutson (1978), using charcoal in variable quantities for the differing pH values. These were placed in small borosil, heat resistant glass vivaria, 3 cm deep and 5 cm in diameter. Varying concentrations of salinity was made with the help of Sodium chloride solutions. These solutions were prepared by dissolving Analar Sodium chloride in triple-distilled water in the quantities required, as given by Richards (1954). However, when the moisture content of the substrate kept lowering a few drops of triple distilled water only was added to culture-media.

Experiments were conducted in incubators at temperatures of 20°, 25° and 30°C. The control experiment was conducted under ambient temperature in the laboratory. The pH used were 6.2, 5.2, and 4.2 for 20°, 25° and 30°C respectively while it was 4.2 for the room temperature (control). Salinity concentrations used were at 1%, 2% and 3% levels. In this respect the experiments were in the form of a randomized block-design where the first set of experiment comprised of 20°C, 6.2 pH and 1% salinity, the second set was at 25°C, 5.2 pH and 2% salinity, while the third was with 30°C, 4.2 pH and 3% salinity. The controls were at room temperature and 4.2 pH. Yeast in agar and boiled banana both sterilized were used as food. Five replicates of each experiment were conducted for all the four species undertaken.

For every experiment 2 individuals of each species were used, small enough not to have been previously oviposited. Males and females were differentiated by the presence of aedaegus and heavy cilia on the abdomen of the male in contrast to the female. Cultures were examined twice daily, once in the morning hours (1000 hrs.) and the other in the evening hours (1600 hrs.).

Food was administered just before sunset. Egg development time was calculated from the day of oviposition to when more than 50% of the eggs of a single batch had hatched. The significant differences between the results obtained for fecundity and mortality at the various tempearature, pH and salinity levels were tested statistically. Length measurements were taken twice daily and the population count was recorded. All experiments (five replicates each) were continued for each of the four species upto the sexually matured stage, which in the present case was upto the 6th instar.

RESULTS

Seira indica revealed that oviposition decreased (60 eggs), with increased pH and reduced temperature and salinity. As seen from Table I the number of eggs laid was seen maximum (78 eggs) under ambient conditions, even though the pH was low. But immediately after hatching (1st instar), there was a sudden drop (50 individuals) in the hatchability under lab-conditions, though it was not so, under the remaining three experimental conditions (70, 65 and 57 individuals). In the subsequent instars (second to sixth) though there was a steady drop in numbers, yet they more or less stabilized (25 to 30 individuals) at the last instar stage irrespective of the fecundity.

In *Seira lateralis*, oviposition depended on temperature as in *S. indica*. However, the number of eggs laid was much more and in fact nearly one and half times (90-100 eggs) than that of *S. indica*. The duration of days either for hatching or for the development of the instars, was observed to be maximum under maximum temperature regimes. However, in the development stages from first to sixth instar, there was negligible difference in the number of days between two moults (TableII). Simlarly the maximum diameter of eggs obtained at all experimental setups were more or less the same.

The third species *Salina yosii* showed a trend of oviposition and development similar to that of *S. indica* and *S. lateralis*. However, the number of eggs laid in this species was nearly double that of *S. indica* and one and half times that of *S. lateralis*. The maximum eggs laid (130-132) was under the maximum temperature and salinity and minimum pH values. However, the ambient temperature which recorded the maximum fecundity (130 eggs) showed the least survival (100 individuals) in the sixth instar, while even the least eggs (120 eggs) laid at the lowest temperature and salinity and highest pH values recorded 103 individuals for the last instar (Table lll).

The fourth species, *Entomobrya: kali*, had the lowest oviposition rate which was nearly half that of *S. indica* (40 to 48 eggs). However, it was seen, that at maximum temperatures and highest salinity but with lowest pH not only the maximum eggs were laid but proportionally the survival was also maximum at the 6th instar stage, and as in all the other species the duration of days taken either for hatching or for the different stages between moults, was similar in this species also (Table IV).

It was seen that the maximum percentage (97%) of eggs hatched were in *Seira indica* at the highest temperature and the lowest (64%) was in the control experiment. A similar trend between these two conditions was observed in the mortality percentage for most of the instars.

Seira lateralis as in *Seira indica* revealed the highest percent of hatchability under maximum temperature series and also the lowest mortality in the first instar. The maximum adult survival was in minimum and medium temperature where nearly 60-64% was observed, while under maximum temperataure series only 50% was the survival percentage (Table V).

TABLE I

Experiment No.		Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
	a.	60±1·0	57±1·0	50±1·0	45±1·0	40±1·0	25±1·0	25±1·0
1	b.	7±2·74	7±2·35	3±1·41	4±1·73	6±1·0	6±1·0	6±1·0
	c.	0·13±0·01	0·25±0·01	0·32±0·01	0·58±0·01	0·58±0·01	0·69±0·01	0·85±0·01
	a.	70±1·0	65±1·0	53±1·0	40±1·0	35±1·0	30±1·0	30±1·0
2	b.	8±1·41	9±1·87	4±1·73	5±1·58	6±2·0	7±1·58	7±1·58
	c.	0·14±0·01	0·30±0·01	0·45±0·01	0·56±0·01	0·60±0·01	0·71±0·01	0·88±0·01
	a.	72±1·0	70±1·0	60±1·0	50±1·0	40±1·0	30±1·0	30±1·0
3	b.	10±1·87	10±1·87	5±1·58	6±2·00	7±2·74	8±2·55	8±2·35
	c.	0·16±0·01	0·31±0·01	0·47±0·01	0·57±0·01	0·63±0·01	0·72±0·01	0·90±0·01
	a.	78±1·0	50±1·0	45±1·0	40±1·0	35±1·0	30±1·0	28±1·0
4	b.	12±3·87	6±2·24	3±1·73	5±2·45	5±2·35	7±2·74	6±2·24
	c.	0·14±0·01	0·34±0·01	0·42±0·01	0·51±0·01	0·60±0·01	0·71±0·01	0·91±0·01

Table I : Fecundity/mortality (a), Days of development (b) and egg diameter/instar length (c) in *Seira indica* at different experimental setups (1-3) and Control (4).

TABLE II

Experiment No.		Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
1	a.	90±1·0	81±1·0	71±1·0	70±1·0	65±1·0	60±1·0	55±1·0
	b.	15±2·92	10±1·87	5±1·58	7±1·87	6±1·41	7±1·41	7±2·74
	c.	0·11±0·01	0·35±0·01	0·48±0·01	0·60±0·01	0·70±0·01	0·86±0·01	0·94±0·01
2	a.	96±1·0	90±1·0	80±1·0	72±1·0	64±1·0	62±1·0	61±1·0
	b.	10±3·0	11±2·55	7±2·40	8±2·74	8±1·12	8±2·35	8±2·83
	c.	0·20±0·01	0·45±0·01	0·55±0·01	0·63±0·01	0·71±0·01	0·88±0·01	0·98±0 01
3	a.	102±1·0	98±1·0	82±1·0	70±1·0	60±1·0	55±1·0	50±1·0
	b.	16±8·94	12±2·83	8±2·74	7±2·69	8±2·24	9±2·55	9±3·32
	c.	0·21±0·01	0·46±0·01	0·60±0·01	0·70±0 01	0·74±0·01	0·90±0·01	1·15±0·01
4	a.	110±1·0	100±1·0	90±1·0	79±1·0	71±1·0	67±1·0	59±1·0
	b.	17±4·95	9±1·73	6±1·22	6±2·24	7±1·22	8±2·74	7±2·45
	c.	0·22±0·02	0·41±0·01	0·56±0·00	0·61±0·01	0·68±0·00	0·83±0·02	0·93±0·01

Table II : Fecundity/mortality (a), Days of development (b) and egg diameter/instar length (c) in *Seria lateralis* at different experimental setups (1-3) and Control (4).

TABLE III

Experiment No.		Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
	a.	120±1·0	110±1·0	107±1·0	105±1·0	104±1·0	103±1·0	103±1·0
1	b.	10±2·92	11±3·0	5±2·0	6±1·0	7±2·74	7±2·74	7±2·06
	c.	0·24±0 01	0·55±0·01	0·70±0·01	0·80±0·01	0·92±0·01	1·15±0·01	2·05±0·01
	a.	126±1·0	124±1·0	114±1·0	113±1·0	108±1·0	106±1·0	104±1·0
2	b.	11±4·1	12±2·74	7±2·74	7±2·74	9±2·83	8±2·45	8±2·45
	c.	0·27±0·01	0·58±0·01	0·74±0·01	0·94±0·01	1·10±0·01	1·18±0·01	2·50±0·01
	a.	130±1·0	128±1·0	120±1·0	118±1·0	115±1·0	111±1·0	108±1·0
3	b.	12±3·46	14±3·74	8±2·24	9±2·24	10±2·29	9±4·03	9±3·74
	c.	0·28±0·01	0·59±0·01	0·76±0·02	0·98±0·00	1·12±0·01	1·22±0·01	2·52±0·01
	a.	132±1·0	130±1·0	110±1·0	108±1·0	106±1·0	104±1·0	100±1·0
4	b.	10±1·41	6±1·0	7±1·58	8±2·0	8±2·35	8±2·35	9±2·83
	c.	0·27±0·02	0·56±0·01	0·65±0·01	0·71±0·01	0·85±0·0	0·98±0·01	1·80±0·01

Table III : Fecundity/mortality (a), Days of development (b) and egg diameter/instar length (c) *Salina yosii* at different experimental setups (1-3) and Control (4).

TABLE IV

Experiment No.		Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
	a.	40±1·0	35±1·0	34±0·56	32±1·0	31±1·0	28±1·0	27±1·0
1	b.	2±0·71	5±1·22	6±1·29	7±2·74	8±2·74	8±2·24	8±2·83
	c.	0·47±0·02	0·70±0·01	0·85±0·01	0·96±0·00	1·10±0·01	1·40±0·01	3·25±0·01
	a.	42±1·0	30±1·0	28±1·0	26±1·0	24±1·0	22±1·0	20±1·0
2	b.	3±1·41	6±1·41	7±2·0	8±2·83	10±3·0	9±3·54	9±1·0
	c.	0·47±0·01	0·75±0·02	0·91±0·01	0·99±0·01	1·14±0·01	1·60±0·01	3·60±0·01
	a.	48±1·0	40±1·0	38±1·0	36±1·0	35±1·0	33±1·0	30±1·0
3	b.	4±1·41	7±2·0	8±2·0	9±2·0	11±3·67	10±3·67	10±1·23
	c.	0·48±0·01	0·78±0·01	0·98±0·01	1·10±0·01	1·30±0·01	1·90±0·01	3·70±0·01
	a.	44±1·0	36±1·0	32±1·0	31±1·0	30±1·0	28±1·0	26±1·0
4	b.	2±0·71	4±1·0	5±2·0	6±2·83	7±2·0	8±2·74	8±2·74
	c.	0·43±0·02	0·68±0·01	0·72±0·01	0·85±0·01	1·06±0·01	1·20±0·01	3·10±0·01

Table IV : Fecundity/mortality (a), Days of development (b) and egg diameter/instar length (c) in *Entomobrya kali* at different experimental setups (1-3) and Control (4).

TABLE V

Experiment No.		Hatchability	I instar	II instar	III instar	IV instar	V instar	VI instar	Adult
1	(A)	95·00	5·00	12·28	10·00	11·11	37·50	00·00	41·67
	(B)	90·00	10·00	12·35	1·41	7·14	7·69	8·33	61·11
	(C)	91·67	8·33	2·73	1·87	0·95	0·96	0·00	85·83
	(D)	87·50	12·50	2·86	5·88	3·13	6·45	3·57	67·50
2	(A)	92·36	7·14	18·46	24·53	12·50	14·29	0·00	42·86
	(B)	93·75	6·25	11·11	10·00	11·11	3·13	1·61	63·54
	(C)	98·41	1·59	8·06	0·88	4.42	1·85	1·87	82·54
	(D)	71·43	28·57	6·67	7·14	7·69	8·33	9·09	47·62
3	(A)	97·22	2·78	14·29	16·67	20·00	25·00	0·00	41·67
	(B)	96·08	3·92	10·20	14·63	14·29	8·33	9·09	49·02
	(C)	98·46	1·54	6·25	1·67	1·69	3·48	2·70	83·08
	(D)	83·33	16·67	5·00	5·26	2·78	5·71	9·09	62·50
4	(A)	64·10	48·72	10·00	11·11	12·50	11·42	6·67	35·90
	(B)	90·97	9·09	10·00	12·22	10·13	5·63	11·94	53·64
	(C)	98·48	1·52	15·38	1·82	1·85	1·89	3·85	75·76
	(D)	81·82	18·18	11·11	3·13	3·23	6·67	7·14	59·09

Table V : The natality and mortality percentages in the four species of Collembola (A : *Seira indica*, B : *Seira lateralis*, C : *Salina yosii* and D : *Entomobrya kali*) under the different experimental setups (1-3) and Control (4).

In *Salina yosii*, the percentage of hatching was seen to be nearly the same (98.5%) at medium, maximum and ambient temperatures while the minimum (92%) was under minimum temperature. However, a reverse trend was observed in the mortality percentage of 1st instar, and no clear cut uniformity was seen in any of the other instars. The percentage of adult survival at the end of the experiment was seen to be maximum under maximum temperature (nearly 86%), while the lowest (76%) was observed in the control. In the other two experimental conditions, the percentage survival was very near to the maximum recording 83% (Table V).

Entomobrya kali in contrast to all the other three species, recorded the maximum percentage of hatchability (nearly 88%) under low temperatures, while the lowest (71%) was seen under medium temperature series. The percentage of mortality from the first to sixth instar, as well as the adult was nearly the same under the different experimental setups except that significant maximum mortality (28%) was seen for the first instar at medium temperatures (Table V).

In all the species, the maximum number of males in relation to females was seen to be in medium temperatures. This was significantly shown for *Seira indica* and *Seira lateralis*. However, in *Salina yosii* and *Entomobrya kali*, the male-female ratio was more or less the same under the different experimental conditions (Table VI).

Table VI

Experiment No.	A	B	C	D
1	1·5 : 1	1·5 : 1	1·42 : 1	2·9 : 1
2	4·6 : 1	1·9 : 1	1·36 : 1	3·0 : 1
3	2·4 : 1	1·5 : 1	1·30 : 1	1·9 : 1
4	2·8 : 1	1·0 : 1	1·43 : 1	2·2 : 1

Table VI : The male : female ratio in the four species of Collembola (A : *Seira indica*, B : *Seira lateralis*, C : *Salina yosii*, D : *Entomobrya kali*) under the different experimental setups (1-3) and Control (4).

It was seen that in *Seira indica* fecundity was highly positively significant, $p \angle 0.01$, and no significance between temperature and the numbers in each instar. Temperature and the number of days were significant only in the egg (hatching) and in the V and VI instars development, all positively significant, the former at $p \angle 0.05$ and the latter two at $p \angle 0.01$

level. Temperature was significant for the I, III, IV and VI instars all at $p \angle 0.01$ level. pH had the same correlation except that it was negatively correlated. Salinity revealed a more or less similar phenomenon as temperature. The multivariate analysis was highly significant at $p \angle 0.01$ levels in all cases except for the egg stage and the V instar where the level of significance was at $p \angle 0.05$ (Table VII).

In *Seira lateralis*, temperature, with either egg-numbers or number of instars, showed no significance at all, except in the second instar stage. Temperature and number of days involved in hatching and in development of instars I, II, was positively significant at $p \angle 0{\cdot}01$. Finally temperature with egg-diameter or length of the various instars was seen to be positively signifcant. pH was non-significant either for the egg-number or the number of different instars, but was negatively significant with the number of days and the length of the various stages. The multiple correlation values were all positively significant at $p \angle 0.01$ (Table VIII).

In *Salina yosii* the various environmental factors seem to follow a similar pattern of significant correlations, whether it was temperature, pH or salinity.

The multiple correlation showed a positive significance in all cases at $p \angle 0.01$ level except for the V instar where the level was at $p \angle 0.05$ and for the I instar it was not significant (Table IX).

In *Entomobrya kali* it was seen that the various environmental factors with either the number of eggs or number of instars had no significance except that pH showed a negative significance only for the I instar at $p \angle 0{\cdot}01$ level. The number of days and the eggs hatching period was seen to be significant with all environmental factors except pH which was negatively significant. Multiple correlation was seen to be highly positively significant at $p \angle 0.01$ level except for the first instar where it was not significant (Table X).

DISCUSSION

The present study incorporated the life history of four dominant species of collembola of the family Entomobryidae from abandoned jhum fallows in N. E. India. Two of the species were from the youngest and two were from the oldest abandoned fallows. The primary aim was to identify from life history studies in laboratory, whether the population dynamics of these species could be correlated to field conditions. It is known that in many collembola the length of life-cycle varies in different species as also the time of the year when the eggs are laid. However, in most cases two or more generations may be produced within a year.

The results revealed that though the species were different and inhabiting different soil conditions, yet they revealed similarities in their life-history strategies. *Seira indica* had maximum production of eggs, maximum percentage of hatching and maximum size

TABLE VII

	Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
Temp. & Egg No./Instar No.	0·850**	0·233	0·302	0·307	0·272	0·344	0·262
Temp. & Days	0·521*	0·285	0·293	0·210	–0·192	0·808**	0·713**
Temp. & Egg Dia./Instar length	0·217	0·857**	–0·041	0·819**	0·790**	–0·350	0·843**
pH & Egg No./Instar No.	–0·956**	–0·082	–0·191	–0·301	–0·154	–0·286*	–0·171
pH & Days	–0·579**	–0·031	–0·023	0·010	0·380	–0·826**	–0·640**
pH & Egg Dia./Instar length	–0·363	–0·951**	0·042	–0·741**	–0·658**	–0·355	–0·811**
Sal. & Egg No./Instar No.	0·957**	–0·091	0·067	–0·236	0·054	0·224	0·060
Sal. & Days	0·624**	–0·233	–0·217	–0·132	–0·421	0·716	0·451
Sal. & Egg Dia./Instar length	0·473**	0·954**	–0·099	0·545*	0·472*	–0·308	0·674**
Mult. Cor.	0·503*	0·968**	0·500*	0·987**	0·873**	0·500*	0·947**

* = $p < 0·05$

** = $p < 0·01$

Table VII : Correlation Co-efficient between the various experimental factors and the different life history stages of *Seira indica*.

TABLE VIII

	Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
Temp. & Egg No./Instar No.	0·101	0·195	0·444	–0·073	0·369	0·275	0·194
Temp. & Days	0·732**	0·904**	0·726**	0·213	–0·293	–0·263	–0·311
Temp. & Egg Dia./Instar length	0·529*	0·838**	0·975**	0·780**	0·446*	0·308	0·711**
pH & Egg No./Instar No.	–0·156	–0·029	0·335	–0·128	–0·312	–0·261	–0·118
pH & Days	–0·934**	–0·991**	–0·935**	–0·574**	–0·094	–0·109	0·006
pH & Egg Dia./Instar length	–0·692**	–0·708**	–0·885**	–0·487*	–0·080	0·076	–0·348
Sal. & Egg No./Instar No.	0·208	–0·095	0·212	0·059	0·200	0·204	0·042
Sal. & Days	0·990**	0·963**	0·967**	–0·082	0·324	0·292	0·041
Sal. & Egg Dia./Instar length	0·713**	–0·498*	0·738**	0·465*	–0·146	–0·320	0·176
Mult. Cor.	0·663**	0·979**	0·984**	0·966**	0·934**	0·967**	0·991**

* = $p < 0.05$

** = $p < 0.01$

Table VIII : Correlation Co-efficient between the various environmental factors and the different life history stages of *Seira lateralis*.

TABLE IX

	Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
Temp. & Egg No./Instar No.	0·177	−0·040	0·880**	0·402	0·290	0·283	0·305
Temp. & Days	0·890**	0·911**	0·750**	0·116	0·746**	0·686**	0·206
Temp. & Egg Dia./Instar length	0·762**	0·193	0·176	0·302	0·335	0·038	0·193
pH & Egg No./Instar No.	−0·109	−0·135	−0·324	−0·361	−0·264	−0·215	−0·354
pH & Days	−0·980**	−0·975**	0·568**	−0·114	−0·573**	−0·493	−0·039
pH & Egg Dia./Instar length	−0·663**	−0·232	−0·082	−0·033	−0·103	−0·230	−0·058
Sal. & Egg No./Instar No.	0·038	0·245	0·205	0·267	0·171	0·168	0·034
Sal. & Days	0·958**	0·910**	0·339	−0·234	−0·347	0·279	−0·257
Sal. & Egg Dia./Instar length	0·532*	0·308	−0·338	−0·237	−0·184	0·306	−0·326
Mult. Cor.	0·732**	0·397	0·978**	0·996**	0·983**	0·456*	0·999**

* = $p < 0·05$

** = $p < 0·01$

Table IX : Correlation Co-efficient between the various environmental factors and the diflerent life history stages of *Salina yosii.*

TABLE X

	Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
Temp. & Egg No./Instar No.	0·428	0·188	0·182	0·146	0·330	0·226	0·235
Temp. & Days	0·881**	0·489*	0·250	0·204	0·324	0·422	0·232
Temp. & Egg Dia/Instar length	–0·166	0.166	0·119	0·206	0·460*	0·365	0·319
pH & Egg No./Instar No.	–0·306	–0·892**	–0·034	–0·026	–0·166	–0·150	–0·154
pH & Days	–0·773**	–0·389	–0·103	–0·084	–0·208	–0·307	–0·153
pH & Egg Dia./Instar length	0·361	–0·096	0·123	–0·037	–0·231	–0·123	–0·113
Sal. & Egg No./Instar No.	0·148	–0·130	–0·113	–0·086	0·000	0·119	0·054
Sal. & Days	0·651**	0·396	0·837**	0·098	0·226	0·308	0·201
Sal. & Egg Dia./Instar length	–0·553**	0·069	–0·373	–0·273	0·000	–0·130	–0·169
Mult. Cor.	0·882**	0·139	0·993**	0·986**	0·985**	0·996**	0·996**

* $= p < 0·05$
** $= p < 0·01$

Table X : **Correlation coeffecient between the various environmental factors and the different life history stages of *Entomobrya kali*.**

either of the egg diameter or the instar length when temperature and salinity was high and pH was low. Similarly in *Seira lateralis* it was so except that the number of eggs laid, the size of the eggs and different instars were more. *Salina yosii* also revealed a similar trend as in *Seira indica* and *Seira lateralis* except that the eggs were nearly double that of *S. indica* and one and half times that of *S. lateralis*. The egg diameter and the instar lengths increased in this species, while the percentage of hatching was similar to *S. indica* and *S. lateralis*. *Entomobrya kali* showed the lowest oviposition in comparison to all the others. All the other aspects were similar to *S. indica*. Percentage of hatching was however maximum at lower temperatures in this species.

The percentage of mortality in the various instars was minimum in *S. indica* under maximum temperature and salinity and low pH conditions. *S. lateralis* was similar to *S. indica*. In *Salina yosii* the maximum percentage mortality was seen in first instar under low temperature and salinity with high pH in contrast to *S. indica* and *S. lateralis*. In *Entomobrya kali* the percentage of mortality in various instars was more or less similar under the different environmental setups.

Temperature therefore, was related to either egg-development, duration of each instar, total life span of species and the production of males and females. Salinity also which was maximum at these higher temperatures might have played some role along with low pH. Green (1964a) revealed that limited reproductive period observed in laboratory conditions, will be different from field because the period of development was seen to be nearly three times under culture conditions in contrast to field. This was supported by Snider (1973) who got maximum eggs of *Folsomia candida* and also attained the maximum longivity. These are further supported by Marshall and Kevan (1962). The highest fecundity in the present study was seen in *Salina yosii* where the longivity was also maximum in comparison to the other species. The fecundity being less or the development period being enhanced may be attributed to the accumulation of excretory products (Christiansen, 1963 and Snider, 1973). Moreover the attribution of density could have played another important role in the growth and rate of development. Green (1964b) showed that fecundity could be increased by reducing the density of overcrowded cultures.

The present study did show that the high temperature and salinity had a definite relationship to fecundity and rate of development in all the species studied. The optimum temperature for hatching was shown to be (22-24°C) by Marshal and Kevan (1962) ; while Snider (1971) revealed that 21°C was optimum. Choudhuri (1963) while agreeing that temperature is one criteria for the percontage of egg to complete the development yet he found no significant differences between the wide range of temperatures which he had used for *Onychiurus*.

The effect of salinity is understandable as conductance values have also been quite high during the high levels of population density under field conditions. Hutson (1974, 1978), showed that at higher conductivity collembola species is able to survive and reproduce adequately. Such results are comparable with plant ecologists where the yield of crops was directly related to conductance and therefore to salinity.

However temperature was positively significant to fecundity while all others were non-significant in *S. indica*. Similarly except for the II instar in *S. lateralis* and *Salina yosii* where a positive significance existed, in all other cases there was no significance at all. Mortality therefore was not affected by temperature. Temperature did play a role in the development time either for the hatching period or for the different molts. In *Seira lateralis* and *Salina yosii* temperature was significantly related to egg diameter as also for *Seira indica* and *Seira lateralis* where other instars revealed some significance, while for *Salina yosii* it was non-significant and in *Entomobrya kali* for IVth instar only. This sort of variation revealed that *Seira indica and Seīra lateralis* from the youngest abandoned fallow there was some correlation with temperature while for older abandoned fallow species like *Salina yosii* and *Entomobrya kali* there was very little significance, with temperature. Usually established species show very little variations with minor fluctuations of temperature.

pH was seen to be negatively but significantly correlated in all cases. Like temperature, pH also does not play any significant role in the oviposition rate. Similarly it did not reveal any significance in the mortality of the instars in any of these species. In relation to length of days of development, there was significance in all the species for hatching, though negative. In *Seira lateralis* and *Salina yosii* the length of developmental days of earlier instars also showed significant negative relationships while for *Seira indica* it was seen in the last two instars only.

Salinity also revealed a similar pattern like temperature for either fecundity or the number of instars as well as for the length of days of development and for different size measurements.

In most cases for all the species the multiple correlation was highly significant. This therefore proves that temperature and salinity acts positively in that with increase in temperature and salinity, there is a definite relationship with the length of days and the size of instar, while it is negatively significant for pH, hence higher the pH, lower these possibilities.

This has the support Niijima (1973) where she had observed a direct relationship between temperature and early maturity. Hutson (1974, 1978) had said that either one or all three factors (pH, conductivity and salinity) played a significant role in the species of collembola that he had used. In the present study we have also found that though individual factors do seem to play a role at times in some species, yet it was the synergestic effect of all the abiotic factors which seemed to be responsible forthe total life history strategy for the four species of collembola.

SUMMARY

The aim of the present study was to identily the reproduction strategies of some important speecies of the dominant groups of soil fauna from N. E. India and to relate it to their population dynamics in natural conditions. Experiments were carried out in four different species of collembola from abandoned jhum fallows. Their life histories were observed in relation to some environmental factors like temperature, pH and salinity. The various stages, their development and correlations are presented and discussed.

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