EFFECT OF TEMPERATURE AND HUMIDITY ON THE FECUNDITY AND LONGEVITY OF *CHELONUS RUFUS* LYLE (BRACONIDAE: HYMENOPTERA)

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Introduction

The ability of a parasite or a predatory insect to outnumber the host lies in the fact that it should be able to reproduce more than the host reproduction, an inherent ability of an insect to multiply is a physiological process which largely depends upon the environmental conditions. Insects are "Poikilothermic" is a known fact and they change their body temperature according to the external conditions. This is one of the main factors determining their distribution and abundance at any place and at any time.

In recent years various theories have been put forward to analyse the dynamics of insect populations. Andrewartha and Birch (1954–60) developed a theory that the environment of any animal comprises four compounds; weather, food, other organisms and a place to live. Andrewartha and Birch (1960) observed that theoretically an animal's chance to survive and multiply might be said to depend on its whole environment, but in practice one or several compounds usually turn out to be important enough to account for nearly all the variabilities that have been observed in the density of population. In support of their view, the authors mention the conclusions derived by the observations gathered for 94 years on the pest *Oncopera fasciculata* (Walker) by Madge and Corne (1956). The data showed that survival and abundance of this pest was directly dependent upon its desiccation and rainfall of that area rather than all the influences. Thus temperature and humidity are undoubtedly two major factors which influence most of the physiological activity of insects. The several factors that affect the fecundity of an insect are: (i) genotype of organism, (ii) temperature, (iii) humidity, (iv) nutrition, (v) oviposition stimuli and (vi) presence of other individuals (Robertson and Sang, 1944).

In the present paper, the effect of these two dominant factors, *i.e.*, temperature and humidity on the fecundity and longevity of *Chelonus rufus* Lyle an egg larval parasite of *Earias* spp. has been investigated in some detail.

MATERIAL AND METHODS

Chelonus rufus Lyle is being successfully mass-reared on the alternate host *Corcyra cephalonica* St. in the parasite laboratory of the Division of Entomology. The selected temperatures were maintained in electrically operated thermostat incubators. The different humidities were maintained with solutions of potassium hydroxide of different concentrations as given by Buxton (1931). The figures for relative humidity are only approximate and differ somewhat at different temperatures, as has been shown by Solomon (1951) but are considered sufficiently accurate for these investigations.

Glass tubes, open at both ends measuring 3″×1″, were used as oviposition cages for the parasites. To a freshly emerged, mated pair of *C. rufus* a standard number of 50 *Corcyra* eggs was exposed for oviposition. After every 24 hours, the tubes were removed from the desiccators and the parasitised eggs taken out for dissection. A fresh batch of 50 eggs was offered for parasitization. Cut raisins were provided as food. Each treatment had 3 replications. The parasitised eggs were carefully dissected under a "Stereoscopic binoculars" and the number of parasite eggs recorded. The process was continued till the death of the female parasite.

OBSERVATIONS

The data recorded as a result of daily dissections of the host larvæ have been tabulated and prescribed in Table I.

TABLE I

The effect of different temperatures and humidities on the fecundity of Chelonus rufus

Humidity in %	Temperatures in ° C.						Total	Mean
	5	20	25	30	35	40		
45	248	470	955	923	746	76	3418	189·91
60	366	163	246	999	642	115	2501	138·9
70	253	31	624	1134	1022	122	3186	177·0
90	358	91	229	1035	719	329	2761	153·4
Total ..	1195	755	2054	4091	3129	642	11866	..
Mean ..	99·58	62·91	171·16	340·91	260·75	53·50		

Statistical Analysis

Source	D.F.	S.S.	M.S.	F	Table 'F' 5%	Table 'F' 1%
Temperature ..	5	807421·31	161484·31	4·2744	2·42	3·49
R.H. ..	3	28386·28	9462·09	0·2504	2·79	4·29
Interaction ..	15	180944·36	12062·95	0·3193	..	..
Error ..	48	1813387·33	37778·90	..	..	..
Total ..	71	2830139·38		..	..	..

S.Em. = 56·1092. C.D. = 155·52.

From the above analysis it is seen that the effect of temperature on the fecundity of *Chelonus rufus* is significant, whereas humidity and the interaction between temperature and humidity have not given significant results on the fecundity. The rate of egg-laying is accelerated up to an optimum temperature of 30° C. and then the rate declines. At 40° C. the number of eggs laid declined nearly 7 times from that of 30° C. and 5 times from that of 35° C. It is also apparent that there is no significant difference between the humidities. If at all there is any difference in the mean number of eggs laid in different humidities, it is more due to the effect of temperature rather than humidity itself.

TABLE II

The effect of temperatures and humidities on the longevity of the female parasite C. rufus

Humidity in %	Temperatures in ° C. 15	20	25	30	35	40	Total	Mean
45	144	49	51	46	26	6	322	17·88
60	84	37	37	31	33	18	240	13·33
70	96	48	53	45	48	8	298	16·55
90	163	19	45	48	28	15	319	17·77
Total ..	487	153	186	170	136	47	1179	..
Mean ..	40·58	12·75	15·50	14·17	11·41	3·91		

Statistical analysis

Source	D.F.	S.S.	M.S.	F	Table 'F' 5%	Table 'F' 1%
Temperature ..	5	9425·46	1885·09	18·9076	2·48	3·45
R.H. ..	3	241·04	80·34	0·8058	2·79	4·29
Interaction ..	15	1164·71	77·64	0·7787	1·92	2·55
Error ..	48	4785·67	99·70	..	..	..
Total ..	71	15616·88	..	..	..	..

S.Em. for temperature = 2·882. C.D. = 7·9884.

That the longevity of the females is largely influenced by temperature is apparent. Humidity has little effect on the longevity of the female parasite and so also the interatcion between temperature and humidity. It is also seen that a rise in temperature beyond 35° C. suddenly brings down the span of life of females. Apparently the females live longer at lower temperatures.

TABLE III

The effect of different temperatures and humidities on the longevity of the male C. rufus

Humidity in %	Temperatures in ° C. 15	20	25	30	35	40	Total	Mean
45	36	25	13	9	9	3	95	5·28
60	42	28	14	10	9	4	107	5·91
70	14	13	22	20	16	3	88	4·88
90	84	10	25	6	15	5	145	8·05
Total ..	176	76	74	45	49	15	435	
Mean ..	14·66	6·33	6·16	3·75	4·08	1·25		

Statistical analysis

Source	D.F.	S.S.	M.S.	F	Table 'F' 5%	Table 'F' 1%
Temperature ..	5	1078·38	215·67	32·7268	2·48	3·45
R.H. ..	3	107·60	35·86	5·4415	2·79	4·29
Interaction ..	15	1113·56	74·23	11·2640	1·92	2·55
Error ..	48	316·34	6·59	..	..	..
Total ..	71	2615·88	..	..	..	..

S.Em. for temperature	= 0·0734	C.D. for temperature	= 0·20
S.Em. for relative humidity	= 0·06067	C.D. for relative humidity	= 0·1681
S.Em. for interaction	= 1·482	C.D. for interaction	= 4·107

The results are significant with respect to each other as regards both temperature and humidity. Low temperature and high humidities are congenial for the prolongation of the male life-span. The interaction between temperature and humidity also shows that the combination of 15° C. and all the humidities is significantly superior to other combinations of temperature and relative humidity.

TABLE IV

The effect of temperature and humidity on the length of the oviposition period

Humidity in %	Temperatures in ° C. 15	20	25	30	35	40	Total	Mean
45	96	35	34	38	23	5	231	12·83
60	55	8	12	29	22	5	131	7·28
70	40	8	27	43	36	3	157	8·72
90	96	3	18	36	26	14	191	10·61
Total ..	287	54	89	146	107	27	710	..
Mean ..	23·91	4·50	7·41	12·17	8·91	2·25		

Statistical analysis

Source	D.F.	S.S.	M.S.	F	Table 'F' 5%	Table 'F' 1%
Temperature ..	5	3556·95	711·39	6·2065	2·48	3·45
R.H. ..	3	398·39	132·80	1·1626	2·79	4·29
Interaction ..	15	190·61	12·70	0·089	..	..
Error ..	48	5482·67	114·22	..	..	..
Total ..	71	9628·62	..	..	..	..

S.Em. for temperature = 9·518. C.D. = 8·4732

The analysis of the data shows that temperature has a significant effect on the length of the oviposition period. As in the case of fecundity, humidity does not seem to have a significant influence on oviposition period.

Since all the experiments on the longevity and fecundity were conducted in thermostatically controlled incubators which were totally dark, a few experiments were conducted to investigate the effect of light, if any, on the fecundity of *Chelonus rufus*. The data recorded have been tabulated in Table V.

TABLE V

Effect of light and darkness on the fecundity of Chelonus rufus *at* 25° *C.*

Humidity in %	Daylight	Dark	Total	Mean
45	299	955	1254	209
60	239	246	485	80·8
70	313	624	937	156·1
90	293	229	522	87
Total ..	1144	2054	3198	..
Mean ..	95·33	171·17	266·50	

Statistical analysis

Source	D.F.	S.S.	M.S.	F	Total 'F' 5%	Total 'F' 1%
Daylight	.. 1	39999·40	39999·40	2·111	4·49	8·53
Humidity	.. 3	66898·23	22299·41	1·2	..	..
Interaction	.. 3	48534·27	16178·09	..	..	..
Error	.. 16	303130·00	18944·31	..	..	..
Total	.. 23	458561·90				

S.Em. = 38·71304. C.D. = 107·50. Mean (Daylight) = 95·33. Mean (Dark) = 171·17

The analysis of variance table shows that there is no significant difference in the number of eggs laid between the treatments, daylight and darkness both at 5% level and 1% level. Therefore it can be inferred that *C. rufus* is not influenced much by daylight for oviposition.

Discussion

The study of the effect of temperature on the fecundity has two aspects; the maximum and minimum limiting temperature for oviposition and the effect of different temperatures within these limits on the oviposition period, rate of oviposition and total egg production.

Insects after emerging pass through a brief period when no eggs are laid and this period is known as the "pre-oviposition" period.

Generally the pre-oviposition period is the time taken for the maturation of gonads. In the majority of cases the maturation of gonads is influenced through temperature; high temperatures shorten the pre-oviposition period and lower temperatures prolong the pre-oviposition period. During the course of the present studies it has been found that the parasite *Chelonus rufus* Lyle normally has a short pre-oviposition period. However, it varies according to the condition under which the parasite is reared during the immature stages and on the condition under which the adults are kept. The conclusion can be drawn from the fact that the parasites reared at 25–27° C. and about 70% R.H. and the adults kept under the same conditions usually

have a pre-oviposition period of 2–4 days. But when the parasites are reared at 25–27° C. and about 70% R.H. and the adults transferred to 15° C. will have a prolonged pre-oviposition period that may extend up to 17 days. Ahmad and Ghulamullah (1941) arrived at the same conclusion, when they studied *Microbracon greeni* Ashmead a parasite of the cotton bollworms. Skoblo (1941) observed that *Bracon brevicornis* Wesmael reared at 30° C. and kept at 30° C., 23–26° C., 17–19° C. and 14–16° C. had an average pre-oviposition period of 1, 1·8, 2·6 and 8 days respectively.

In most of the insects oviposition is a continuous process under normal conditions in the presence of host. For every insect there is an optimum level of temperature at which the oviposition period is continuous and the total egg production will also be high. If there is any decrease or increase from the optimum temperature, the rate of reproduction also decreases or increases. Several workers like Burnett (1954) in the case of *Dahlbominus fuscipennis*; Frick *et. al.* (1954) in the case of *Rhagoletis cingulata* have shown that the rate of reproduction will increase with the increase in temperature to a certain level and a decrease in temperature lowers down the rate of reproduction. Vernon and Ray (1960) observed that temperature is generally more critical than humidity, light intensity or food in controlling the oviposition rate. They also observed that temperature range between 28° C. and 36° C. as most optimum. In *Chelonus rufus* also more or less the same trend is seen.

The effect of high temperature on fecundity may increase the velocity of oviposition, but the total oviposition is always less because of the fact that insects cannot survive after certain upper limit. The upper limit for most of the insects is 40° C., but under the present investigation it is found that at 40° C. the process of egg-laying though reduced did not completely cease.

The effects of humidity on the fecundity of insects have been studied by a number of workers and they have come to the conclusion that humidity by itself has little effect. The present findings also show that the fecundity of the parasite is not much affected by change in humidity.

SUMMARY

Chelonus rufus Lyle is an egg larval parasite of the cotton bollworm *Earias* spp. in India. Investigations on the effect of temperature and humidity on the fecundity and longevity of the parasite have been studied.

(*a*) Temperature has a profound influence on the fecundity, longevity and oviposition days of the parasite.

(*b*) Maximum fecundity is obtained at 30° C., and lower and higher temperatures greatly reduced the number of eggs laid.

(*c*) Optimum temperature for the longevity of the female is 25° C., though there is not significant difference between 25 and 30° C. in this respect. However, at 15° C., the longevity is increased to three times, but the fecundity is very much reduced. At 40° C. the longevity is about four times less than that at optimum temperature.

(*d*) Daylight or darkness do not affect the fecundity.

(*e*) Humidity and the interaction between relative humidity and temperature has no marked effect on both fecundity and longevity of the female.

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