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Effect of low temperature on biological attributes of *Chilo partellus* (Swinhoe)

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Abstract
The effect of low temperature on biological parameters of *C. partellus* was studied in the laboratory of Department of Entomology, Rajasthan College of Agriculture, Udaipur during *Kharif* 2011. Longest pupal period, 16.42 and 22.68 days, was observed at 3 ^{0}C under 5 and 10 days storage respectively. Adult emergence at 5, 10 and 15 days storage ranged from 12.0 to 69.0, 7.0 to 55.0 and 9.0 to 40.0 per cent respectively. Sex ratio, 0.68 to 0.43 were observed at 3 ^{0}C while females were increased comparatively to 0.94, 0.94 and 0.91 at 11 ^{0}C under 5, 10 and 15 days storage respectively. Number of eggs observed at 3, 5, 7, 9 and 11 ^{0}C under 5, 10 and 15 days ranged from 49.75 to 184.75, 31.5 to 168.75 and 39.75 to 151.50, respectively. Longest life span, 3.75, 3.25 and 3.0 days was recorded at 11^{0}C under 5, 10 and 15 days respectively.

Keywords: *Chilo partellus*, pupal development, adult emergence, sex ratio, fecundity, adult longevity.

1. Introduction
Maize is attacked by over 250 species of insect and pests [1]. Maize stem borer, *C. partellus* is an important pest of maize in Africa and Asia [2]. Adults of *C. partellus* live for about 2–5 days and do not disperse far from emergence sites. The larval stage passes through six instars and the total larval period ranges from 20 to 28 days. The total development from egg to adult takes 25–50 days with five or more successive generation during single maize growing season [3]. The effect of temperature on development, survival and reproduction of maize pest, *Diatraea lineolata* (Walkar). They found that developmental times were inversely related to temperature, duration from eggs to adult decreased from 65 days at 22 ^{0}C to 39 days at 31 ^{0}C. Development time from egg to adult was longer for females than males at 28 and 31 ^{0}C. Fecundity, egg viability, oviposition period and adult longevity were reduced with increasing temperature [4]. Optimum range of temperature for development of *C. partellus* between 20º-30 ºC. The natural enemies at various constant temperatures showed that 25 ºC temperatures was most suitable for high parasitism, emergence, fecundity and longevity, and that between 25º to 32 ºC was better for faster rate of development. Temperature of >32 ºC are unsuitable for survival [5]. Therefore, the present study was conducted to investigate the effect of low temperature on the pupal development of *C. partellus*.

2. Material and Methods
To study the effect of low temperature on the pupal development of *C. partellus*, a laboratory experiment was conducted at Department of Entomology, Rajasthan College of Agriculture, Udaipur during *Kharif* season 2011. The culture of *C. partellus* was obtained from the Maize Entomology Laboratory of All India Coordinated Maize Improvement Project, Udaipur which was multiplied in the laboratory under 27 ºC ± 1 °C and 75 ± 5 per cent relative humidity for experimentation. Seventy five pupae were stored at 3, 5, 7, 9 and 11 ± 1 ºC for 15 days. Out of these, 25 pupae were taken out at 5th, 10th and 15th days and kept at 27 ºC ± 1 °C temperature and 75 ± 5 per cent relative humidity. Four replications were made for each treatment. Observations on pupal period, adult emergence, sex ratio, fecundity and adult longevity were recorded and analyzed by Completely Randomized Design. Adult moths generally have dark brown patterned forewings and white to gray-brown hind wings with a wing span of 25-30 mm.

3. Results and Discussion
The pupae of *C. partellus* were stored at varied temperatures, 3 to 11^{0}C for different periods, 5

to 15 days and effect recorded on biological parameters *viz*., pupal development, adult emergence, sex ratio, fecundity and adult longevity are presented as belows:-

3.1 Pupal period

The data showed that significantly longer pupal period, 16.42 days, was recorded at 3 °C followed by 15.25, 14.46, 13.58 and 13.07 day at 5, 7, 9 and 11^{0}C respectively (Table-1). It is also apparent from the data that pupal period recorded at 5 °C was statistically at par with 7 and 9 ^{0}C while pupal period observed at 9 ^{0}C was also at par with 11 ^{0}C. Pupae stored for 10 days at different temperatures showed that maximum pupal period, 22.68 days, was observed at 3 ^{0}C followed by 21.85 days at 5 ^{0}C but was statistically at par. The pupal period, 20.94 days observed at 7 ^{0}C was also at par with 5 ^{0}C. Minimum pupal period, 18.95 days, was observed at 11 ^{0}C followed by 19.72 days and was statistically at par.

The pupal period was enhanced when stored for longer period, 15 days at different test temperatures. Longest pupal period, 29.11 days, was recorded at 5 ^{0}C followed by 27.47 and 26.71 days at 7 and 9^{0}C respectively. It is also evident from the table that pupal period recorded at 5 ^{0}C was significantly different to each other test temperatures while at 7 and 9 ^{0}C were at par statistically. Shortest pupal period, 24.92 days, was recorded at 11 ^{0}C and was significantly different to others.

The present findings are in close conformity with the investigation of Mohamed [6] who reported that the pupal duration of *Pegomyia mixta* was 37.5 days at 15 ^{0}C and 11.5 days at 35 ^{0}C with 7.5 ^{0}C threshold for pupal development. Vargas *et al*. [7] observed survival and development of immature stages of four Hawaiian fruit flies reared at five constant temperatures ranging from 16 to 32 ^{0}C. They reported that thermal requirements for development in the pupal stage were greater than egg and larval stages in all species. In contrary Urbaneja *et al*. [8] reported that pupae of *Phyllocnistis citrella* could survive at lower (10 ^{0}C) and higher temperature (35 ^{0}C) respectively.

3.2 Adult emergence

It is evident from the data (Table-1) that storage of pupae for 5 days at low temperature, 3 ^{0}C, adversely affected the adult emergence, 12.0 per cent only and was significantly low compared to 41.0, 58.0, 65.0 and 69.0 per cent at 5, 7, 9 and 11 ^{0}C respectively. The increase in the temperature i.e. 7 to 11 ^{0}C did not affected adult emergence and was found statistically at par. The storage of pupae for 10 days at test durations showed little variation on adult emergence being significantly maximum 55.0 per cent at 11 ^{0}C followed by 48.0, 38.0, 20.0 and 7.0 per cent at 9, 7, 5 and 3 ^{0}C respectively. The data also showed that adult emergence at 9 ^{0}C was at par with T_3 (7 ^{0}C) and T_5 (11 ^{0}C) while T_1 (3 ^{0}C) and T_2 (5 ^{0}C) was significantly different to each other.

The effect of temperature on adult emergence after storage of pupae for maximum duration, 15 days, showed very significant difference among test temperatures. No emergence was observed at 3 ^{0}C while 9.0, 21.0, 31.0 and 40.0 per cent was achieved at 5, 7, 9 and 11 ^{0}C respectively. This clearly emphasized that increase in temperature significantly increase the adult emergence while increase in duration at different temperatures decreased the adult emergence. The results of present investigation were also supported by Torres *et al*. [9] who observed that at 10-20 ^{0}C, only 7 per cent nymphs of *Podisus nigrispinus* (Dallas) could reached the adult stage, whereas at 27, 15-25 and 17-27 ^{0}C, 93.0, 87.3 and 91.1 per cent adult emergence was achieved respectively.

3.3 Sex ratio

The data recorded on sex ratio of *C. partellus* after storage of pupae at different temperatures under varied duration (Table-2) clearly showed that sex ratio is affected significantly with temperature. It is also evident from the data that increase in temperature favored more female biased sex ratio. Storage of pupae for 5 days at varied temperatures *viz*., 3 to 11 ^{0}C had varied sex ratio from 0.68 to 0.94 being maximum female oriented at 11 ^{0}C and minimum at 3 ^{0}C. Similar results were recorded when pupae were stored for 10 days. More female biased sex ratio, 0.94 was recorded at 11 ^{0}C followed by 0.88, 0.81, 0.65 and 0.43 at 9, 7, 5 and 3 ^{0}C respectively. Low temperature, 3 ^{0}C, for 15 days completely inhibited the pupal development with nil adult emergences while significant more female biased sex ratio, 0.91, was recorded at 11 ^{0}C followed by 0.83, 0.72 and 0.57 at 9, 7 and 5 ^{0}C respectively. Pandey and Tripathi [10] investigated the effect of temperature on the development, fecundity, progeny, sex ratio and life table of *Campoletis chlorideae* (Uchida) on larvae of *H. armigera*. They reported that development times shortened as temperature increased from 12 to 13 ^{0}C. A reciprocal linear relationship between temperature and longevity was observed in the range of 12-17 ^{0}C. The maximum mortality of pupae occurred at 37 ^{0}C.

3.4 Fecundity

The data recorded (Table-2) on fecundity of females after storage of pupae at different temperature *viz*., 3, 5, 7, 9 and 11 ^{0}C for varied duration *viz*., 5, 10 and 15 days showed that storage of pupae for 5 days at low temperature, 3 ^{0}C adversely affected the fecundity, 49.75 eggs /female and was significantly low compared to 83.50, 127.25, 153.75 and 184.75 eggs /female at 5, 7, 9 and 11 ^{0}C respectively. Fecundity recorded at all test temperatures was significantly different to each other. The storage of pupae at different temperatures for 10 days showed similar effect on fecundity of females which ranged from 31.5 to 168.75 eggs /female. The effect of temperature on fecundity after storage of pupae for maximum duration, 15 days, showed very significant difference among test temperatures. Nil fecundity was observed at 3 ^{0}C, while 39.75, 90.50, 130.25 and 151.50 eggs /female were achieved at 5, 7, 9 and 11 ^{0}C respectively. All treatments were significantly different to each other. Rodriguez *et al*. [4] found that the effect of temperature on development, survival and reproduction of maize pest, *Diatraea lineolata* (Walkar) developmental times were inversely related to temperature, duration from eggs to adult decreased from 65 days at 22 ^{0}C to 39 days at 31 ^{0}C. Development time from egg to adult was longer for females than males at 28 and 31 ^{0}C. Fecundity, egg viability, oviposition period and adult longevity were reduced with increasing temperature.

3.5 Adult longevity

It is visible from the data (Table-2) that storage of pupae for 5 days at low temperature, 3 ^{0}C adversely affected the adult longevity, 1.50 days only and significantly low as compared to 2.75, 3.0 and 3.75 days at 7, 9 and 11 ^{0}C respectively and statistically at par with 2.25 days at 5 ^{0}C. The increase in temperature from 7 to 11 ^{0}C also increased the longevity of adults. It is evident from the table that adult longevity recorded at 7 ^{0}C was statistically at par with 5, 9 and 11 ^{0}C, while, maximum longevity observed at 11 ^{0}C was at par with

7 and 9 ^{0}C only.

The adult longevity recorded at 10 days storage of pupae on different temperatures showed that longest longevity, 3.25 days was observed at 11 ^{0}C but was statistically at par with 2.5, 2.25 and 2.0 days at 9, 7 and 5 ^{0}C respectively. It is also evident from the table-5 that longevity recorded at 5 ^{0}C was at par with 7 ^{0}C also. Shortest longevity and significantly different, 1.25 days, was recorded at 3 ^{0}C. The effect of temperature on adult longevity after storage of pupae for maximum duration, 15 days showed no adult emergence resulting nil adult longevity at 3 ^{0}C, while 1.75, 2.0, 2.75 and 3.0 days longevity was achieved at 5, 7, 9 and 11^{0}C respectively. It is also evident from the Table-2 that longevity recorded at 5, 7 and 9 ^{0}C was statistically at par while at 9^{0}C was non significantly different to 11 ^{0}C. Overall impact of temperature on adult life span of *C. partellus* after storage of pupae at different temperatures showed that increase in temperature increased the longevity while decrease in temperature drastically reduced the longevity.

Many workers have conducted the experiments on the effect of temperature on biological parameters of adult *viz.*, sex ratio, fecundity and longevity etc. The results of present investigation are in close conformity with the findings of other workers. Lu *et al.* [11] reported that adult life span of *Plutella xylostella* (Linnaeus) decreased with an increase in temperature and was longest at 16 ^{0}C. The work conducted by Veeravel and Bhaskaran [12] confirmed the findings of present investigation wherein increase in temperature from 18 to 36 ^{0}C resulted in faster development of the predators, *C. transversalis* and *M. sexmaculatus*. Adult longevity was greater at 24 ^{0}C than at other test temperatures (18 or 30 or 36 ^{0}C). Among the adults, the females lived longer and produced more eggs at 30 than at 20 ^{0}C. Bai and Chen (1998) [13] reported that at high temperatures, the life span of adult *Anopheles dirus* is clearly shortened. At 33±1 ^{0}C, the average life time is 1.3 days, which is just 11.1 per cent of it at 25±1 ^{0}C. Uraichuen *et al.* [14] reported that adult longevity of *Sitophilus zeamais* was greatest at 20 ^{0}C (14.5 days for females and 20.6 days for males) and shortest at 35 ^{0}C (4.5 days for females and 3.6 days for males).

Table 1: Effect of temperature on pupal development and adult emergence of *C. partellus*

S. No.	Treatments (^{0}C)	Mean pupal period (days) at different storage periods			Mean adult emergence (%) at different storage periods		
		5 Days	10 Days	15 Days	5 Days	10 Days	15 Days
T_1	3	16.42	22.68	0.00	20.14 (12.00)	14.94 (7.00)	0.57 (0.00)
T_2	5	15.25	21.85	29.11	39.75 (41.00)	26.51 (20.00)	17.39 (9.00)
T_3	7	14.46	20.94	27.47	49.71 (58.00)	38.01 (38.00)	27.16 (21.00)
T_4	9	13.58	19.72	26.71	53.86 (65.00)	43.83 (48.00)	33.80 (31.00)
T_5	11	13.07	18.95	24.92	56.51 (69.00)	47.88 (55.00)	39.15 (40.00)
SEm±		0.333	0.417	0.306	2.855	1.96	1.649
CD(P=0.05)		1.005	1.258	0.923	8.605	5.91	4.970
CV (%)		4.581	4.008	2.830	12.978	11.46	13.964

Figures in parentheses represent retransformed per cent values

Table 2: Effect of temperature on sex ratio, fecundity and adult longevity of *C. partellus*

S. No.	Treatments (^{0}C)	Mean female (%) emerged			Mean fecundity / female at different storage periods			Mean adult life span (days) at different storage periods		
		5 Days	10 Days	15 Days	5 Days	10 Days	15 Days	5 Days	10 Days	15 Days
T_1	3	55.56 (0.68)	36.62 (0.43)	5.74 (0.00)	49.75	31.50	0.00	1.50	1.25	0.00
T_2	5	59.71 (0.74)	53.95 (0.65)	50.18 (0.57)	83.50	63.75	39.75	2.25	2.00	1.75
T_3	7	63.25 (0.79)	64.52 (0.81)	58.59 (0.72)	127.25	99.25	90.50	2.75	2.25	2.00
T_4	9	67.31 (0.84)	72.66 (0.88)	68.36 (0.83)	153.75	136.50	130.25	3.00	2.50	2.75
T_5	11	75.50 (0.94)	79.90 (0.94)	74.70 (0.91)	184.75	168.75	151.50	3.75	3.25	3.00
SEm±		0.054	0.117	0.104	3.549	4.412	3.208	0.347	0.392	0.353
CD(P=0.05)		0.165	0.353	0.315	10.697	13.298	9.668	1.047	1.183	1.065
CV (%)		13.740	31.617	34.607	5.925	8.829	7.786	26.234	34.901	37.216

Figures in parentheses represent retransformed per cent values

4. Conclusion

The studies on pupal period at different temperatures *viz*., 3 to 11^{0}C under varied storage durations 5 to 15 days showed that decrease in the temperature either prolonged the pupal period or inhibited development completely. The pupal period was also prolonged when pupae were kept for longer duration compared to shorter duration at any temperature. The Adult emergence from pupae of *C. partellus* under varied temperature and duration greatly differ to each other and increase in temperature is directly proportional to adult emergence. Sex ratio exhibited at different temperature under different storage period showed that decrease in temperature favoured more female biased sex ratio. Very similar trends in fecundity were observed wherein low temperature retarted the

fecundity while higher temperature favoured the fecundity. The adults emerged from pupae stored at 3 to 11 ^{0}C for 5 to 15 days showed higher temperature favoured the adult emergence.

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