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Effect of Different Temperature Regimes on Biology of Bruchid, *Callosobruchus maculatus* (Fab.) and Curculionid, *Sitophilus zeamais* (Mots.)

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ABSTRACT

An experiment was conducted at entomology lab at Division of Crop Protection, ICAR Research Complex for NEH Region and at School of Crop Protection, College of Post Graduate Studies, Umiam, Barapani, Meghalaya to assess the effect of different temperature regimes on biology of bruchid (*Callosobruchus maculatus* Fab.) and curculionid (*Sitophilus zeamais* Mots.). These pests cause severe damage to stored grains and thus studies were conducted to understand the effect the four different temperatures ranging from 20 to 35°C on their biology. The developmental period viz., incubation, larval, pupal, adult longevity were found to decrease with increase in temperature in both of these stored grain pests. Pre-oviposition and oviposition periods showed the similar trend in both the insects studied. However, it was found that fecundity was higher at 30°C in both the insects. Low and higher temperatures reduced the fecundity rates of these insects. This study concludes that temperature deviations from the optimum cause harmful effects on the biology of bruchid and curculionid and higher temperatures during the developmental stages of insects cause rapid population build up and higher population size within short period of time, thus resulting in higher per cent of grain infestation during storage of food grains.

1. Introduction

In recent times, paramount importance is given on good production practices, efficacious crop protection and handling for higher and better yields, sufficient for meeting the needs of increasing population. But little or no emphasis is given on effective storage requirements with minimum post-harvest losses. In India, production of food grains reached 252.22 million tonnes during 2015-16. (GoI 2016). However, every year, loss of 12 to 16 million tonnes of food grains was estimated. India, being tropical country, with warm and humid climate there is a huge chance of rapid multiplication of storage pests in storehouses. Stored grain pests being small in size and cryptic in behaviour are usually unnoticed when present in low numbers. They are highly prolific, in that several generations occur in a year. Pulse beetle, *Callosobruchus maculatus* (Fab.) also known as spotted cowpea bruchid or cowpea weevil is a major pest of stored pulses. Apart from pulses, it also causes qualitative and quantitative damage to cucurbitaceous and solanaceous vegetable seeds (Mukherjee *et al*., 1970). Among various crops in storage, most susceptible crop for insect damage is pulses (5%) when compared to maize (3.5%), wheat (2.5%) and paddy (2%) (Deshpande and Singh 2001). The bruchid lays eggs in the field initially which serves as source of infestation later during storage. Only the grubs cause the damage. A loss of 50-60% was noticed in stored pulses after 6 months of traditional storage (Caswell 1973).

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Maize weevil, *Sitophilus zeamais* (Mots.) is one of the prominent and damaging primary feeders of stored maize, wheat and rice grains occurring all over the world. It is also a pest on pasta, flours and other cereal products. Usually the infestation in the storage houses occurs due to previously infested grains or cross-infestation (Haile 2006) or pest entry during various post-harvest operations. Both the adults and the grubs cause the damage to the grains resulting in mould growth and cause contamination and depreciation of the grains (Parugrug and Roxas 2008).

An improper interaction between biotic and abiotic components of storage environment can lead to grain deterioration. Abiotic factors such as temperature, relative humidity and photoperiod influence the survival, development and reproduction of insects in an ecosystem (Mookherjee and Chawla 1964). However, out of these, temperature has a strong impact on insect survival, distribution and reproduction as they are poikilothermic in nature (Rao 2016). For the development of effective management strategies against insect, it is essential to understand various abiotic interactions that affect survival, development and population dynamics. Apart from this, fluctuating temperatures brought forth by the climate change is aggravating the need for understanding the biology of the insects at different temperatures in order to comprehend the population dynamics at the changing climate scenario. Information on effects of temperature on the biology of bruchid and curculionid will assist in predicting the population size in advance thereby, designing a management strategy. Hence, a simulation based study was undertaken in the laboratory to evaluate the impact of different temperatures on the biology of bruchid (*C. maculatus*) and curculionid (*S. zeamais*).

2. Materials and Methods

(i) Experiment location

The experiment was conducted during the year 2017-2018 in the entomology lab at Division of Crop Protection, ICAR Research Complex for NEH Region and at School of Crop Protection, College of Post Graduate Studies, Umiam, Barapani, Meghalaya.

(ii) Source of insect cultures

Curculionid, *Sitophilus zeamais* (Mots.) and bruchid, *Callosobruchus maculatus* (Fab.) adults were collected from storage houses at Shillong and nearby crop fields at Umiam, Meghalaya.

(iii) Maintenance of insect culture for the experiment

The adults of bruchid and curculionid collected were brought to the entomology lab. The adults were separated from infested grains and mass reared on mungbean (*Vigna radiata*) seeds (Credland and Wright 1989) and maize grains (Davis and Dry 1985), respectively in plastic containers covered with muslin cloth. Mungbean seeds and maize grains were purchased from local market at Shillong, Meghalaya and stored in a freezer at −20°C to maintain freshness. The grains were washed in tap water, dried and heated to prevent pre-infestation before using, either for the rearing or for other experiments. Separated adults of bruchid and curculionid were introduced into fresh uninfested grains at 30 ± 1 °C. The adults obtained from stock culture were sub cultured and used for the experiments. The stock culture was cleaned from time to time to prevent the parasitoid infestation and fresh uninfested grains were provided timely to prevent microbial contamination and to maintain the productivity of the insect.

(iv) Effect of different temperatures on biology of bruchid, *C. maculatus* (Fab.)

Developmental bioassays were carried out using different batches of the bruchid in a BOD incubator, which was set at four constant temperatures of 20, 25, 30 and 35°C (Firake and Khan 2014). Paper strips containing uninfested grains (10g) were exposed to a pair of newly unmated pair of bruchid in a plastic container covered with aluminium foil. Five eggs (one day old) were marked randomly on the paper strip for data collection. Data was recorded on biological parameters like incubation period of eggs, grub period, pupal period, adult longevity for male and female, pre-oviposition period, oviposition period and fecundity at different temperatures.

(v) Effect of different temperatures on biology of curculionid, *S. zeamais* (Mots.)

Developmental bioassays were carried out at different temperatures *i.e.* 20, 25, 30 and 35°C in a BOD incubator using different batches of curculionid obtained from the laboratory culture according to the procedure developed by Firake and Khan (2014). Uninfested grains (10g) were provided in a plastic container covered with aluminium foil having holes. A pair of newly emerged adults were collected and introduced into containers. Separation of sexes was done based on the dimorphic rostral and taxonomic characteristics (Halstead 1963). After 3 days of adult introduction, the grains were stained with acid fuschin

dye (Holloway 1985) for egg identification. The five grains with eggs were marked and kept separately whereas the other grains were dissected on timely intervals for accuracy in developmental period data.

(vi) Experimental design and statistical analysis

The study on effect of different temperature regimes on biology of bruchid and curculionid was carried out with a completely randomized design. Experiment was replicated thrice and each replication had 10 sub replications each. Data obtained for biological parameters at different temperatures for both the insects viz., bruchid and curculionid were subjected to statistical analysis using one way analysis of variance (ANOVA). All the statistical analysis were carried out in SPSS statistics 21 software.

3. Results and Discussion

(a) Effect of different temperatures on biology of bruchid, C. maculatus (Fab.)

Present study has shown a correlation between temperature and biology of the bruchid (Table 1). It revealed that incubation period of eggs was highest at 20°C (7.01 days) whereas lowest period was at 35°C (4.35 days) and maximum grub period was recorded at 20°C (21.01 days) and the minimum grub period was at 35°C (12.07 days). Mean pupal period was highest at 20°C (6.02 days) and lowest at 35°C (3.41 days), respectively. Adult longevity was less in males when compared to females at all the temperatures studied. Longest male longevity duration was recorded at 20°C (11.65 days) whereas shortest at 35°C (7.50 days). In case of female adult longevity, highest duration of 13.61 days and lowest duration of 8.76 days were recorded at 20°C and 35°C, respectively. The reason behind reduced longevity period is explained by a study conducted by Chihrane and Lauge (1996), who concluded that premature mortality and higher mortality rate in insects is noticed when temperature deviates from optimum level. Pre-oviposition period was observed to be shortest at 35°C (1.33 hrs) whereas longest at 20°C (2.60 hrs). Similar results were obtained by Devi and Devi (2014), who stated that at 27°C and 80% RH, female started oviposition on suitable host within 1 hour after mating. Similarly, oviposition period also showed same trend having the longest period at 20°C (8.61 days) and shortest at 35°C (7.65 days). However, there is a significant difference in fecundity rate where the maximum fecundity was observed at optimum temperature of 30°C (103.96 eggs/adult) but there was not much difference at 35°C (103.07) and minimum fecundity rate was observed at 20°C (93.35 eggs/adult). post-embryonic development caused reduced fecundity as a result of the disruption of ovarian function.

(b) Effect of temperature on biology of curculionid, S. zeamais (Mots.)

Present investigation on study of biology of curculionid at different temperature regimes revealed that mean incubation period was maximum (6.65 days) and minimum (5.33 days) at 20°C and 35°C, respectively (Table 2). Mean grub period was also found to be longest at 20°C (35.91 days) and shortest at 35°C (17.95 days). Bhuiyah *et al.* (1990) reported that grub period ranged from 16 to 20 days at 23 to 35°C and 79 to 87 per cent relative humidity in maize seeds. Similarly, mean pupal period had longest duration of 7.98 days and shortest duration of 4.25 days at 20°C and 35°C, respectively. It was noticed from the study that at lower temperatures the period of development was higher and as the temperature increases the developmental period decreased. The major reasons for reduced survival at higher temperatures may be due to accumulation of toxic compounds that disturbs the metabolism and behaviour of insects or the denaturation of proteins (Campbell *et al.,* 1974). There was a significant difference among different temperatures in all the parameters studied. Adult longevity in males was higher at 20°C (93.02 days) whereas lower at 35°C (71.65 days) and in case of female adult longevity it was observed that maximum period of 125.43 days and minimum period of 80.42 days at 20°C and 35°C, respectively. Similar findings were reported by Sangma (2011), who observed that adult longevity with food ranged from 80-105 days for female and 75-103 days for male under laboratory conditions with temperature of 22-27°C and 70-85 per cent RH. Pre-oviposition period of curculionid ranged from 1 to 3 days during 20 to 35°C during the experimental period. The longest pre-oviposition period was recorded at 20°C (3.28 days) whereas shortest at 35°C (1.87 days). This was in correspondence with the findings of Tadesse (1991), who observed that mating took place within a few hours after the adult emergence and eggs were laid after 2-3 days after mating. As the temperature was altered during the study, oviposition period of curculionid was noticed to be highest at 30°C (80.33 days). However, there was a slight decrease at 35°C (71.55 days) but the least period of oviposition was recorded at 20 °C (63.93 days). Fecundity rate of curculionid was found to be 90.47 eggs/adult at 30°C which had a significant difference among the other temperatures studied. The least fecundity rate was noticed at 20°C (83.57 eggs/adult). Correspondingly, Mookherjee and Chawla (1964) also concluded from their study that maximum number of eggs/day/female was attained at 30 °C.

Conclusions

Present study concludes that both the bruchid and curculionid had a longer developmental period at low temperature (20°C), and shortest developmental period at the high temperature (35°C). However, the fecundity was observed to be highest at 30°C and the adult longevity was reduced as temperature increased. Thus it is manifested from the present study that variations above or below the optimum temperature results in deviations in the survival and development of bruchid and curculionid. Thereby, it can be understood that temperature plays the major role in insect biology and reproduction. Making it evident from the investigation that increase in temperature reduced the days required for completion of development and thereby there will be more number of generations per year. This not only results in higher insect population buildup but also paves way to higher per cent of grain infestation during storage.

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Table 1. Effect of different temperatures on bruchid, *C.maculatus* (Fab.)

Temperatures (°C)	Developmental time (in days)			Adult Longevity		Pre-Oviposition period (Hrs)	Oviposition period (in Days)	Fecundity (No. of eggs)
	Incubation period	Grub period	Pupal period	Male	Female			
20	*7.01[a]	21.01[a]	6.02[a]	11.65[a]	13.61[a]	2.60[a]	8.61[a]	93.35[d]
25	6.65[b]	17.12[b]	5.62[b]	10.34[b]	12.03[b]	2.32[a]	8.03[b]	98.22[c]
30	4.67[c]	13.13[c]	4.36[c]	9.01[c]	11.46[c]	1.63[b]	7.65[c]	103.96[a]
35	4.35[d]	12.07[d]	3.41[d]	7.50[d]	8.76[d]	1.33[b]	6.62[d]	103.07[b]
SE m(±)	0.05	0.05	0.04	0.04	0.03	0.13	0.04	0.17
CV	1.59	0.65	1.58	0.78	0.60	11.48	1.06	0.31
CD at 5%	0.17	0.19	0.14	0.14	0.03	0.42	0.15	0.58

(One-way ANOVA, $p \leq 0.05$, Tukey's HSD)

* Different letters after mean values indicate significant differences among treatments.

Table 2. Effect of different temperatures on curculionid

Temperatures (°C)	Developmental time (in days)			Adult Longevity		Pre-Oviposition period (in days)	Oviposition period (in Days)	Fecundity (No. of eggs)
	Incubation period	Grub period	Pupal period	Male	Female			
20	*6.65[a]	35.91[a]	12.03[a]	93.02[a]	125.43[a]	3.28[a]	63.93[d]	83.57[d]
25	6.03[b]	29.08[b]	7.98[b]	88.74[b]	108.13[b]	2.64[b]	69.18[c]	87.37[c]
30	5.67[c]	24.01[c]	6.14[c]	87.39[c]	93.20[c]	2.03[c]	80.33[a]	90.47[a]
35	5.33[d]	17.95[d]	4.25[d]	71.65[d]	80.42[d]	1.87[d]	71.55[b]	87.69[b]
SE m(±)	0.05	0.07	0.05	0.41	0.29	0.02	0.07	0.05
CV	1.61	0.51	1.29	0.83	0.49	1.50	0.17	0.10
CD at 5%	0.17	0.25	0.18	1.34	0.94	0.06	0.23	0.17

(One-way ANOVA, $p \leq 0.05$, Tukey's HSD)

** Different letters after mean values indicate significant differences among treatments.*

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