

**EFFECT OF COFFEE ON THE GROWTH AND DEVELOPMENT OF  
THE RED FLOUR BEETLE, *TRIBOLIUM CASTANEUM* (HERBST)  
(COLEOPTERA: TENEBRIONIDAE)**

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**Abstract:** Effect of various concentrations of coffee, *Coffea arabica*, viz. 12.50%, 25% and 50% on the growth and development of the red flour beetle, *Tribolium castaneum* (Herbst) was determined. Coffee lengthened the larval and pupal periods significantly. There was also a significant reduction in the pupal recovery and adult emergence of the beetle following treatment. The food with 50% coffee had the most detrimental effects on the beetle. Coffee extract could be used as useful botanical pesticide for controlling red flour beetle.

**Key words:** Coffee, *Tribolium castaneum*, growth, development.

**INTRODUCTION**

The red flour beetle, *Tribolium castaneum* (Herbst) is a major pest of stored food grains and is cosmopolitan in distribution (Good 1933). Both adults and larvae are able to exploit a wide variety of stored commodities (Ziegler 1977). Their presence in the stored products results in both contamination and substantial economic damage due to loss of the product's market price and decreased nutritional value (Burkholder and Faustini 1991). This species has had a long association with human stored food and has been found in association with a wide range of commodities including grain, flour, peas, beans, cacao, nuts, dried fruits, and species, but milled grain products such as flour appear to be their preferred food (Good 1936). Protection of grains, stored for food as well as seed, from the attack of insect pests without imparting toxic effect to human beings and other animals is desirable.

Pest control is a major concern in agriculture and horticulture growers for under developed agro-based countries (Ahmed *et al.* 2009). The red flour beetle is a common and the most vicious pest among important stored –product insect pests all over the world (Pranoto *et al.* 1991). It has been reported that the germ part (embryo portion) of the grain is destroyed by *T. castaneum*. Their presence in grain type stored foods directly affects both the quantity and quality of the commodity (Sagheer *et al.* 2011, Okonkwo and Okoye 1996, Rahman *et al.* 2011).

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\*Deceased, Obituary noted in this volume.

Farmers use various synthetic insecticides and fumigants to control pests, which have serious effects on environment, including pest resistance to pesticides, pest revival, and lethal on the non-target organisms.

Botanical insecticides are considered as an alternative to the synthetic chemicals for being biodegradable, pest specific, non-hazardous to human health and environment and leaving no toxic residue in nature (Farhana *et al.* 2006, Periera and Wohlgemuth 1982). The present work was aimed at studying the effect of coffee on the growth and development of *T. castaneum*, which seemed important from the point of nutritional regulation of the pest.

### MATERIAL AND METHODS

Adults of *T. castaneum* were collected from the stock culture of the Department of Zoology, Rajshahi University. A large number of beetles were put on a thin film of whole meal flour previously passed through a 60 micrometer mesh sieve in a beaker for egg collection. Eggs were collected by sieving the flour and were incubated at  $29 \pm 2^{\circ}\text{C}$  in a Petri dish for hatching of the larvae. Fresh wheat flour mixed with brewer's yeast powder (19:1) were used as experimental food media. Twelve plastic bottles each with 50 gm of the food media were taken and marked as groups 1-4, each having 3 bottles. Bottles of group 1, was used as untreated control, i.e. no coffee was added, respectively. In each bottles of group 2-4, 12.5, 25 and 50% coffee (by weight) was added. About 30 newly hatched larvae were distribution in each bottle. Each plastic bottle was covered with a piece of cloth and kept at room temperatures of  $29 \pm 2^{\circ}\text{C}$ .

Growth of the larvae was assessed at two stages: 10 days after treatment cleaned at maturity (18-day old). Ten day old larvae were collected by sieving, washed from adhered flour particles and were weighed (three larvae at a time because of their lower weight) on an electronic balance (ADAM, Japan). Similarly, mature larvae were collected and individually weighed. The larval period was noted and freshly formed pupae were weighed and counted, and placed in separate Petri dishes for adult emergence. The pupal period was recorded. Freshly eclosed adults were weighed and counted for each food. The co-efficient of variation (CV) and growth indices (G.I.s) of *T. castaneum* at different treatments were calculated. Growth indices (G.I.s) of *T. castaneum* on different food media were also calculated. The following formula was used for calculating the growth index (Saxena 1969).

$$\text{G.I.} = \frac{\text{Adult recovery (\%)}}{\text{Total larval and pupal periods}}$$

## RESULTS AND DISCUSSION

The perusal of data reveals that coffee reduced the growth and development of *T. castaneum* in the following order: wheat flour (control)>12.5% coffee>25% coffee>50% coffee, as shown by analysis of variance (Tables 1& 2). Again, coffee significantly reduced the pupal recovery and adult eclosion (%) of *T. castaneum* in the same order (Table 3). Coffee also distorted the typical sex ratio of 1:1 in favour of the females except control (Table 3). Mukherjee and Ramachandran (1989) observed that *Azadirachta indica* incorporated in wheat flour reduced the growth and survival of *T. castaneum* larvae. Similar results were obtained by Jilani *et al.* (1988) who reported the significant reduction of body weight of *T. castaneum* larvae, pupae and adults by turmeric, sweet flag and neem oil. The toxic effect of caffeine and castor oil to *T. castaneum* adults and larvae has been reported by Mondal and Akhtar (1992).

**Table 1. Effect of coffee on the growth of *Tribolium castaneum* larvae**

Food media	Mean weight $\pm$ SD (mg)					
	10-day old larvae	Mature larvae	Pupae (male)	Pupae (female)	Adults (males)	Adults (females)
Control	3.10 $\pm$ 0.38	3.31 $\pm$ 0.41	2.67 $\pm$ 0.43	2.86 $\pm$ 0.29	2.37 $\pm$ 0.31	2.65 $\pm$ 0.18
12.5% coffee*	2.38 $\pm$ 0.28	2.83 $\pm$ 0.41	2.32 $\pm$ 0.39	2.44 $\pm$ 0.33	2.04 $\pm$ 0.36	2.12 $\pm$ 0.31
25% coffee	1.95 $\pm$ 0.35	2.36 $\pm$ 0.43	2.18 $\pm$ 0.27	2.29 $\pm$ 0.29	2.00 $\pm$ 0.33	2.08 $\pm$ 0.38
50% coffee	1.30 $\pm$ 0.22	2.29 $\pm$ 0.35	2.03 $\pm$ 0.28	2.12 $\pm$ 0.30	1.66 $\pm$ 0.26	1.73 $\pm$ 0.26
F-value	82.35***	41.86***	17.96***	32.03***	25.07***	49.62***

\*Note: \*\*\* Highly significant at P=0.001 87.50% control food (wheat flour+ yeast, 19:1) +12.50% coffee and so on.

**Table 2. Effect of coffee on the development of *Tribolium castaneum* larvae**

Food media	Larval period				Pupal period			
	No.	Mean $\pm$ SD	C.V. (%)	t-value	No.	Mean $\pm$ SD	C.V. (%)	t-value
Control	337	18.93 $\pm$ 0.42	2.22	-	321	7.83 $\pm$ 0.46	5.87	-
12.5% coffee*	265	22.06 $\pm$ 0.98	4.44	-3.64	238	8.46 $\pm$ 0.82	18.38	-1.05
25% coffee	247	23.61 $\pm$ 0.28	1.18	-15.70	234	9.29 $\pm$ 0.32	3.44	-3.03
50% coffee	226	25.72 $\pm$ 0.46	1.79	-27.85	186	11.22 $\pm$ 0.33	2.94	-6.84

\*Note: 87.50% control food (wheat flour+ yeast, 19:1)+12.50% coffee and so on.

The percentage of adult emergence is an important factor for further infestation. The highest adult emergence indicates the highest infestation. In the present investigation it was found that due to the effect of coffee adult emergence was significantly decreased which is a very much promising aspect to control this pest through nutritional regulation.

**Table 3. Effect of coffee on the sex ratio, pupal recovery and adult emergence (%) and growth index of *Tribolium castaneum***

Food media	Male (%)	Female (%)	Male: female	$\chi^2$ Value	Pupae (%)	Adults (%)	Growth index
Control	51.04	48.96	1:0.96	0.14	93.61	89.17	3.33
12.5% coffee*	46.04	53.96	1:1.17	1.66	73.61	66.11	2.17
25% coffee	46.96	53.04	1:1.13	0.91	68.61	65.00	1.97
50% coffee	47.79	52.21	1:1.09	0.44	62.78	51.67	1.40

\*Note: 87.50% control food (wheat flour+ yeast, 19:1) +12.50% coffee and so on.

The pesticidal property of coffee has been documented by a number of researchers. Caffeine (an alkaloid of the methylxanthine family) is naturally produced by a number of plant species, including coffee, tea, mate and guarana (Ashihara and Crozier 2001). Caffeine acts as a chemical defense in these plants, showing repellent or toxicant properties. The first direct evidence of caffeine acting as an insecticide was reported in tobacco hornworm, *Manduca sexta* larvae (Nathanson 1984), at caffeine concentrations similar to those found in coffee seeds (i.e., 0.8-1.8 wt%). Caffeine aqueous solutions (2.0 wt %) have also shown molluscicidal activity against the slug, *Veronicella cubensis* and orchid snail, *Zonitoides arboreous* (Hollingsworth *et al.* 2002, 2003). Other pesticide applications of caffeine include fungi control (Arora and Ohlan 1997), bird repellent (Avery *et al.* 2005, Linz *et al.* 2006) and pest coyotes control (Johnston, 2005). A report was obtained for the resistance of coffee seeds to the berry borer, *Hypothenemus hampei* (Guerreiro and Mazzafera 2003). Caffeine produced high mortality in the fruit fly, *Drosophila melanogaster* (Nigsch *et al.* 1977, Zimmering *et al.* 1977) and the moth fly, *Telmatoscopus albipunctatus* (Sengal *et al.* 1977). It also significantly slowed down the growth and development of the latter species. Caffeine inhibits oviposition and delayed development of the shot-hole borer beetle, *Xyleborus fornicatus* (Hewavitharanage *et al.* 1999). Studies on *D. prosaltans* demonstrated a series of deleterious biological effects (Itoyama and Bicudo 1992, 1997), which lead to the suggestion of caffeine's usefulness as an alternative insect control method. Coffee also significantly reduced the population of adults, a finding corroborating with that obtained by Itoyama *et al.* (1992) in *D. prosaltans*. Higher concentrations of used coffee grounds induced very high larval mortality of *Ochlerotatus notoscriptus* (Derraik and Slaney, 2005). Caffeine and used coffee grounds completely checked the development of *Aedes aegypti* at the early stages in treatments with the concentrations 1.0 and 50 mg/ml respectively (Laranja *et al.* 2003).

Perusal of the data shows that coffee produced detrimental effects on all the biological parameters of *T. castaneum*. It could be suggested that caffeine may

prove to be a successful botanical pesticide for the management of the red flour beetle and other storage pests.

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