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Growth and Development of the Lesser Mealworm, *Alphitobius diaperinus* (Panzer) (Coleoptera: Tenebrionidae) on Cereal Flours

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Abstract: The effect of different cereal flours, e.g. wheat, barley, corn and rice flours on the lesser mealworm, *Alphitobius diaperinus* (Panzer) has been worked out. Cereal flours reduced the growth of all the developmental stages of the beetle. The pupal and adult recoveries (%) were also lowered, and the larval and pupal durations were lengthened in the tenebrionid when grown on cereal flours. The fecundity and egg viability (%) of *A. diaperinus* were also significantly reduced when reared on these flours.

Key words: *Alphitobius diaperinus,* cereal flours, growth, development

INTRODUCTION

The darking beetle, *Alphitobius diaperinus* (Panzer) is a major pest of a great variety of stored products. The species is cosmopolitan in distribution and is associated with wheat, barley, rice, oatmeal, soybeans, cowpeas, peanuts, etc. and has been reported from linseed, cottonseed, oilseed products, tobacco, skims, drugs, poultry litter, etc.[1-3].

A. diaperinus is frequently found to infest commercial poultry production units in Europe[4], Asia[5] and USA[6]. The darking beetle has been implicated in the transmission of several diseases and disease agents, viz., Newcastle disease, avian influenza, infectious bursal disease, Mereck's disease (Avian leucosis), fowl pox, Salmonellasis, *Aspergillus* spp., Reovirus, Rotavirus, *Eimeria* (coccidiosis), tapeworms, and caecal worms[7-12].

According to Geier[13], one way to control insect pests is to modify intrinsically favourable habitats in such a way that they no longer provide adequate environments for the pest population concerned, e.g. by furnishing unsuitable sources of food.). Stored products insects present a number of problems associated with insecticidal treatment[14-16]. Recently there is a growing interest in insect pest control through nutritional regulations[17].

Wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), corn (*Zea mays*) and rice (*Oryza sativa*) are important sources of carbohydrates, among others. The following investigation was undertaken to determine the effects of different cereal flours, viz., wheat, barley, corn and rice on the growth and development *of A. diaperinus*, which seemed promising from the nutritional regulation of the pest.

MATERIALS AND METHODS

A. diaperinus were collected from the storehouse of a flour mills at Saheb Bazar, Rajshahi City Corporation. A large number of beetles were placed on a thin layer of wholemeal flour in a petri dish. Eggs were collected on the following day by sieving and were incubated. Newly hatched larvae, 100 for each food, were transferred to plastic jars, each containing 250 g food medium. The foods were wheat, barley, corn and rice flours. A similar batch of control insects was maintained on a whole meal flour-yeast (20:1.5) medium. Slices of potato were kept inside the jars for humidity control, which were replaced when required. The growth of *A. diaperinus* larvae at different instars was assessed on an electric balance. Mature larvae from different foods were placed in separate Petri dishes for pupation. The larval period was recorded. Fresh pupae were sexed by the microscopic examination for exogenital processes of the females[18]. Pupae were individually weighed, and kept for adult emergence. Freshly formed adults were similarly weighed and the pupal period was noted.

The growth indices (GIs) of the beetle on various food media were computed using the formula[19].

For determining fecundity of the females resulting from different foods, newly emerged adults, in pairs of opposite sexes, were placed in glass vials (3.5×1.8 cm) containing food media. Fifteen females were used for oviposition for each flour. Egg counting was continued for 45 days at 3-day intervals. The percent reproduction control was calculated by the formula[20].

The viability of eggs laid by *A. diaperinus* females grown on different flours was also recorded. The fertility

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is given here as the percentage of first instar larvae that hatch out from an accurately known number of eggs[21].

The experiments were replicated three times and were conducted at 29±2°C.

RESULTS AND DISCUSSION

Cereal flours reduced the growth of larvae, pupae and adults of *A. diaperinus* (Table 1). The growth of *A. diaperinus* larvae on the cereal flours did not differ significantly up to the 2nd instar. However, from the 3rd to the 8th instars foods produced significant effects on the growth of the insects. Cereal flours significantly lowered pupation and adult emergence (%) in *A. diaperinus* (Table 2). The developmental periods of *A. diaperinus* were also significantly lengthened when they were reared on cereal flours (Table 3). *A. diaperinus* females resulting from cereal flours laid significantly fewer eggs. The order of oviposition was barley> corn> rice> (Table 4). The value of percent reproduction control shows that rice flour offered the greatest check on the fecundity of the beetle. It was also recorded that the lowest and highest fertility of eggs were on rice and barley flours, respectively (Table 4). There was also a significant reduction in the size of the eggs laid by the females grown on cereal flours (Table 5).

Reduced growth was recorded by Haque[22], Majid and Khan[23] working with another tenebrionid, *Tribolium confusum* and Rashid *et al.*[24] working with *T. anaphe*. Larval weight is one of the important criteria of the suitability of a food[25]. However, this is a less satisfactory factor than developmental periods because its increase is episodic with intervals in which it decreases, as pointed out by Sokoloff[26]. The nutrients available in the foodstuffs are converted into body tissues and energy for all the activities as life demands by various physiological and biochemical processes.

According to Purseglove[27], wheat contains carbohydrate 70%, protein 11.50%, fat 2%, fibre 2%, ash 1.5% and water 13%; barley approximately contains carbohydrate 68%, protein 12%, fats 2%, fibre 3.5% ash 1.5% and water 13%; corn contains starch 77%, bisugar 2%, pentosugar 5%, protein 9%, fat 5% and ash 2% and rice has carbohydrate 82.1%, protein 6.9%, fat 0.5%, fibre 0.2% and ash 0.6%.

The differential susceptibility of *A. diaperinus* to the experimental cereal flours is due to the chemical composition of these foods and if a food lacks in essential components, some of the metabolic functions are deprived of essential factors for its normal and optimum activities. Abnormal nutrition can result in disease and mortality[28]. In addition, nutritional imbalance may result in slow growth and development[29]. The survival rates and developmental periods influence the rate of infestation of a pest greatly.

Table 1: Effect of cereal flours on the growth of *A. diaperinus* (N=30)

Stages	Foods	Mean wt. (mg)±SD	Mean length (mm)±SD
Larvae 1st instar	Wheat flour	0.24±0.08	1.51±0.20
	Barley flour	0.25±0.08	1.59±0.16
	Corn flour	0.24±0.08	1.49±0.17
	Rice flour	0.23±0.07	1.49±0.17
2nd instar	Wheat flour	0.71±0.11	2.72±0.46
	Barley flour	0.73±0.10	2.80±0.47
	Corn flour	0.69±0.12	2.67±0.48
	Rice flour	0.62±0.14	2.62±0.50
3rd instar	Wheat flour	2.97±0.70	4.23±0.50
	Barley flour	3.27±0.68	4.50±0.39
	Corn flour	2.63±0.79	3.80±0.43
	Rice flour	2.53±0.80	3.23±0.52
4th instar	Wheat flour	7.54±1.14	6.56±1.05
	Barley flour	7.70±1.10	6.76±1.09
	Corn flour	6.77±1.05	5.85±1.03
	Rice flour	6.57±1.02	5.48±0.95
5th instar	Wheat flour	15.33±1.51	8.54±0.94
	Barley flour	15.87±1.38	8.97±0.81
	Corn flour	14.30±1.55	7.79±1.05
	Rice flour	13.90±1.59	7.49±0.99
6th instar	Wheat flour	19.00±1.96	9.81±1.14
	Barley flour	20.07±2.04	10.28±1.15
	Corn flour	17.70±2.00	9.34±1.07
	Rice flour	17.13±2.06	9.12±1.21
7th instar	Wheat flour	23.47±2.17	11.46±1.04
	Barley flour	24.50±2.20	11.88±1.05
	Corn flour	21.20±2.54	11.18±1.03
	Rice flour	20.73± 2.17	10.80±1.09
8th instar	Wheat flour	26.90±2.66	14.49±1.52
	Barley flour	28.83±2.95	15.66±1.25
	Corn flour	24.80±2.70	13.77±1.61
	Rice flour	24.00±3.08	13.61±1.42
Pupae	Wheat flour	M 17.13±1.89	M 6.87±0.91
		F 20.00±1.46	F 7.55±0.60
	Barley flour	M 18.03±1.64	M 7.13±0.69
		F 20.83±1.46	F 8.01±0.58
	Corn flour	M 16.33±1.90	M 6.49±0.75
		F 18.87±1.38	F 7.20±0.71
	Rice flour	M 15.97±1.60	M 6.29±0.53
		F 18.40±1.43	F 7.02±0.76
Adult	Wheat flour	M 15.43±1.64	M 6.51±0.49
		F 18.73±1.82	F 7.01±0.61
	Barley flour	M 16.30±1.48	M 6.99±0.60
		F 19.47±1.99	F 7.58±0.45
	Corn flour	M 14.67±1.51	M 6.24±0.59
		F 17.27±1.54	F 6.71±0.79
	Rice flour	M 14.07±1.48	M 6.17±0.53
		F 16.97±1.56	F 6.54±0.65

*Note: M = Male; F = Female.

Table 2: Effect cereal flours on the formation of various stages of *A. diaperinus*

Food	No. of larvae used	Pupal recovery (%)	Adult recovery (%)	GI
Control	200	95.00	88.00	2.24
Wheat flour	200	93.00	91.00	2.35
Barley flour	200	94.50	82.50	1.99
Corn flour	200	88.00	79.00	1.87
Rice flour	200	83.50		

Table 3: Effect of cereal flours on the duration of larval and pupal stages of *A. diaperinus*

	Larval periods (days)		Pupal periods (days)	
Food	No. of Obs.	Mean±SD (95% conf. limits)	No. of Obs.	Mean±SD (95% conf. limits)
Wheat flour	186	32.19±1.59 (31.96-32.41)	176	6.86±0.41 (6.81-6.93)
Barley flour	189	31.31±1.29 (31.12-31.49)	182	6.75±0.55 (6.67-6.83)
Corn flour	176	34.11±1.04 (33.95-34.26)	165	7.25±0.55 (7.17-7.33)
Rice flour	167	35.40±1.02 (35.22-35.57)	158	7.63±0.17 (7.60-7.65)

Table 4: Fecundity and fertility of *A. diaperinus* reared on cereal flours

Food	Total no. of eggs used	Mean oviposition M±SD	Egg/Day/Female	P.R.C	Fertility (%) Mean±SD	No. of eggs hatched
Wheat flour	1519	101.27±16.32	3.62	-	80.84±6.06	1228
Barley flour	1728	155.20±18.65	4.11	13.76	87.92±7.24	1519
Corn flour	1264	84.53±16.37	6.07	16.79	69.54±6.90	879
Rice flour	1194	79.60±13.96	7.74	21.39	63.33±5.45	756

Table 5: Effect of cereal flours on the egg size of *A. diaperinus*

Food	Length (mm)±SD	Width (mm)±SD
Wheat flour	0.79±0.06	0.34±0.09
Barley flour	0.80±0.07	0.39±0.08
Corn flour	0.66±0.10	0.33±0.06
Rice flour	0.61±0.10	0.31±0.05

Food is an important factor that influences an insect's chance to survive and multiply by modifying its fecundity, longevity or the speed of development. The adults of *A. diaperinus* are long-lived and produce eggs over a long period, belonging to the second type of oviposition in Coleoptera[30]. The intrinsic rate of increase of a pest is principally determined by the number of eggs laid during the early life[31].

Fertility is one of the prime factors for the survival of a pest population. Fertility factors are generally studied in order to evaluate their frequency in nature to elucidate the evolutionary forces that maintain the set limits and to describe at various levels, viz., morphological, cytological, physiological and biochemical, any anomalies found[32]. Majid[33] obtained reduced hatchability of the eggs of *T. confusum* when fed on rice flour.

Reduced reproductive potential of various tenebrionids on cereal flours has also been observed by a number of researchers[22-24,34].

Pratt *et al.*[27] gave a comprehensive review and prospectus of insect pest control strategies based on nutritional principles. According to them, for proper insect nutrition two major factors are:

a) the digestibility, i.e. availability of nutrients and the nutritive value of the foodstuffs and
b) the qualitative and quantitative requirements of these animals.

If these two variables are not coordinated harmoniously, the result is metabolic injury or malnutrition. This is why we should direct our attention to nutritional faults or the factors that give rise to abnormal nutrition of the pests concerned.

The significantly reduced growth and development as well as the reproductive potential of *A. diaperinus* on cereal flours are very much promising for managing the pest nutritionally.

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