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Field Evaluation of Different Grain Bait Bases Against Indian Crested Porcupine, *Hystrix indica**

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Abstract.- Indian crested porcupine, *Hystrix indica*, is widely distributed and a serious pest of forest plantations and agricultural crops. Field trials, conducted in Balakot-Abbottabad tract (Pakistan), suggested that in no-choice food preference tests, groundnut was the most preferred food item, followed by maize, wheat, millet, rice, grams and oats. The present results suggested that significantly higher quantities of all the grains were consumed in cracked form than in the whole form, except for rice, where the difference was not significant. Preference for groundnut over other grains was confirmed in both multiple-choice and paired-choice tests. Consumption of all the food grains significantly increased with increasing duration of exposure, indicating a shy and careful nature of the species in sampling a novel food. No-choice tests of groundnut and maize offered in pure form and in different proportions revealed that groundnut and maize offered in 1:1 combination, can be a useful and cost effective bait base.

Key words: Indian crested porcupine; *Hystrix indica*; grain baits; food preference; groundnut; maize; consumption.

INTRODUCTION

Indian crested porcupine (*Hystrix indica* Kerr) is a widely distributed rodent in the subcontinent, inhabiting temperate scrublands, grasslands, forests, steppe mountains and sandy deserts (Gurung and Singh, 1996; Roberts, 1997; Khan *et al*., 2000; Siddique and Arshad, 2004). It is basically herbivorous and causes damage to forest plantations (Ahmed and Chaudhry, 1977; Greaves and Khan, 1978), fruit trees (Mian *et al*., 1988) and agricultural crops (Khan *et al*., 2000). Porcupine claims 38.1% to 90% of the young plants of *Pinus* spp. (Sheikher, 1998; Khan *et al*., 2000; Hussain, 2004), 42% of *Robinia pseudoacacia* (Khan *et al*., 2000) and 30% and 12% to seedlings of *Azadirachta indica*, and *Eucalyptus* spp., respectively (Idris and Rana, 2001). Amongst crops, maize, potato and groundnut are more susceptible to porcupine damage (Brooks *et al*., 1988; Khan *et al*., 2000; Mian *et al*., 2007). Success of afforestation programmes and food security requires that such losses be minimized through controlling the porcupine population.

Rodenticides are the main stay of all present-day practical porcupine control programmes. Physical control methods (trapping, snaring, dog hunting, electric fencing, policing) are largely ineffective and biological/genetic control methods are still to be developed. Effective rodenticide control mainly depends upon a higher acceptance of the bait base as compared with the naturally available foods (Petrusewicz, 1967). Detailed studies are, therefore, required on the bait base, which should be cheap, easily available and above all acceptable to porcupine under the field conditions of the specific area. Pervez (2006) studied the preferences for 6 cereal grain foods (wheat, rice, maize, barley, sorghum and millet) in no-choice and choice tests with captive porcupines. The results of the study revealed that rice was the most consumed and sorghum was the least consumed. The preference of these food baits is still to be tested under field conditions. Mian *et al.* (2007) evaluated 7 grain foods (groundnut, barley, wheat, rice, sorghum, maize and black grams) under the field conditions of the central Punjab (Pakistan), where groundnut and wheat are dominant crops, and the results showed that groundnut was the most

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preferred and black grams was the least consumed. Northern parts of Pakistan, fall at comparatively higher latitude and altitude, have a good forested cover, and maize is the dominant crop. The present attempt is designed to test whether the porcupine food preference is species dependent or is controlled by the acclimatization to the availability of the food in an area. For this purpose different combiantions of the available grain baits have been tested under the field conditions of the forest ecosystem of the northern Pakistan.

MATERIALS AND METHODS

Study area

The study was conducted at two localities, *i.e.*, Abbottabad and Balakot (34° N, 73° E), falling in the western reaches of the summer monsoons, with peak precipitation received during July-August. The area has forested vegetation with an open canopy. The winters are harsh with occasional snowfall, while summers are mild. While composition of the vegetation varies in different areas, yet *Quercus dilata*, Q. *incana, Acer caesium, Populus ciliate, Taxus baccata, Pinus roxburghii, P. wallichiana, Berberis ceratophyla, B. lyceum, B. heteropoda, Viburnum nervosum, Skimmia laureola, Fragaria* sp., *Viola* sp., *Impatiens* spp., *Clematis gouriana, Cassia* spp., *Apluda aristata, Themeda anathera, Aristida cyanantha, Picea smithiana, Cedrus deodara, Indigofera gerardiana, Sambucus ebulus, Sorbaia tementosa* and *Plactranthus rugosus* are the dominant angiosperm plant species. Maize was the major crop during the study period. In addition, some vegetables, like potato, cabbage and cauliflowers were also available in some areas.

Experimental design

Experiments were conducted in different sets, between April and September 2005. In the first set, seven locally available food grains, (wheat, rice, maize, millet, groundnut, grams and oats) were offered in their whole form under a no-choice test, *i.e*., each food item placed in separate burrow. In the second test the above mentioned food items were offered in their cracked form under a no-choice test. Based upon the results of the first two experiments, in the third experiment four more preferred items, (groundnut, maize, wheat and millet) were offered in cracked form under a multiple-choice test (all four items offered simultaneously at a burrow). The two most preferred items (groundnut and maize) were then offered in the porcupine burrows under a paired-choice test.

Considering a relatively higher cost of the most preferred food item (groundnut) and the very cheap price of maize, the second highest preferred food grain, groundnut and maize were tested in different proportions, *i.e*., groundnut alone, groundnut - maize 1:1, 1:3, 1:7 and maize alone, under a no-choice test conditions.

Experimental method

Active porcupine burrows, as determined by presence of fresh footprints, quills and / or fresh faecal pellets, were located during a survey of the denning habitat. The active status of the burrows was confirmed by observing the porcupine footprints on the tracking patches.

Each set of the experiment was conducted at 20 randomly selected burrows in the Abbottabad – Balakot tract. At each burrow, 1 kg (using balance with a minimum count of 1 g) of each food item was offered in earthen bowls deep in the burrow opening. Food items were placed in the burrows in the late evening and were collected in the following morning. The left-over bait and spillage were collected and weighed, and daily consumption recorded. Each bowl was replenished daily and offered again in the next evening. The bowls carrying different food items were placed in random order in each burrow, during different days (Inglis *et al*., 1996). Each test was continued for 5-6 days (5 days for no-choice and 6 days for all other tests). A rest period of 7 days was allowed between different tests to nullify the effect of the previous possible acclimatization (Johnston *et al*., 2005).

Statistical analysis

Food consumption data of different food grains was subjected to one-way analysis of variance (ANOVA), using a 5% significance level. Simple linear regression was used to work out the

relationship between consumption of food items and nights of exposure to food items.

RESULTS

No-choice tests

Whole form

Results on the average consumption of different grains in whole form (Table I) showed that groundnut was the most preferred food item, followed by maize, rice, millet, wheat and grams, while oats was the least consumed. The ANOVA value suggested that differences in the consumption of different food items were significant ($P < 0.05$) from one another, except between wheat and millet, rice and millet, rice and wheat, and grams and oats ($P > 0.05$). Consumption of groundnut ($R^2 = 0.83$, $F_{1,4} = 15.23$, $P = 0.02$) and maize ($R^2 = 0.86$, $F_{1,4} = 18.99$, $P = 0.02$) showed a positive significant regression (Fig. 1) with increase in nights of porcupine exposure to these food grains. The

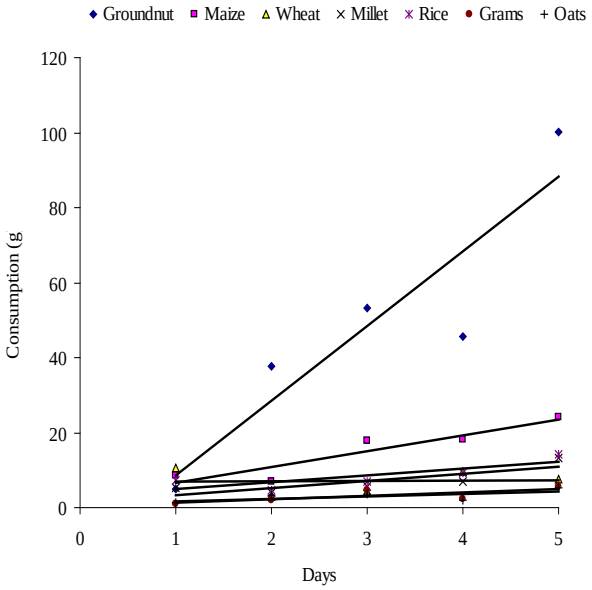

Fig. 1. Relationship between consumption of different food items in their whole form and increase in test nights by Indian crested porcupine in no-choice test.

regression of consumption of millet ($R^2 = 0.68$, $F_{1,4} = 6.53$, $P = 0.08$), rice ($R^2 = 0.66$, $F1_{,4} = 5.94$, $P = 0.09$), grams ($R^2 = 0.57$, $F_{1,4} = 4.09$, $P = 0.13$) and oats ($R^2 = 0.46$, $F_{1,4} = 2.65$, $P = 0.20$) was positive, yet, non-significant, and wheat ($R^2 = -0.03$, $F_{1,4} = 0.01$, $P = 0.92$) showed a non-significant negative regression. The rate of increase per night (slope of regression line) was highest in case of groundnut (19.85 g/ night), followed by maize (4.22 g), millet (1.90 g), rice (1.85 g), grams (0.92 g) and oats (0.67 g)), while, the consumption of wheat decreased by 0.12 g per night.

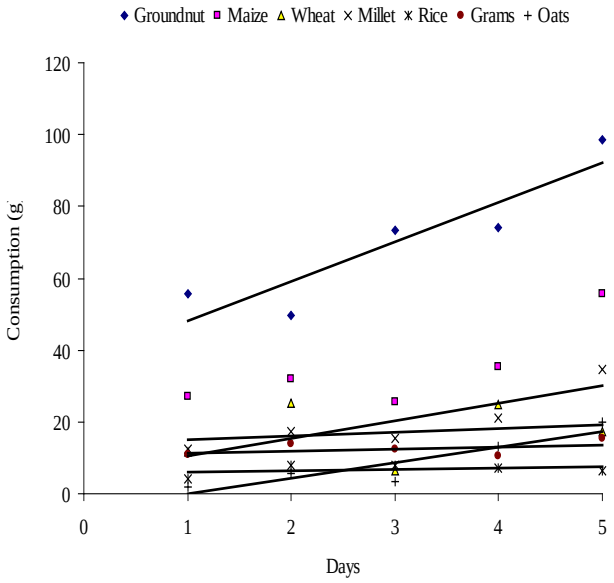

Fig. 2. Relationship between consumption of different food items in their cracked form and increase in test nights by Indian crested porcupine in no-choice test.

Cracked form

The average consumption of seven food grains presented to porcupine under no-choice tests (Table II) suggested that groundnut was the most preferred food item in cracked form, followed by maize, millet, wheat, grams, oats and rice. The ANOVA values also indicated that the consumption of different food items were significantly different ($P < 0.05$) from one another, except, between wheat and millet, grams and wheat, rice and oats, and grams and oats. Consumption of groundnut ($R^2 = 0.82$, $F_{1,4} = 14.31$, $P = 0.03$), oats ($R^2 = 0.86$, $F_{1,4} = 14.65$, $P = 0.03$) and millet ($R^2 = 0.77$, $F_{1,4} = 10.43$, $P = 0.04$) showed a significant positive regression (Fig. 2) with the increasing nights of exposure to food items. The regression was non-significant, yet

positive, with maize (R^2 = 0.62, $F_{1,4}$ = 5.04, P = 0.11), while, it was non-significant for other food items, *i.e.*, rice (R^2 = 0.16, $F_{1,4}$= 0.58, P = 0.49), grams (R^2 = 0.20, $F_{1,4}$ = 0.76, P = 0.44) and wheat (R^2 = 0.04, $F_{1,4}$ = 0.13, P = 0.74). The rate of increase per night (slope of regression line) was highest in case of groundnut (11.00 g/ night), followed by maize (6.05 g), millet (4.85 g), oats (4.30 g), wheat (1.07 g), grams (0.57 g) and rice (0.42 g).

Table I.- **Average consumption of different grain food baits in their whole form by Indian crested porcupine in no-choice tests under the field conditions of Abbottabad – Balakot tract, Pakistan (n = 20 burrows, for all individual experimental sets).**

Food item	Consumption (Mean ± SE, g)	$F_{(1,199)}$ values					
		Groundnut	Maize	Rice	Millet	Wheat	Grams
Groundnut	48.4 ± 6.55						
Maize	15.1 ± 2.37	25.29 *					
Rice	8.5 ± 1.81	36.53 *	5.50 *				
Millet	7.1 ± 1.21	37.89 *	10.23 *	0.43			
Wheat	7.0 ± 1.29	37.42 *	14.34 *	0.47	0.00		
Grams	3.1 ± 0.76	49.51*	26.84 *	9.18 *	6.66 *	8.43 *	
Oats	3.0 ± 0.97	47.94 *	26.49 *	10.61 *	6.48 *	7.11 *	0.00

* P < 0.05

Table II.- **Average consumption of different grain food baits in their cracked form by Indian crested porcupine in no-choice tests under the field conditions of Abbottabad – Balakot tract, Pakistan (n = burrows, 20 for all individual experimental sets).**

Food item	Consumption (Mean ± SE, g)	$F_{(1,199)}$ values					
		Groundnut	Maize	Millet	Wheat	Oats	Rice
Groundnut	70.2 ± 7.26						
Maize	35.1 ± 5.50	16.34 *					
Millet	20.2 ± 2.93	46.14 *	7.10 *				
Wheat	17.1 ± 2.27	52.67 *	10.75 *	0.95			
Oats	12.5 ± 1.91	69.83 *	24.82 *	14.62 *	9.61 *		
Rice	8.7 ± 1.87	76.38 *	28.92 *	20.32 *	19.17 *	0.85	
Grams	6.7 ± 1.25	59.53 *	16.04 *	5.74 *	3.12	2.91	7.06 *

* P < 0.05

The comparison between consumption of whole and cracked forms (Table III), suggested that significantly (P < 0.05) higher quantities of all the grains were consumed in cracked form, except for rice, where the difference was not significant.

Choice tests

Results on the average consumption of four preferred grain foods offered in cracked form to porcupine under the multiple-choice tests (Table IV) showed significant differences (P < 0.05) from one another. Groundnut (relative preference = 70.18%) remained the most preferred bait, followed by maize

Table III.- **Mean ± SE consumption (g) and F values of different grains (whole versus cracked form) by Indian crested porcupine in no-choice tests.**

Food item	Whole	Cracked	$F_{(1, 199)}$ values
Groundnut	48.40 ± 6.55	70.25 ± 7.26	5.57 *
Maize	15.15 ± 2.37	35.10 ± 5.50	11.89 *
Millet	7.05 ± 1.21	20.25 ± 2.93	17.87 *
Wheat	7.05 ± 1.29	17.10 ± 2.27	23.53 *
Rice	8.50 ± 1.81	6.75 ± 1.25	0.64
Grams	3.10 ± 0.76	12.50 ± 1.91	27.47 *
Oats	3.10 ± 0.97	8.75 ± 1.87	8.04 *

* P < 0.05

(25.27%), wheat (3.13%) and millet (1.40%). Consumption of groundnut (R^2 = 0.87, $F_{1,5}$ = 29.12, P = 0.00) and millet (R^2 = 0.68, $F_{1,5}$ = 8.88, P = 0.04) exhibited a positive and significant regression

Table IV. - Consumption of different grain food items in cracked form by Indian crested porcupine in multiple- choice test.

Food item	Consumption (g)		$F_{(1,239)}$ values		
	Mean ± SE	Relative (%)	Groundnut	Maize	Wheat
Groundnut	72.66 ± 7.74	70.18%			
Maize	26.16 ± 4.62	25.27%	50.62 *		
Wheat	3.25 ± 0.84	3.13%	79.07 *	24.22 *	
Millet	1.45 ± 0.37	1.40%	83.77 *	27.96 *	4.11 *

Table V.- Average consumption of groundnut and maize grains offered in cracked form in pure form and in different proportions by Indian crested porcupine in multiple-choice test under the field conditions of Abbottabad – Balakot tract, Pakistan (n = 20).

Food item	Consumption (Mean ± SE, g)	$F_{(1,239)}$ values			
		Groundnut pure	Groundnut–maize (1:1)	Groundnut-maize 1:3)	Groundnut-maize (1:7)
Groundnut pure	75.0 ± 6.52				
Groundnut - maize (1:1)	71.2 ± 5.59	0.95			
Groundnut – maize (1:3)	45.3 ± 4.50	23.67 *	22.13 *		
Groundnut - maize (1:7)	24.1 ± 3.52	79.05 *	77.78 *	26.59 *	
Maize pure	21.0 ± 3.28	78.43 *	77.86 *	27.82 *	0.77

* P < 0.05

(Fig. 3) against the nights of exposure to the baits, while maize (R^2 = 0.03, $F_{1,5}$ = 0.14, P = 0.72) and wheat (R^2 = 0.37, $F_{1,5}$ = 2.43, P = 0.19) showed a lower and non-significant regression. The rate of increase per night was the highest in case of groundnut (15.90 g/ night), followed by maize (0. 90 g), millet (0.55 g) and wheat (0.42 g).

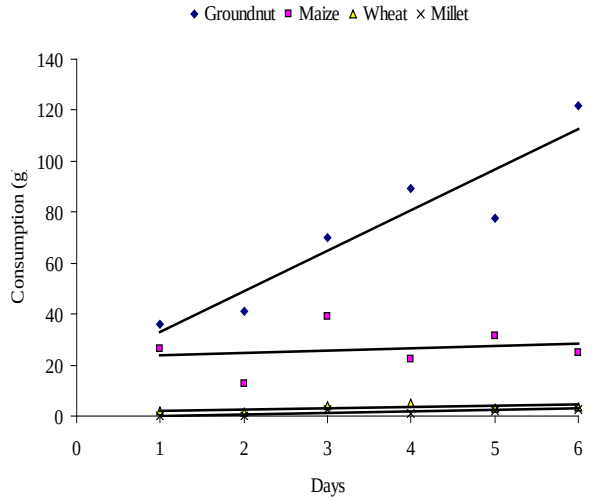

Fig. 3. Relationship between consumption of different food items in their cracked form and increase in test nights by Indian crested porcupine in multiple-choice test.

Results of paired-choice tests (groundnut and maize) confirmed those of single-choice and multiple-choice tests and groundnut was significantly ($F_{1,\ 239}$ = 36.85, P < 0.05) more consumed (62.79 ± 5.81 g/ night) than maize (25.54 ± 2.63 g). Consumption of groundnut and maize (Fig. 4) also increased with each increase in days of porcupine exposure to these items (groundnut 9.73 g/ night and maize 1.69 g). The regression of consumption was positive and significant in case of groundnut (R^2 = 0.64, $F_{1,5}$ = 7.13, P = 0.05), and positive, yet, non-significant in case of maize (R^2 = 0.37, $F_{1,5}$ = 2.40, P = 0.19).

Mixtures of groundnut and maize

The results of no-choice tests (Table V) showed that the consumption of the bait mixture decreased with the decrease in the proportion of groundnut in the mixture. Pure groundnut was consumed in non-significantly different from the

groundnut - maize (1:1) mixture, and both were consumed significantly higher than the groundnut - maize (1:3) mixture, groundnut - maize (1:7) mixture and pure maize. Groundnut – maize (1:3) mixture was consumed significantly higher than groundnut – maize (1:7) mixture and maize alone, both of which were non-significantly different from each other.

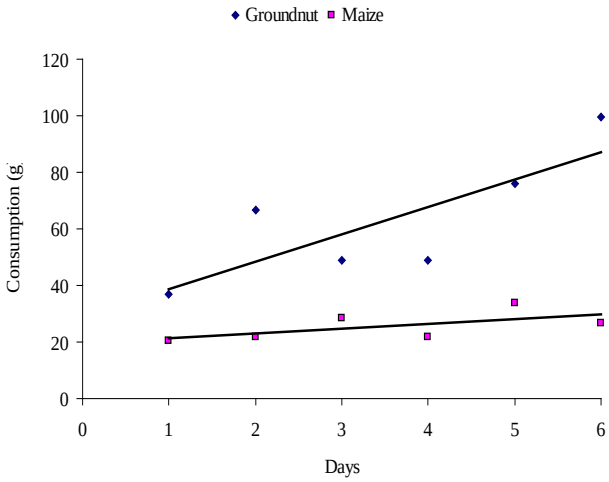

Fig. 4. Relationship between consumption of groundnut and maize in their cracked form and increase in test nights by Indian crested porcupine in paired-choice test.

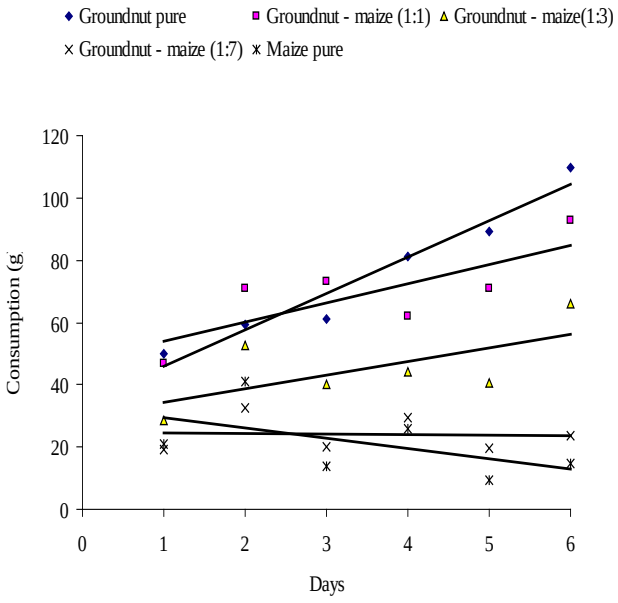

Fig. 5. Relationship between consumption of groundnut and maize, offered in different proportions and increase in test nights by Indian crested porcupine in no-choice test.

The linear regression of consumption (Fig. 5) with the progressive nights, reflected that groundnut pure (R^2 = 0.94, $F_{1,5}$ = 74.51 , P = 0.00) and groundnut – maize (1:1) mixture (R^2 = 0.74, $F_{1,4}$ = 14.31, P = 0.03) showed a significant positive regression, with increase in days of porcupine exposure to these food grains. Groundnut – maize (1:3) mixture (R^2 = 0.42, $F_{1,5}$ = 5.04, P = 0.11) exhibited a positive but non-significant regression, while groundnut – maize (1:7) mixture (R^2 = -0.006, $F_{1,5}$ = 0.02, P = 0.88) and maize alone (R^2 = -0.29, $F_{1,5}$ = 1.65, P = 0.26) showed a non-significant and negative regression. The rate of increase per night was highest in case of groundnut alone (11.68 g / night), followed by groundnut - maize (1:1) mixture (6.77 g/night) and groundnut - maize (1:3) mixture (4.45 g/night). In contrast, a decreasing trend was recorded in case of groundnut - maize (1:7) mixture (0.24 g/night) and maize alone (3.31 g/night).

DISCUSSION

Groundnut has consistently appeared as the most preferred food item under all the presently conducted experimental sets with the Indian crested porcupine. Maize is the second most frequently consumed food grain, yet its consumption always remained significantly lower than the groundnut. The consumption of all other food items tested under the present conditions has remained significantly lower. The preference for groundnut was further confirmed by a consistent decrease in the bait intake when the proportion of the groundnut decreased in groundnut - maize mixtures. The general field observations suggested that porcupine selectively picked groundnut from the mixture. The preference for groundnut has been reported by Mian *et al.* (2007) in a multiple-choice test carried out in groundnut growing area of central Punjab (Pakistan). Severe damage to groundnut crop by porcupine has been reported in the groundnut growing areas of Rawalpindi Division, Pakistan

(Brooks *et al*., 1988; Mian *et al*., 2007). The consistent maintenance of preference for groundnut, even in the non-groundnut growing area under the present study reflects a real preference of porcupine for this bait. Pervez (2006) did not try groundnut and hence his studies have no bearing on the relative preference for groundnut under his experimental conditions of southern Sindh (Pakistan). The preference of groundnut by other rodents has been indicated as peanut butter has been effectively used as poison bait additive for control of lesser bandicoot rat (*Bandicota bengalensis*) in wheat fields of the central Punjab (Pakistan) and peanut oil for Norway rats (*Rattus norvegicus*) in the USA (Meehan, 1984) and in India (Sridhara and Srihari, 1983). Bhardwaj and Khan (1979 a, b) believed that groundnut oil has a neutral flavour for rodents, but it may mask the flavour of some other cereals.

Maize has appeared as the second most frequently consumed cereal grain in the present study. The stomach content and faecal pellet studies undertaken in this area on the population of porcupine indicated a significant consumption of the maize by the porcupine, apart from the dependence upon wild plant species, like, *Pinus roxburghii, Malia azedrach, Sorghum helepense* and *Diospyros lotus* (Inayatullah, 2006). The second choice of porcupine has shifted from wheat in central Punjab, Pakistan (wheat crop dominated tract) (Mian *et al*., 2007) and to maize in hilly tracts under present study area, where maize is the dominant crop.

Rice was the most preferred food for the Indian crested porcupine, when originally trapped from rice growing area of Sindh (Pakistan) and maize was shifted to fourth position in the order of preference (Pervez, 2006). Thus porcupine preferred groundnut on the basis of its higher fat content, while the second choice shifted from maize in hilly areas, to wheat in northern Punjab (Pakistan) and rice in southern part of Sindh (Pakistan).

Most of the field rodents are selective in choosing their foods, when different natural foods are available (Prakash, 1969; Jackson, 1965). Food prefernces are influenced by calorigenic value (Mathur *et al*., 1992), and palatability of the food item (Young, 1946) and the behaviour of the species (Barnett, 1956). Daily requirements of different nutrients, like, fats, proteins and carbohydrates, may also affect the feeding preference of the specific animal and / or population of an area (Stenseth, 1977). It appears that Indian crested porcupine, like other rodents (Imiazumi *et al*., 2001; Elizalde and Sclafani, 1990; Ramirez, 1993), has a preference for diets having higher oil contents. The second choice of the foods depends on the acclimatization of the animal or population to the frequently available food in the area.

All the food items (except rice) were consumed in significantly higher quantities when presented in cracked form than in whole form. No study is available on porcupine, but the preference for cracked grains over whole grains has been reported for house mouse (Jackson, 1965; Rao and Prakash, 1980). The definite reason for the preference of cracked forms of grains is difficult to suggest. The increased consumption of the bait material in cracked form may have practical value for porcupine control as it can carry a higher quantity of the rodenticides.

Gradual increase in average daily consumption of different food items with each increase in duration of exposure to the bait material presented at the dens indicates a careful nature of the species, which is shy to accept a novel object/ food (neophobia). The increased exposure of the animal results in acclimatization of the animal to the novel food. Similar observations were reported by Mian *et al.* (2007). However, the observations of Mian *et al.* (2007) were limited to three nights, where the animal started with a cautious feeding on the first night, which was followed by a cherished feeding on the second night and moderate feeding on the third night. The results have a practical value, suggesting that an acclimatization of the animal is required to the basic bait material before the poison baiting can be started.

The results of the experiments for the preference and consumption of different food grains suggest that groundnut and maize (1:1) is equally consumed in cracked form by the porcupine in the area as groundnut alone and this mixture is consumed in significantly higher quatities than maize alone or groundnut and maize in the ratio of 1:3 or 1:7. This observation has a practical value in porcupine control in the area as it reduces the cost of the bait (groundnut being some 5 times expensive

than maize) without scarificing the bait efficiency. Further, maize in cracked form can carry more of the rodenticide than groundnut, thus increasing the efficacy of the poison baiting. Khan and Mian (2008) used whole maize grain bait of coumatetralyl (0.0375%) and obtained 100% reduction in Indian cresetd porcupine activity, after two weeks of baiting in the Potohar area. Further studies in other habitats may be required before the results of the present study are practically applied in an area.

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