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Evaluation of Fresh Food Baits for the Management of Indian Crested Porcupine, *Hystrix indica* Kerr (Rodentia: Hystricidae)

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Abstract.- Indian crested porcupine, *Hystrix indica,* is widely distributed and a serious pest of forest and agricultural plantations. Field trials, conducted in Abbottabad - Balakot (Pakistan), suggested that in both no-choice and multiple-choice tests guava was preferred by porcupine over potato, carrot and sweet potato. Consumption of fresh food items significantly increased with increasing duration of exposure to novel food, indicating that pre-baiting acclimatization of porcupine is required before poison baiting. Consumption of zinc phosphide impregnated guava bait, offered after three days of pre-baiting with guava, exhibited a decline and no bait was consumed on 3rd day of poison baiting. Degree of decline in bait consumption gradually increased with increasing zinc phosphide concentration between 1% and 3%. Higher reduction in burrow activity (55%) was recorded with 2% zinc phosphide, as compared with 1% (35%) and 3% (15%), suggesting that 2% zinc phosphide can be used for control of porcupines, using guava bait base.

Key words: *Hystrix indica*, fresh bait, feeding preference, pest management, guava, carrot, potato, sweet potato, zinc phosphide.

INTRODUCTION

Porcupines are among the world's largest rodents, present in New and Old Worlds. The Old World porcupines (genus *Hystrix*) have been little studied because of their shy nature, nocturnal habits and tendency to live in remote and inaccessible places (Gurung and Singh, 1996). Indian crested porcupine, *Hystrix indica*, is a herbivore and a fossorial species, which is widely distributed (Roberts, 1997) and a serious pest of forest plantations and agricultural crops in Pakistan (Ahmad and Chaudhry, 1977; Khan *et al*., 2000) and many other countries of the old world (Alkon and Saltz, 1985; Sheiker, 1998; Idris and Rana, 2001). It is a large rodent, weighing 11-18 Kg (Gurung and Singh, 1996) and its distribution range extends throughout the southeast and the central Asia and parts of the Middle East, including countries like India, Nepal, Bhutan, Bangladesh, Sri Lanka, Israel, Yamen and Saudi Arabia (Roberts, 1997). The species is very cautious, strictly nocturnal and lives in extensive burrow system, usually having more than one opening, appearing on some raised edge. The burrows are scattered in the denning habitat, and are occupied by one or more family groups. They regularly come out of the burrow to forage, usually during night, as forage is not stored in the burrows (Roberts, 1997; Mian *et al*., 2007).

Porcupine population needs to be controlled to increase yield/productivity of forests and agriculture and to reduce soil erosion in watersheds to increase the life of water reservoires. Physical control practices (trapping, snaring, dog hunting, electric fencing, policing, etc.) are largely ineffective and biological control not available (limited populations of effective large predators available under a general anthropogenic effects on large carnivores, and few effective specific parasites known), leaving with the only alternative of using chemicals for its management (Hadler and Buckle, 1992). The use of anticoagulant rodenticides, for the control of porcupine requires higher operational cost (Khan and Mian, 2008), while the fumigation of porcupine burrows is only feasible in the loamy soils (Mushtaq *et al*., 2008a). The acute rodenticides are better for giving the quick knockdown, but they have little selectively ad poor efficacy (Prakash ad Mathur, 1992), as almost all rodent species often

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exhibit strong shyness for such chemicals (Sterner, 1994). Success of rodenticide control largely depends upon a better acceptance of bait by the target species than the food available in the wild, so that lethal quatity of rodenticide is passively consumed as the bait has to compete with foods available in the wild (Petrusewicz, 1967). Economics of rodenticide control also demands that food bait material and the rodenticide should be cheap and readily available in local market. Zinc phosphide is the most commonly used and popular rodenticide in major parts of the world, yet poison bait aversion is a problem associated with most of the acute rodenticides (Prakash, 1988; Idris and Prakash, 1992), therefore, a pre-baiting period of 2 – 3 days is usually suggested, before starting poison-baiting (Prakash, 1988).

Different workers have tried grain baits for the control of porcupines (Ahmed *et al*., 2003; Khan and Mian, 2008; Mushtaq *et al*, 2008b), but a little attention has been paid to fresh bait materials. Guava, potato, carrots and sweet potato are cheap and available in local markets in the Indian subcontinent. Zinc phosphide is a cheap and acute rodenticide but has have limited value in rodent control due to its garlic-like smell and bitter taste (Sterner, 1994). Faulkner and Dodge (1962) achieved 94% kill of tree porcupine (*Erethizon dorsatum*) using apples soaked in 72% granulated sugar and 28% sodium arsenite, yet similarly treated apples were not consumed when zinc phosphide was used. Sliced potato and squash were used as fresh bait with sodium fluoroacetate and strychnine to achieve 88% and 40% reduction in Indian porcupine burrow activity, respectively (Khan *et al*., 1992). A 86.66% reduction of porcupines population was achieved using potato, cabbage, carrot and gauva with sodium flouroacetate (Ahmad *et al.*, 2003). When ripened bitter goured and chopped mango stones was used with 1080, temik, warfarin and endrin 19.5%, 100%, 85.7% and 38.88% mortality was acheived (Arshad *et al*., 1988). Present study has been designed with the belief that gauva, with its smell and taste, can be used as effective bait material for delivery of lethal quantities of zinc phosphide to porcupine, especially if its concentration is optimized and a pre-baiting of three days is practised.

MATERIALS AND METHODS

Study area

The field trials were conducted in Abbottabad-Balakot tract (34° NL, 73° E). The area is representative of the Tarbela Watershed Management ecology, which is spread over some 16,058 km^2 of the southern slopes of the western extremities of the Himalayan Mountain Range. The valleys are generally narrow and usually with perennial streams, receiving water from the springs. Though high mountains are present around the study tract, yet the valleys under the present study are located at an attitude of 1500 – 2000 m above sea line. The study was conducted between September 2005 and January 2006, when wild vegetation was mostly dry and cultivated vegetables (sweet peas, cauliflower, cabbage, turnip and potato) were available at scattered patches.

Burrow selection

The study area was extensively surveyed to locate the porcupine burrows with the help of the local staff of the Forest Department and the information available with the local farmers and/ or sheppards. Each burrow was carefully examined for the signs of porcupine activity, like, the fresh quills, foot prints on loose soil, recent signs of excavation and fresh faecal pellets, near the main openings of the burrow. The active status of the burrow was confirmed by laying fine soil dirt tracking patches in front of the burrow opening for three consecutive nights and observing the footprints the following morning. The burrow was considered active only when porcupine foot prints were found on the tracking patch.

Bait preference tests

Four (cheap, locally available and palatable to rodents) fresh food items, *i.e.*, guava (*Psidium guajava*), potato (*Solanum tuberosum*), sweet potato (*Ipomoea batatas*) and carrot (*Daucus carota*), were offered under no-choice and multiple-choice tests. In no-choice tests each food item was offered, separately, at 20 randomly selected burrows, while in multiple-choice test all the food items were offered together at 20 burrows.

Weighed quantity (1 kg) of each item (cut in to about 1 cm^3 pieces) was placed in earthen bowls 20-30 cm deep into borrow in late evening. Bowls were collected early next morning. Left-over and spillage food was weighed and daily consumption recorded. Position of bowls was changed each night during multiple-choice test to avoid the positional preference/ effect, following Inglis *et al*. (1996). Each test continued for 7 days. A rest period of 7 days was allowed between different tests to nullify the effect of previous feeding trials (Johnston *et al*., 2005).

Poison baiting

Zinc phosphide (80%, marketed under the trade name, 'Agzinphos', A. G. Services) was tested at three concentrations (1, 2 and 3%) for porcupine control. Rodenticide was placed in small holes, created by inserting a steel rod (0.50 cm diameter) in guava fruit to prepare the relevant poison bait formulation.

For each experimental set, 40 active burrows were randomly divided into two groups, *i.e.*, experimental and control, of 20 burrows each. Plain guava fruit weighing 1 kg was offered in earthen bowls at the burrow entrance for first three nights (pre-baiting) in all the burrows. Selected poison bait was then offered to experimental group, only, on nights 4-6, while plain bait continued in control group.

To estimate the reduction in burrow activity, fine soil dirt tracking patches were applied in front of the burrow opening and observed for the footprints, the following morning. The burrow was considered active only when porcupine foot prints were found on the tracking patches. The burrow activity was monitored till five days, to calculate the reduction in porcupine burrow activity.

Statistical analysis

Statistical calculations were performed using computer software Microsoft Excel 2000. Mean consumption and standard deviation of each parameter were calculated. Student's 't' test was applied for comparison of different treatments, using a 5% level of significance. Simple linear regression was used to work out the relationship between consumption of food items and to measure the degree of association between the two variables (Steel and Torrie, 1984). Pre-baiting and poison-baiting ratio was calculated by dividing average per night bait consumed during pre-baiting by average per night bait consumed during poison-baiting.

RESULTS

Bait preference tests

No-choice test showed (Table I) that guava (93.9±8.20 g/night) was the most favourably consumed food item, followed by potato (50.4±5.82 g/night), carrot (40.0±5.15 g/night) and sweet potato (21.8±2.29 g/night). The `t' values revealed a significant ($P < 0.05$) difference between the consumption of food items in all cases, except between potato and carrot, where the difference was not significant ($P > 0.05$). Consumption of different food items during different nights (Fig. 1) suggested that intakes of all the different food items increased

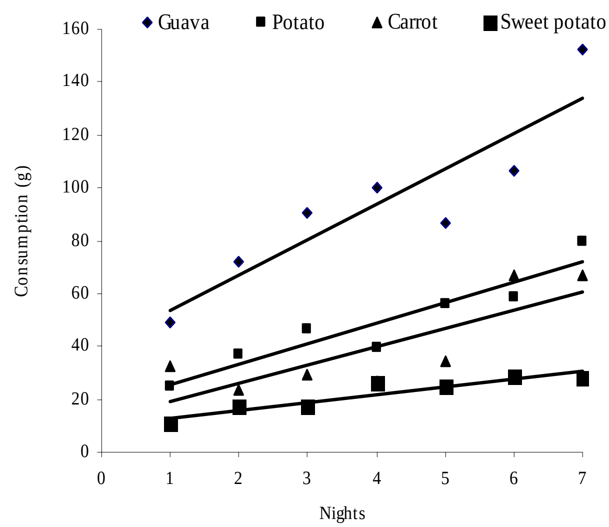

Fig. 1. Relationship between consumption of different fresh food items with the increase in duration of exposure by Indian crested porcupine in no-choice test.

with each increase in nights of porcupine exposure to the novel food item. The rate of increase per night (slope of regression line) was the highest in case of guava (13.36 g), followed by potato (7.71 g), carrot (6.91 g) and sweat potato (2.93 g). The regression of consumption with nights was positive and significant for all the four food items (Guava: R^2 = 0.81, $F_{1, 6}$ = 22.09, P = 0.0053; Potato: $R^{2 =}$ 0.88, $F_{1, 6}$

= 38.75, P = 0.001; Carrot: R^2 = 0.64, $F_{1, 6}$ = 8.96, P = 0.030 and sweet potato: R^2 = 0.86, $F_{1, 6}$ = 33.11, P = 0.002).

Table I.- Consumption of different fresh food items by Indian crested porcupine under no-choice test under the field conditions of Abbottabad – Balakot tract, Pakistan. (n = 20 burrows for 7 nights, for each individual experimental set).

Food item	Consumption (g)	$t_{(276)}$ statistics		
		Guava	Potato	Carrot
Guava	93.9±8.20			
Potato	50.4±5.82	4.18 *		
Carrot	40.0±5.15	5.41 *	1.35	
Sweet potato	21.8±2.29	8.24 *	4.56 *	3.19 *

Mean±SEM; * P < 0.05

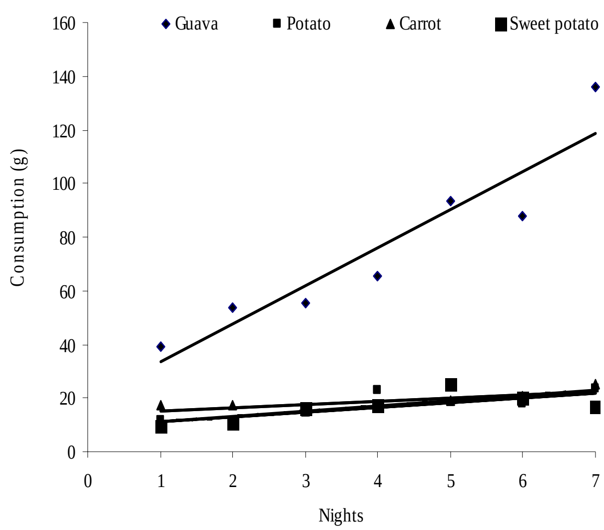

Fig. 2. Relationship between consumption of different fresh food items with the increase in duration of exposure by Indian crested porcupine in multiple-choice test.

Results of multiple-choice test (Table II) conformed to those of no-choice test, though guava emerged as the most preferred food, consumed some four times more than carrot, potato and/ or sweet potato. The t values also revealed that guava was consumed in significantly higher quantities than other three food items (potato, carrot and sweet potato), which were not significantly different from one another in their consumption. Consumption of different food items during different test nights in multiple-choice test (Fig. 2) revealed that rate of increase per night (slope of regression line) was highest in case of guava (14.18 g), while the consumption of remaining three food items showed, almost, a similar pattern (carrot = 1.90 g, sweet potato = 1.79 g, potato = 1.24 g). The regression of consumption with nights of exposure to such food items was positive and significant in case of guava (R^2 = 0.87, $F_{1, 6}$ = 34.21, P = 0.002), potato (R^2 = 0.66, $F_{1, 6}$ = 10.03, P = 0.025), carrot (R^2 = 0.62, $F_{1, 6}$ = 8.28, P = 0.034) and positive yet non-significant, in case of sweet potato (R^2 = 0.50, $F_{1, 6}$ = 5.11, P = 0.073).

Poison baiting

Experiments performed to test acceptance of zinc phosphide poisoned guava and control baits (Table III), revealed normal consumption of guava bait over the first three pre-baiting nights in all the experimental sets. There was however, a marked difference in bait consumption pattern in the treatment group for nights 4 – 6 (poison baiting), when control was compared with guava bait having different zinc phosphide concentrations. Consumption of 3% zinc phosphide poison bait showed a sharp decline starting from night 4 (1^{st} poison baiting night), and there was virtually no consumption on two subsequent nights. Poison / pre bait consumption ratio was 0.13 for poison bait and 1.63 for control bait. Poison bait consumption in groups exposed to 1% and 2% zinc phosphide on night 4 was though not significantly different from that of the night 3, yet an eminent decline was observed over next two nights, and decline was more steep with 2% than with 1% poison bait. Poison / pre bait consumption ratio was 0.42 (1.35 for control) for 1% zinc phosphide and 0.37 (1.62 for control) for 2% zinc phosphide.

Efficacy of poison baiting, as judged by reduction in burrow activity (Table III), was the highest (55% reduction) in test using 2% zinc phosphide, followed by 1% (35%) and 3% (15%) zinc phosphide – bait groups, while in all the control groups, no reduction in burrow activity was recorded.

Table II.- **Consumption of different fresh food items by Indian crested porcupine in multiple-choice test under the field conditions of Abbottabad – Balakot, Pakistan (n = 20 burrows for 7 nights, for each individual experimental set).**

Food item	Consumption		$t_{(276)}$ statistics		
	Mean±SE (g)	Relative (%)	Guava	Potato	Carrot
Guava	75.9±7.87	59.54			
Carrot	18.6±2.68	14.63	6.84 *		
Potato	17.0±2.50	13.30	7.10 *	0.44	
Sweet potato	15.9±2.11	12.51	7.30 *	0.63	0.14

$P < 0.05$

DISCUSSION

Both in no-choice and multiple-choice tests, guava was the most preferred food item, which was consumed in significantly higher quantities than potato, carrot and sweet potato. The preference for guava could be due to its taste and smell, which still needs to be confirmed. The present results partly supported studies of Chaudhry and Ahmed (1975) as they suggested that porcupines ignored potato and cucumber, though readily consumed guava and apples. Guava is cheap and remains available in the area for major part of the year and could be used as bait for delivery of different chemical poisons for the control of porcupine.

Present results indicated that intake of all the food items offered gradually increased with the increasing length of the porcupine exposure to such food items. This behaviour may indicate a careful nature of species, which like other wild and commensal rodents (Prakash, 1988), is shy to accept a novel object/food (neophobia). However, the length of exposure resulted in gradual acclimatization of the species/animals. This demanded that a sufficiently longer pre-baiting with the plain bait was required to acclimatize the animals to consume the lethal quantities of the poison bait, on subsequent exposure of the poison baiting. Further studies are required to know the optimal length of pre-baiting for different bait bases for making poison baiting more effective and economical.

An eminent decline in consumption of zinc phosphide impregnated guava bait appeared in all the poison bait formulations, yet it is more pronounced when 3% zinc phosphide was used as compared to those using 1% or 2% zinc phosphide. A decrease in the poison bait consumption can be attributed to decrease in the population, caused by physical killing of porcupines, and to poison bait aversion of the target animals. It appears that there was a definite zinc phosphide bait aversion, which increased with the increasing concentration of zinc phosphide, which was expected as guava had limits of its potentials to mask zinc phosphide smell/ taste. Bait consumption data, when judged with reduction in porcupine burrow activity, indicated that, despite such bait aversion, guava facilitated passive consumption of lethal quantities of zinc phosphide when it is applied at 2% concentration. This was understandable as decreasing concentration directly decreased quantity of rodenticide consumed, while increasing concentration caused higher bait aversion. Further refinement of optimal concentration of zinc phosphide is probably required, yet 55% reduction in the population of this large rodent pest using 2% zinc phosphide suggestd that this cheap and readily available rodenticide can be used at least for an initial control of porcupine population using guava bait.

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Table III.- Consumption (g, Mean±SE) of guava fruit bait with and without (control) different concentrations of zinc phosphide during different pre-and poison-baiting nights by Indian crested porcupine, and its reduction in burrow activity, under the field conditions of Abbottabad – Balakot tract, Pakistan (n = 20 burrows, for each individual experimental set).

Bait type	Baiting nights								Poison / pre-bait consumption ratio	Reduction in burrow activity (%)
	Pre-baiting*			Mean±SE	Poison-baiting			Mean±SE		
	1	2	3		4	5	6			
Zn_2p_3 (1%)	58.0±13.96	82.7 ±15. 38	88.3±19.82	76.4±9.56	85.8±21.44	10.7 ±5.75	0.0±0.00	32.2±8.18	0.42	35
Control	61.5±16.64	84.0±14.66	115.1±16.95	84.9±9.59	106.5±19.09	117.7±23.16	121.2±20.82	115.2±12.00	1.35	-
Zn_2p_3 (2%)	65.1±12.91	90.5±15.75	98.8±16.52	84.8±8.79	93.7±21.45	1.25±0.9	0.0±0.00	31.7±9.06	0.37	55
Control	55.0±12.42	63.0±12.92	98.8±17.49	72.3±8.57	109.5±19.59	117.9±22.91	125.2±20.94	117.5±12.05	1.62	-
Zn_2p_3 (3%)	55.7±15.13	80.2±19.01	88.1±15.75	74.7±9.43	29.7±12.85	1.0±0.58	0.0±0.00	10.2±4.58	0.13	15
Control	47.3±14.90	77.0±19.93	86.9±23.42	70.4±11.41	90.1±19.76	121.9±23.12	131.8±20.64	114.6±12.26	1.63	-

*Without zinc phosphide

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