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Testing of Groundnut – Maize Bait as Carrier of Zinc Phosphide for the Management of Indian Crested Porcupine, *Hystrix indica* Kerr (Rodentia: Hystricidae)

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Abstract.- Indian crested porcupine, *Hystrix indica*, is a serious pest of forest plantations, orchards and agricultural crops in different countries of the world. Field trials, conducted in Abbottabad - Balakot (Pakistan), suggested that consumption of groundnut – maize (1:1) bait poisoned with zinc phosphide, offered after three nights of pre-baiting practice, exhibited a decline and negligible amount of bait was consumed on 3rd night of poison baiting. Degree of decline in bait consumption gradually increased with increasing zinc phosphide concentration from 1% to 3%. The consumption of poison bait with or without saccharin (5%) during the poison baiting nights were not significantly different, however, there was a persistent trend where the baits having 5% saccharin, as taste additive, were consumed in higher quantities as compared with those having no saccharin. This trend was equally reflected in the data on average consumption of control bait during each test night. Higher reduction in burrow activity (55%) was recorded with 2% zinc phosphide and 5% saccharin (without saccharin supplementation, 45% reduction was recorded), as compared with 1% (35% with saccharin and 30% without saccharin) and 3% (25% with saccharin and 15% without saccharin). The study suggested that 2% zinc phosphide can be used by using groundnut – maize (1:1) as bait base and 5% saccharin, at least for the initial control campaign of this mammal pest species. Further refinement of the rodenticide and sweetener concentrations may be more useful.

Key words: Indian crested porcupine, *Hystrix indica,* zinc phosphide, grain baits, groundnut, maize, saccharin.

INTRODUCTION

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 habitats (Gurung and Singh, 1996). Indian crested porcupine, *Hystrix indica*, is a herbivore species; it is widely distributed in Pakistan (Roberts, 1997) and a serious pest of forest plantations and agricultural crops in Pakistan and many other countries of the old world (Alkon and Saltz, 1985; Sheiker, 1998; Khan *et al*., 2000; Idris and Rana, 2001; Ahmed *et al*., 2003). Indian crested porcupine 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. It is strictly nocturnal and lives in extensive burrow systems, 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 and regularly come out of the burrow to forage, usually during night (Roberts, 1997).

Keeping in view, the damage estimates caused by rodents and to increase productivity of forests and agricultural crops and to reduce soil erosion in watersheds, to increase the life-span of water reservoirs, their population needs to be managed (Meerburg *et al*., 2009). Traditional control methods (trapping, snaring, dog hunting, electric fencing, active policing, etc.) are largely ineffective and the biological controlling agents have limited populations, leaving with the only alternative of using rodenticides for its control (Hadler and Buckle, 1992). Anticoagulant rodenticides, for the control of porcupine require long baiting periods and involve higher operational cost (Khan and Mian, 2008), while the fumigation of porcupine burrows is only feasible in the loamy soils (Mushtaq *et al*., 2008). The acute rodenticides

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are better option for giving the quick knockdown, but they have poor efficacy (Prakash and Mathur, 1992), as almost all rodent pest species often exhibit strong shyness for such compounds (Sterner, 1994). Success of any rodenticide control campaign mainly depends upon better acceptance of bait material by the target pest species than the foods available in the natural environment, so that lethal quantity of rodenticide is passively consumed, as the bait has to compete with foods available in the wild habitat (Petrusewicz, 1967). Economics of rodenticide control campaigns, also, demands that food bait material and the rodenticide should be economical and readily available in the local markets in the remote areas. Zinc phosphide is the most economical, commonly used and popular rodenticide in major parts of the world, but have limited value in rodent control due to its garlic-like smell and bitter taste (Sterner, 1994; Johnston *et al*., 2005). Similarly, poison bait aversion is a serious problem associated with this acute rodenticide (Prakash, 1988; Idris and Prakash, 1992), therefore, a pre-baiting period of 2 – 3 days is usually suggested, before starting poison-baiting (Prakash, 1988) but studies are not available in this regard against Indian crested porcupine.

Successful studies, using zinc phosphide as active ingredient, against Indian crested porcupine are lacking. Khan *et al*. (2006) claimed 27.78% reduction in porcupine burrow activity in Potohar (Punjab, Pakistan) by using 2% zinc phosphide and maize grains as bait base, without any pre-baiting, while Mushtaq *et al*. (2010) achieved 55% reduction in burrow activity by using guava as fresh food bait and practicing pre-baiting for three days. Present study has been designed with the hypothesis that, as groundnut – maize (1:1), is a favored bait combination by Indian crested porcupine (Mushtaq *et al*., 2009), and saccharin further enhances the bait consumption (Mushtaq, 2009), the porcupine population may be controlled by using a bait formulation, consisting of groundnut – maize (1:1) as bait base and saccharin (5%) as additive and incorporating zinc phosphide as the active ingredient, especially if its concentration is optimized and a pre-baiting of three nights is practiced.

MATERIALS AND METHODS

Study area

Field experiments were conducted in Abbottabad- Balakot tract (34° NL, 73° E), a representative of the Tarbela Watershed Management ecology, which spreads over some 16,058 km^2 of the southern slopes of the western extremities of the Himalayan Mountain Range. Valleys are generally narrow and usually with perennial streams, receiving water from the springs. The study was conducted between July 2006 and January 2007, when wild grasses and herbs were generally dry. Cultivated potato was available in the area. During September - November maize was the dominant crop of the study area, and notice-able porcupine damage to the crop was observed by the senior author and, also reported by the local farmers.

Burrow selection

Study area was extensively surveyed to locate the porcupine burrows with the help of the local staff of the Forest Department and the local farmers and hunters. Burrows were minutely examined for porcupine activity symbols, like, fresh quills, foot prints on loose soil, recent signs of excavation and fresh faecal pellets, near the openings. Active status of the burrow was, confirmed by placing fine soil powder tracking patches in front of the burrow opening and observing the footprints, the following morning. The burrow was considered active only if the porcupine foot prints were recorded on the tracking patches for three consecutive nights.

Preparation of bait material

Zinc phosphide (80%, marketed under the trade name, ‘Agzinphos’, A. G. Services) was tested for its effectiveness for porcupine control at three concentrations, *i.e.*, 1, 2 and 3%. The bait formulations were prepared by thoroughly mixing the ingredients in combinations as given in Table I. Groundnut and maize grain (1:1, cracked) bait was used in all the poison bait consumption experiments and tested under no-choice test, with 5% saccharin and without saccharin supplementation. For all bait preparations a measured quantity of rodenticide was dissolved in distilled water (for saccharin supplemented baits, measured quantity of saccharin was also added), which was then mixed with the cracked groundnut – maize grains 1:1 mixture and packed in the plastic bags. Plain bait using groundnut – maize 1:1 and 5% saccharin, was used as control in all the experimental sets.

Table I.- Different bait formulations used in different sets of bait consumption experiments against Indian crested porcupine.

Bait type	Bait formulations
Saccharin supplemented bait (SSB)	1. Zinc phosphide 1% + saccharin 5% + groundnut – maize 1:1 2. Zinc phosphide 2% + saccharin 5% + groundnut – maize 1:1 3. Zinc phosphide 3% + saccharin 5% + groundnut – maize 1:1
Without saccharin supplementation (WSS)	1. Zinc phosphide 1% + groundnut – maize 1:1 2. Zinc phosphide 2% + groundnut – maize 1:1 3. Zinc phosphide 3% + groundnut – maize 1:1
Control (C)	Saccharin 5% + groundnut – maize 1:1

Experimental procedure

For each experimental set (each zinc phosphide concentration, i.e., 1%, 2% and 3%), 60 active porcupine burrows were randomly divided into two groups, *i.e.*, experimental (20 burrows for saccharin supplemented bait and 20 for without saccharin supplementation) and control (20 burrows). At each burrow a weighed quantity (1 kg, using top loading balance with a minimum count of 1 g) of the bait material was offered in earthen bowls under no-choice tests. Earthen bowls carrying the bait materials were placed deep at the burrow opening, late in the evening, when the human and livestock activity subsided. Burrow baiting has proved more effective and safer than the surface baiting against field rodents (Parshad and Malhi, 1995; Khan *et al*., 1998). Each burrow was visited in the next morning for recording consumption. The food material left unconsumed, in the bowls and spillage, were weighed and the difference between the weights of the bait offered and that of the left bait over was considered as consumption by the porcupine during the night (daily consumption) and the bowls were replenished daily. Plain bait material was offered at all the burrows for first three nights (pre-baiting), and the selected poison bait was then offered to the experimental group, only, on nights 4-6, while the plain bait continued in control group. Reduction in porcupine burrow activity was estimated by applying fine soil dirt tracking patches in front of the burrow opening and observed for the footprints, the following morning. The burrow was considered active, only, if porcupine foot prints were found on the tracking patches. Burrow activity was monitored till five days, to calculate the reduction in burrow activity.

Statistical analysis

Mean consumption and standard deviation of each parameter were calculated sing computer software Microsoft Excel 2000. Student's 't' test was applied for comparison of different treatments, using 5% level of significance. Simple linear regression was used to work out the relationship between consumption of bait material and increase in duration of bait exposure and to measure the degree of association between the two variables (Steel and Torrie, 1980). Pre-baiting and poison-baiting ratios were calculated by dividing average per night bait consumed during pre-baiting by average per night bait consumed during the poison baiting.

RESULTS

Results of the experiments conducted to test the consumption of groundnut – maize grain (1:1) bait, with or without 5% saccharin, treated with different concentrations of zinc phosphide against Indian crested porcupine during different test nights (Table II) suggested that there was a direct increase in average bait consumed in control (bait + saccharin) groups, during treatment nights (4 – 6) by 1.46 – 1.73 times as compared with the average consumption during the first three nights. The bait consumption during the test nights gradually increased and the consumption during different baiting nights in the three control groups was almost similar (variations between these groups can easily be regarded as chance variations). The consumption of the poison baits, however, decreased by 0.17-0.19, 0.44-0.53 and 0.51-0.58 times of the average of three pre-baiting nights in the experimental groups exposed to 3%, 2% and 1% zinc phosphide, respectively. The group presented with 1% zinc phosphide poison bait exhibited a milder response in

Table II.- Consumption (g, mean ± SE) of groundnut – maize (1:1) grain bait with and without 5% saccharin with different concentrations of zinc phosphide during different pre- and poison-baiting nights by Indian crested porcupine.

Zinc phosphide (%)	Bait type*	Baiting nights								Poison / pre bait consumption ratio	Reduction in burrow activity (%)
		Pre-baiting **				Poison baiting					
		1	2	3	Mean ± SE	4	5	6	Mean ± SE		
1	SSB	53.7 ± 11.90	91.2 ± 14.72	85.5 ± 16.27	76.8 ± 8.46	103.2 ± 17.25	31.5 ± 13.85	0.0 ± 0.00	44.9 ± 9.19	0.58	35
	WSS	55.7 ± 12.90	88.5 ± 16.08	83.1 ± 14.87	75.6 ± 8.53	90.5 ± 17.87	23.7 ± 8.62	0.5 ± 0.50	38.2 ± 8.18	0.51	30
	C	53.0 ± 13.44	74.7 ± 11.62	87.5 ± 12.97	71.7 ± 7.38	94.3 ± 12.99	98.8 ± 13.44	122.1 ± 14.73	105.1 ± 7.95	1.46	00
2	SSB	45.0 ± 12.65	78.7 ± 14.37	99.5 ± 13.20	74.4 ± 8.18	97.7 ± 19.36	10.1 ± 3.43	0.0 ± 0.00	35.9 ± 8.59	0.53	55
	WSS	39.0 ± 13.91	79.0 ± 15.92	94.7 ± 13.44	70.9 ± 8.57	87.2 ± 15.48	7.3 ± 1.89	0.0 ± 0.00	31.5 ± 7.25	0.44	45
	C	42.1 ± 10.08	80.2 ± 15.09	91.8 ± 13.19	71.4 ± 7.85	101.3 ± 18.10	120.2 ± 11.53	117.4 ± 16.10	113.0 ± 8.85	1.58	00
3	SSB	25.9 ± 7.08	66.1 ± 12.87	94.4 ± 19.32	69.3 ± 8.75	39.4 ± 12.93	1.5 ± 0.89	0.2 ± 0.25	13.5 ± 4.86	0.19	25
	WSS	33.8 ± 12.71	60.5 ± 12.58	91.9 ± 15.82	62.1 ± 8.41	31.1 ± 13.19	1.0 ± 0.77	0.0 ± 0.00	10.8 ± 4.71	0.17	25
	C	29.9 ± 9.21	68.1 ± 12.53	91.1 ± 14.43	63.1 ± 7.68	95.4 ± 16.17	110.3 ± 14.58	122.5 ± 16.67	109.4 ± 9.10	1.73	00

*Following Table I, ** Without zinc phosphide

bait consumption. The bait consumption on the first poison baiting night exhibited an increase, which was almost parallel to that exhibited by control group, although the increase was not significant (5% saccharin supplemented bait; $t_{(36)} = 0.89$, $P > 0.05$ and without saccharin supplementation; $t_{(36)} = 0.24$, $P > 0.05$). A sudden decline in the bait consumption was recorded during the second poison baiting night and dropped to almost zero level on the third night. The regression of consumption with nights of exposure to bait (Fig. 1) was positive and significant in case

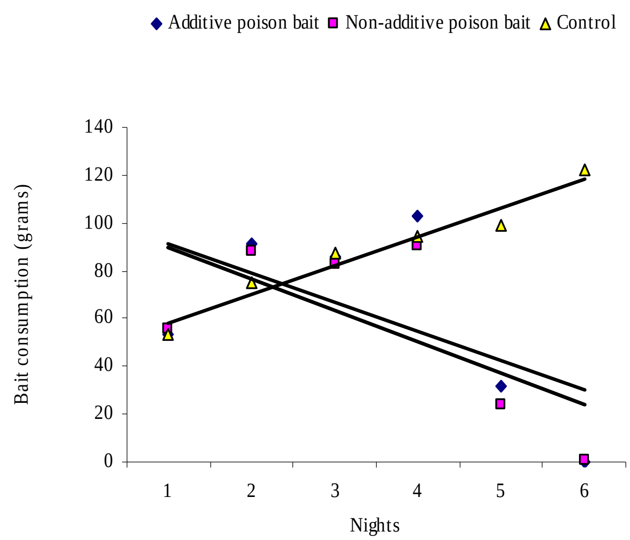

Fig. 1. Consumption of groundnut – maize (1:1) grain bait impregnated with zinc phosphide (1%) and supplemented with and without saccharin (5%) by Indian crested porcupine during different test nights.

of control bait ($R^2 = 0.94$, $F_{1, 5} = 37.19$, $P = 0.00$), while it was negative and non-significant, in case of additive ($R^2 = 0.33$, $F_{1, 5} = 7.32$, $P = 0.07$) and non-additive poison ($R^2 = 0.43$, $F_{1, 5} = 10.68$, $P = 0.05$) baits. The group exposed to 2% zinc phosphide exhibited a mild decrease in the bait consumption during poison baiting nights. The average consumption on the first poison baiting nights was not significantly different (saccharin supplemented bait $t_{(36)} = 0.82$, $P>0.05$ and without saccharin supplementation; $t_{(36)} = 0.25$, $P>0.05$) than that of last pre-baiting nights. The consumption on the second poison baiting night abruptly dropped to a very low level and there was no consumption on third poison baiting night. The regression of consumption with nights of exposure to bait (Fig. 2) was negative and non-significant, in case of additive

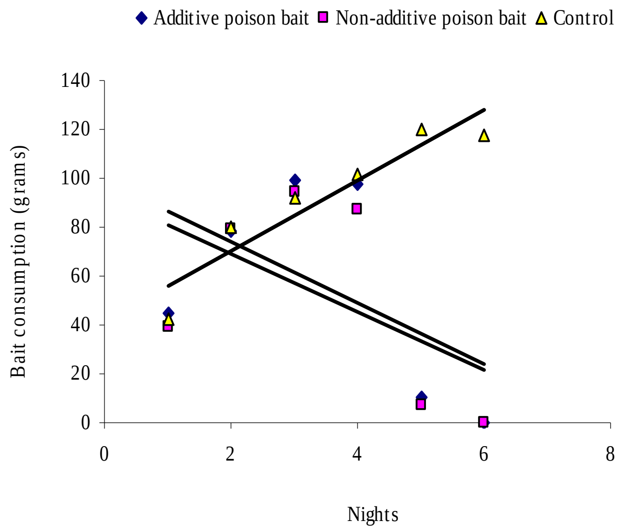

Fig. 2. Consumption of groundnut – maize (1:1) grain impregnated with zinc phosphide (2%) and supplemented with and without saccharin (5%) by Indian crested porcupine during different test nights.

(R^2 = 0.28, $F_{1, 5}$ = 5.55, P = 0.09) and non-additive poison (R^2 = 0.28, $F_{1, 5}$ = 7.35, P = 0.07) baits, while it was positive and significant in case of control bait (R^2 = 0.88, $F_{1, 5}$ = 34.75, P = 0.00). The decrease in the average consumption of poison bait was very sharp for group exposed to 3% zinc phosphide and a significant decline (saccharin supplemented bait; $t_{(36)}$ = 2.12, P < 0.05 and without saccharin supplementation; $t_{(36)}$ = 3.23, P < 0.05) was recorded on the very first poison baiting night when compared with the last pre-baiting nights and there was virtually no consumption of poison bait on second and third poison baiting nights. The regression of consumption (Fig. 3) was negative and non-significant, in case of additive (R^2 = 0.37, $F_{1, 5}$ = 9.31, P = 0.05) and non-additive poison (R^2 = 0.29, $F_{1, 5}$ = 7.58, P = 0.07) baits, while positive and significant in case of control bait (R^2 = 0.91, $F_{1, 5}$ = 81.69, P = 0.00).

The data, also, suggested that the consumption of poison bait with or without saccharin during the poison baiting nights were not

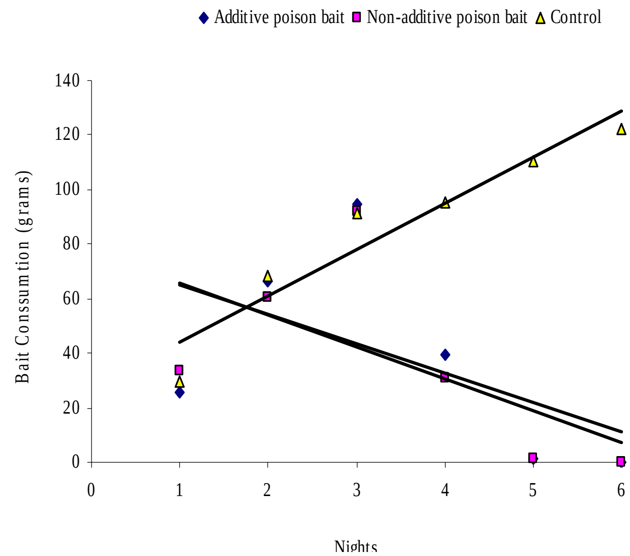

Fig. 3. Consumption of groundnut – maize (1:1) grain bait impregnated with zinc phosphide (3%) and supplemented with and without saccharin (5%) by Indian crested porcupine during different test nights.

significantly different (1% zinc phosphide; $t_{(36)}$ = 0.64, P > 0.05, 2% zinc phosphide; $t_{(36)}$ = 0.46, P > 0.05, 3% zinc phosphide; $t_{(36)}$ =0.89, P > 0.05) however, there was a persistent trend where the baits having 5% saccharin, as taste additive, were consumed in higher quantities as compared with those having no saccharin.

Summary of the activeness of the porcupine burrows under different levels of zinc phosphide baiting and types of the bait material (Table II) suggested that maximum reduction in burrow activity was recorded in the group exposed to 2% zinc phosphide (with saccharin 55%, without saccharin 45%), followed by 1% zinc phosphide (35% and 30%) and least reduction in burrow activity was caused by 3% zinc phosphide treated grains (25% and 15%). There was, however, no reduction in burrow activity in all the control groups, where bait offered did not contained zinc phosphide.

DISCUSSION

In general, Integrated Pest Management (IPM) is preferred above application of rodenticides, as application of rodenticides could lead to the possible development of rodenticide resistance, which is common in many parts of the world (Singleton *et al*., 2004). Yet, due to limited effectiveness and/or unavailability of the alternative methods, rodenticide use is the only effective strategy for controlling porcupine population and minimizing the losses caused by this species (Hadler and Buckle, 1992; Khan and Mian, 2008; Mushtaq *et al*., 2008).

Present trials on testing the effectiveness of groundnut – maize bait as carrier of zinc phosphide suggested that there was a persistent trend of decline in bait consumption with the increase in the duration of bait exposure. There was a negligible amount of bait consumption on third night of poison baiting, in case of 1% and 2% zinc phosphide and there was virtually no bait consumption in the trials using 3% zinc phosphide. On the second poison baiting night, the rate of consumption increased with the decrease in the rodenticide concentration. This is characteristic of the acute rodenticides (Prakash, 1988; Idris and Prakash, 1992), because rodents associate the symptoms of illness with the bait material ingested. This may suggest that a maximum of two nights of the poison baiting can be effectively exercised for zinc phosphide, at least with the present bait and under present baiting conditions. Extending the zinc phosphide baiting beyond the second night is a wasteful exercise, costing labor and material without increasing the intake of the bait or poison. Reduction in the consumption of the bait may be because of the development of bait shyness/ repellence after consumption of a sub-lethal dose of the rodenticides (Prakash, 1988), or because of the death of the porcupine/ porcupines inhabiting the burrows subjected to poison baiting caused by consuming lethal doses of the zinc phosphide.

The present results have consistently suggested that zinc phosphide poison has significantly reduced the intake of the bait. This effect is very strong and almost instant with 3% zinc phosphide and relatively milder and delayed for 1% zinc phosphide. The strong taste and smell of 3% zinc phosphide, has the greatest repellency, while 1% had the lowest repellency. Such behavior is expected and has been reported for many other rodent species (Prakash, 1988; Leung *et al*., 2007). Prakash (1976) recommended that zinc phosphide must not be used in concentration over 2%, while Bhardwaj and Prakash (1982) reported that the acceptability of the bait is reduced with increasing zinc phosphide beyond 2%. The reduction in the bait consumption can be attributed to the poison bait aversion caused by a bitter taste and garlic-like smell of zinc phosphide, where animals directly shun the intake of the bait (Prakash, 1988). The animals consuming a sub-lethal dose of the poison associate the symptoms of illness with the bait and/ or rodenticide and refuse to consume further. Such a zinc phosphide bait shyness and aversion has been previously reported for many rodent species, even after a single exposure to a sub-lethal-dose of zinc phosphide (Sterner, 1994). The period of persistence of the bait shyness varies between 10 to 15 days in *Gerbillus gleadowi* (Rana *et al*., 1975) and 170 days in *Mus platythrix* (Sridhara and Srihari, 1980). Such a logic explains the previously reported relatively low reduction in burrow activity (27.78%) by using 2% zinc phosphide bait without practicing pre-baiting (Khan *et al*., 2006), when the porcupine consumed a sub-lethal quantity of the poison. The lethal effects of the poison baiting depend upon the potentials of the bait to facilitate lethal quantities of zinc phosphide. The present study suggested that though 1% zinc phosphide bait was consumed more, yet it could facilitate the intake of a smaller quantity of zinc phosphide. Similarly, the lower consumption of 3% zinc phosphide bait could carry a smaller quantity of zinc phosphide. A moderate consumption of 2% zinc phosphide forced the animal (s) to ingest a larger quantity of the poison and hence a higher mortality, as indicated by the burrow activity. Further studies are required for working out the efficacy of the bait and poison with longer pre-baiting and the poison baiting restricting to two days.

In all the experiments, zinc phosphide bait with 5% saccharin was consumed in higher quantities than the bait without saccharin. Saccharin has worked as additive and has facilitated the consumption of higher quantities of the poison bait which resulted in a higher reduction in burrow activity. This was expected, yet, required direct testing with the specific rodenticide. With the present results, it can be suggested that 5%

saccharin can result in 10% higher mortality of porcupine and hence it can be exploited in porcupine management programme. Results on the current baiting trials against porcupine, suggested that groundnut – maize (1:1) with 5% saccharin can be used for delivering the lethal quantities of zinc phosphide (2%) to porcupine, at least for an initial control of this large-sized rodent pest. Further experimentation with additives and rodenticide concentration, and pre- and poison-baiting period, can be more useful for improving the management strategies against Indian crested porcupine.

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Table II.- **Consumption (g, mean ± SE) of groundnut – maize (1:1) grain bait with and without 5% saccharin with different concentrations of zinc phosphide during different pre- and poison-baiting nights by Indian crested porcupine.**

Zinc phosphide (%)	Bait type*	Baiting nights: Pre-baiting ** 1	2	3	Mean ± SE	Poison baiting 4	5	6	Mean ± SE	Poison / pre bait consumpt ion ratio	Reduction in burrow activity (%)
1	SSB	53.7 ± 11.90	91.2 ± 14.72	85.5 ± 16.27	76.8 ± 8.46	103.2 ± 17.25	31.5 ± 13.85	0.0 ± 0.00	44.9 ± 9.19	0.58	35
	WSS	55.7 ± 12.90	88.5 ± 16.08	83.1 ± 14.87	75.6 ± 8.53	90.5 ± 17.87	23.7 ± 8.62	0.5 ± 0.50	38.2 ± 8.18	0.51	30
	C	53.0 ± 13.44	74.7 ± 11.62	87.5 ± 12.97	71.7 ± 7.38	94.3 ± 12.99	98.8 ± 13.44	122.1 ± 14.73	105.1 ± 7.95	1.46	00
2	SSB	45.0 ± 12.65	78.7 ± 14.37	99.5 ± 13.20	74.4 ± 8.18	97.7 ± 19.36	10.1 ± 3.43	0.0 ± 0.00	35.9 ± 8.59	0.53	55
	WSS	39.0 ± 13.91	79.0 ± 15.92	94.7 ± 13.44	70.9 ± 8.57	87.2 ± 15.48	7.3 ± 1.89	0.0 ± 0.00	31.5 ± 7.25	0.44	45
	C	42.1 ± 10.08	80.2 ± 15.09	91.8 ± 13.19	71.4 ± 7.85	101.3 ± 18.10	120.2 ± 11.53	117.4 ± 16.10	113.0 ± 8.85	1.58	00
3	SSB	25.9 ± 7.08	66.1 ± 12.87	94.4 ± 19.32	69.3 ± 8.75	39.4 ± 12.93	1.5 ± 0.89	0.2 ± 0.25	13.5 ± 4.86	0.19	25
	WSS	33.8 ± 12.71	60.5 ± 12.58	91.9 ± 15.82	62.1 ± 8.41	31.1 ± 13.19	1.0 ± 0.77	0.0 ± 0.00	10.8 ± 4.71	0.17	25
	C	29.9 ± 9.21	68.1 ± 12.53	91.1 ± 14.43	63.1 ± 7.68	95.4 ± 16.17	110.3 ± 14.58	122.5 ± 16.67	109.4 ± 9.10	1.73	00

*Following Table I, ** Without zinc phosphide