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Investigations on the Use of Poison Baits and Fumigants Against Indian Crested Porcupine (*Hystrix indica)*

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Abstract. Preventive methods were investigated against the Indian crested porcupine as it seriously damages trees, field crops, and vegetables. Large-scale field trials were conducted to determine the efficacy of two poison baits (0.0375% coumatetralyl and 2% zinc phosphide) and two fumigants (carbon monoxide and calcium cyanide powder) against the Indian crested porcupine, *Hystrix indica*, in forest plantations, 'barani' or drylands, and desert rangelands. On the average, carbon monoxide, calcium cyanide and coumatetralyl caused 95.84, 96.52, and 100% mortality, and were equally effective. The zinc phosphide bait yielded 27.78% mortality, indicating that it was less effective and poorly consumed by the porcupines. Use of the two fumigants and the grain bait of coumatetralyl was found to be excellent for the control of Indian crested porcupines in different habitats.

Keywords: *Hystrix indica*, poison baits efficacy, fumigants, Indian crested porcupine management

Introduction

Porcupines are among the world's largest rodents and have been recognized as forest pests in many countries of the New and Old Worlds (Walker, 1999; Harrison, 1972; Faulkner and Dodge, 1962; Spencer, 1950). In Pakistan, *Hystrix indica*, an Old World species, is widely distributed in the irrigated and scrub forest plantations, sandy deserts of Punjab and Sindh, Pothwar plateau (Punjab), and is commonly found in the steppe mountains of Balochistan (Roberts, 1998; Mian *et al.*, 1988), upland valleys of Azad Jammu and Kashmir (AJ&K) and in watershed areas of the North-West Frontier Province (Khan *et al.*, 2000).

The Indian crested porcupine is a generalist forager that exploits a wide variety of cultivated and wild plants, and consumes both the aboveground and sub-surface plant tissues. Geddes and Iles (1991) have ranked the Indian porcupine as a pest of crops, vegetables and fruit orchards in Pakistan. Damage and losses of crops, vegetables and fodder have been reported by Khan *et al.* (2000; 1997), Brooks *et al.* (1988), and Ahmad *et al.* (1987). These studies indicated widespread damage to maize in Faisalabad (Punjab) and AJ&K, and in the groundnut growing areas of the Punjab province, while high damage (17.56%) was recorded for potatoes near Taxila (North-West Frontier Province). Safron (*Crocus sativa*) fields near Mustung (Balochistan, Pakistan) were observed to be seriously damaged by 2-3 visiting porcupines (Mian *et al.*, 1988). Alkon (1985) and Alkon and Saltz (1985), reported heavy damage to irrigated potato fields in the Negev desert of southern Israel.

The most important porcupine damage occurs in the forestry and reforestation areas (Greaves and Khan, 1978; Ahmad and Chaudhry, 1977; Chaudhry and Ahmad, 1975; Chaudhry, 1970). The most commonly and heavily damaged tree species include, *Melia azedarach* (neem), *Morus alba, Robinia pseudoaccacia, Dalbergia sisso, Pinus roxburghii, Bombax ceiba* and *Eucalyptus* spp. Nawaz and Ahmad (1974) calculated a loss of 136,136 ft^3 (5,042 m^3) of wood in different Changa Manga plantations (5263 ha) in the Punjab, valued at Rs. 0.9 million. Sheikher (1998) reported serious damage to forest trees in the Himachal Pradesh province of India, while Idris and Rana (2001) estimated damage of 30% of neem seedlings and 12% of *Eucalyptus* spp. in the Aravelli Hills near Jodhpur, India. Ahmad *et al.* (2003) also recorded porcupine damage to neem plantation in the rangelands of lower Sindh, Pakistan. Another study carried out in India revealed that porcupine caused 5.39% damage to young coconut plants in the coastal Karnataka (Charkraborthy and Girish, 2002). The first author of the present study observed serious and wide spread damage to wild *Pistacia* spp. plantations in the mountain valleys of Muslim Bagh, Balochistan.

The measures to prevent porcupine damage have been little studies, except for some preliminary investigations by Arshad *et al.* (1988), and Chaudhry and Ahmad (1975). They used either aluminium phosphide or baits made from highly toxic

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insecticides, and obtained varying degrees of success. Khan *et al.* (1992) evaluated fumigants and toxic vegetable baits on a much larger scale in the Quetta valley (Baluchistan province). The published literature does not report any work on the use of grain baits made up from acute poisons and anticoagulant compounds against *H. indica*. The present study presents the results of comparative trials on the efficacy of fumigants and grain baits, conducted in different ecological zones of Punjab, Pakistan, particularly in the arid lands. The main objective of the study was to collect data on a much wider-scale to be used in the development of Indian crested porcupine management strategies.

Materials and Methods

Study sites. The areas selected for the study included Hassanabdal, Chakwal, Tanaza Dam, Ratwal and Qutbal experimental areas, which are located in the Pothwar (uneven) plateau (Punjab). The area lies to the south of the northern mountains of Pakistan, and is flanked in the west by the river Indus and on the east by river Jehlum (Fig. 1). This upland area is 305-610 m above sea level, which is located between latitudes 32˚33' and 34˚4'N, and longitudes 71˚89' and 73˚37'E. The area is typified by its denuded and broken terrain, characterized by undulations and irregularities (Ahmad, 1991). Out of the total area of 1.82 million ha, only 0.61 million ha are cultivated, the remaining land being used for rough grazing. Dry farming is the dominant land use. The climate in the plateau is semiarid, warm to hot with subtropical winter and monsoon. The average annual rainfall varies from 1500 mm in the south-east to 375 mm or less in the south-west. The wild vegetation includes, *Zizyphus nummularia, Capparis aphylla, Calotropis procera, Sorghum munja, Cynodon dactylon, Eragrostis cynosuroides, Desmostachya bipinnata* and *Sorghum halepense*, which provide shelter and food to rodents.

Changa Manga and Piranwala are two irrigated forest plantations comprising of different tree species, the dominant ones being *Dalbergia sissoo, Morus alba, Eucalyptus* spp. These plantations are a source of supply for timber, furniture and fuelwood. Dagar Kotli and Karluwala desert ranges, about 25-40 km from Bhakkar, are located in the 'barani' lands ecozone of the Punjab. The average rainfall of 112-180 mm and temperature variations as high as 49 ˚C in the summer and as low as -3 ˚C in the winter are common. Four species of grasses are being seeded in these ranges to enhance the grazing capacity on a sustainable basis. Among these, *Cenchrus ciliaris*, *Sorghum halepense* is and *Elionurus hirsutus* are severely damaged by porcupine digging to eat the underground grass roots.

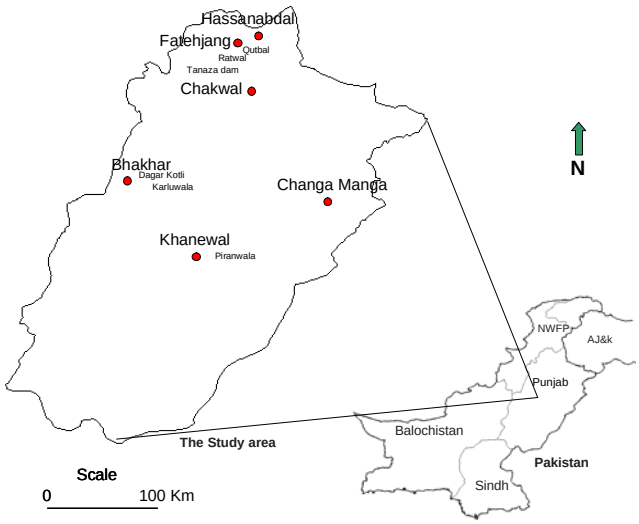

Fig. 1. Map of Pakistan, showing locations of the sites where baiting and fumigation experiments were conducted.

Information on active and live porcupine dens were gathered from the local farmers of the area or through porcupine distribution maps, prepared by forest staff of the plantations. Active dens were physically spotted and confirmed by the presence of foot prints, fecal matter and/or hovering dung flies around or inside the mouth of the den.

Poison baits. Coumatetralyl (Bayer AG, Germany) is an anticoagulant rodenticide and is marketed under the trade mark Racumin. Its subchronic LD_{50} (5-d) for rats is 0.3 mg/kg daily and subacute oral LD_{50} (8-d) for hens > 50 mg/kg daily. Zinc phosphide (AG Services, Karachi) is a grey powder; density 4.54 g/cm^3; m.p. 420 ˚C. It is insoluble in water and is decomposed violently by acids to produce phosphine, which is a potent mammalian poison. Oral LD_{50} for rats is 45.7 mg/kg and for pheasants is 9 mg/kg, The lethal dose for fowls is 7-17 mg/kg. Calcium cyanide (American Cyanamid Company, USA) is soluble in water, diethyl ether and ethnol. It is a weak acid-forming salt, which has a high melting point (564 ˚C). It is very toxic to mammals. An exposure for 30 min at 0.36 g/l air is fatal to man. Acute LD_{50} for rats is 6.44 mg/kg. Its use against rats, porcupines, rabbits is normally restricted to trained pest control operators.

Baits and baiting. Coumatetralyl bait (Rt) was prepared from cracked maize by adding cooking oil (2%) and molasses (2%), which worked as the base materials. The master mix of coumatetralyl (0.75%) was then added to the base materials to give it a final concentration of 0.0375%. The ingredients were mixed using an electric mixer (Hobart) of 5 kg capacity. One kg of the bait was packed in plastic bags. Similarly,

2% bait of zinc phosphide (Zt) was formulated and packed as 100 g plastic sachet.

The baiting trials, using coumatetralyl and zinc phosphide, were conducted at three locations, viz., Tanaza dam, Ratwal and Qutbal (Fateh Jhang district, 35-65 km from Islamabad). The fumigation studies were carried out in three different ecological areas of Pakistan, viz., irrigated forest plantations (Changa Manga, 5236 ha; Piranwala 4970 ha), rangelands (Dagar Kotli, 3267 ha; Karluwala, 6728 ha; Bakhar district), and scrub forest plantations of Chakwal.

One packet each of the formulated baits (without opening) was placed deep inside the active den with the help of a shovel. For identification and observation, each baited den was given a specific number on a 25 cm long flag tape that was secured to a nearby bush or tree. Post-treatment observations were made after two weeks in the case of coumatetralyl and one week after the zinc phosphide applications. For this purpose, dust patches (50 x 50 cm) were laid in front of the mouth of porcupine dens and recorded as negative or positive for foot prints. The second baiting of Racumin was conducted in dens, which were still active after one week.

Fumigation. Carbon monoxide was generated from a two-ingredient cartridge (250 g) that was made up (w/w) from sodium nitrate (65%) and ground charcoal (35%), as described by Savarie *et al.* (1980). The cartridge, after ignition, was placed 25 cm deep into the burrow, which was plugged with vegetation and soil dirt, after ensuring that smoke was being generated smoothly.

Calcium cyanide (40%) powder was pumped into active burrows, using a "Dust-R" pump (B&G Equipment Company, Plumsteadville, PA, USA). The procedure involved was to seal off the emergency exits to the den. Plastic hose-pipe (1.5 m long with 1.25 cm dia) was inserted into the main opening of the den, leaving about 25 cm of the pipe outside the burrow. The mouth of main or major active opening was then firmly sealed using brushwood and soil dirt. After fumigation, the hose-pipe was withdrawn from the burrow which was then sealed. Depending on the size of the mouth of the den, 50-100 strokes (3.2-6.4 g of powder) of the pump were made to drive the powder deep into the den.

A 250 g (dry weight) cartridge was used to fumigate the porcupine dens in forest blocks # 1 (1566 ha), # 3 (610 ha), # 4 (1109 ha) and # 5 (1176 ha) of the Chang Manga plantation, and # 4 (70 ha), # 5 (70 ha), # 9 (76 ha), # 11 (73 ha), # 12 (73 ha), # 13 (173 ha) and # 19A (180 ha) pastures of the Karluwala range. Each block and pasture varied in size from 73 to 1566 ha, respectively. Other locations were Piranwala, Dagar Kotli and Hassan Abdal where 250 g cartridge was also used. Post-treatment observations of fumigants were made after 48 h of fumigations.

Results and Discussion

Baiting. The results of baiting trials are summarized in Table 1. A total of 74 and 36 active dens were treated with baits of 0.0375 % coumatetralyl (Rt) and 2% zinc phosphide (Zt), respectively. After the first baiting with coumatetralyl, the porcupine activity was reduced by 66.67 and 71.43% in the Tanaza dam and Ratwal areas, respectively. The second supplement baiting gave 100% reduction at all the locations studied. At Qutbal, where 36 dens were treated with zinc phosphide, only 27.78% reduction was achieved in the activity of porcupines. The second baiting of zinc phosphide was not conducted as the porcupines stopped feeding after 3-4 days of the baiting which may be attributed to a garlic like smell, bitter taste and development of bait-shyness to zinc phosphide (Rozoska, 1953), while such problems did not exist in the case of coumatetralyl, a tastless compound and having no smell.

Chaudhry and Ahmad (1975) evaluated fresh baits of guava, potato, cucurbit vegetables and apples with the use of potassium cyanide, zinc phosphide, Racumin and Sevin. One to 1.5 g of these chemicals were smeared on the cut-bait pieces. The results indicated that potassium cyanide bait was consumed by the porcupines causing 100% mortality, zinc phosphide bait was avoided, while Racumin and Sevin baits were not consumed at all. Duration of Racumin baiting was not mentioned by these authors. It appears that under-baiting was done and hence they did not record any porcupine mortality with the usage of Rocumin.

Arshad *et al.* (1988) tested the efficacy of Temik (10 G), Wafarin (100%), sodium fluoroacetate (1080) and Endrin (19.5%) with ripened bitter gourd, chopped mango stones and boiled maize. Baits (0.5 kg in weight) were placed in the form of heaps near the dens or in the fields, having signs of porcupine activity or damage. The results of this study indicated 100% mortality with sodium fluoroacetate (1080), 85.7% with Temik, 38.9% with Warfarin, and 36.4% with Endrin. However, this baiting technique (ground surface exposure) is highly hazardous and can cause primary poisoning to livestock and non-target wildlife. Khan *et al.* (1992) observed that vegetable baits of strychnine were less effective than baits prepared from sodium fluoroacetate (1080). However, they did not report any hazards to wildlife and grazing animals, which are inherent in the use of these chemicals. Ahmed *et al.* (2003) obtained 86.7 and 72% porcupine mortality while conducting burrow baiting with 0.03% sodium fluoroacelate (1080) 0.005% and 0.005% Brodifacoum wax blocks.

Table 1. Field effectiveness of coumatetralyl (0.0375%) and zinc phosphide (2%) baits against *Hystrix indica*

Treatment	Location/site	Number of active dens treated	Reduction after first week (%)	Reduction after second week (%)
Coumatetralyl (0.0375%) (Rt)	Tanaza dam	18	66.67 (6)	100.00
	Ratwal	56	71.43 (16)	100.00
Zinc phosphide (2%) (Zt)	Qutbal	36	27.78 (26)	-

The numbers appearing in parentheses indicate the number of active dens

Table 2. Results of carbon monoxide and calcium cyanide fumigation against *Hystrix indica*

Treatment	Location/site	Number of dens treated	Number of dens remaining	Number of dens reopened	Reduction (%)
Carbon monoxide	Changa Manga,	122	117	5	95.90
	Piranwala	33	33	-	100.00
	Dagar Kotli	44	44	-	100.00
	Karluwala	112	100	12	89.29
	Hassan Abdal	50	47	3	94.00
Calcium cyanide	Karluwala	150	142	8	94.66
	Karluwala	78	74	4	94.87
	Chakwal	22	22	-	100.00
	Dagar Kotli	58	56	2	96.55

Further investigations on the use of second generation anticoagulants for the control of Indian crested porcupines are required. Also, bait stations of various types are to be evaluated (Anon, 1968) with the use of anticoagulant baits and strychnine salt blocks.

Fumigation. The results of post-treatment evaluation of the effectiveness of two fumigants are summarized in Table 2. The results of these two fumigants, at different locations, are not significantly different ($F_{(3,4)} = 1.16$, $P = 0.317$, where F value is derived from analysis of variance ANOVA, P is the probablity). The two ingredient gas cartridge gave 95.9% reduction in the live-dens at Changa Manga, while 100% reduction was achieved at Dagar Kotli and Piranwala. At Karluwala and Hassan Abdal, the reduction in activity was 89.29 and 94%, respectively. Overall, average reduction in the activity at five locations was 95.84%. Earlier to this, Khan *et al.* (1992) had obtained 72 and 87% success on using 100 and 150 g cartridges, respectively.

Charcoal and sodium nitrate are relatively innocuous agents and have a low toxicity profile. However, the ignition product, carbon monoxide, is highly toxic to mammals. Savarie *et al.* (1980) stated that its inhalation toxicity is high and a concentration of 0.5% in air can cause collapse, unconsciousness, and death within minutes as it mixes with the blood 300 times faster than oxygen. However, with the use of carbon monoxide generating cartridge in the porcupine burrows there would be minimal, if any, adverse effects on the environment because the gas is inactivated by the soil in the enclosed atmosphere.

The results of fumigation with calcium cyanide (42%) show that it was equally effective when compared with carbon monoxide. The reduction in activity of live-dens was 100% at Chakwal while it ranged between 94.66 and 96.55% at the other three locations. The overall average reduction in activity, as a result of calcium cyanide fumigation, was 96.52%. There was no significant difference in the effectiveness of these two fumigants irrespective of their use in different ecologies and habitats. Nawaz and Ahmad (1974) obtained 83% success in the prevention of porcupine damage to trees in the Changa Manga plantations with the use of cyanogas. They calculated that as a result of this, the damage of 14.5% in the entire plantations was reduced to 0.026%. Chaudhry and Ahmad (1975) did not obtained more than 50% kill with the use of Cymag gas in Khundian forest plantations, Mianwali where they used sodium cyanide at the rate of 112-400 g in plastic bags emptied in each burrow, and obtained only a 50% kill at 400 g, the highest dose per burrow. By this method, hydrogen cyanide gas is not produced in sufficient quantity; also, it is not evenly distributed through the burrow. By the method employed in the present study, the calcium cyanide powder is evenly distributed through the burrow and reacts quickly with the moist air inside the den to produce sufficient quantity of hydrogen cyanide gas to kill the porcupines.

The results of the present study in different ecological areas and habitats of Pakistan did not indicate any difference in the efficacy of these two fumigants. Therefore, based on these findings, the usage of two-ingredient cartridge (250 g) and 50-100 strokes of calcium cyanide (42%) powder per den offer an excellent technique to manage porcupine population in forest plantations and rangelands.

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