PN-ABT-254
ISN-91445

FIELD EVALUATION OF CANDIDATE TOXICANTS, BAITS, AND BAIT DELIVERY SYSTEMS FOR CONTROL OF WILD BOAR

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A Govt. of Pakistan/USAID Project
Vertebrate Pest Control Project
Denver Wildlife Research Center
APHIS, Science and Technology
U.S. Department of Agriculture

and

Pest Management Research Institute
Vertebrate Pest Control Laboratory
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Technical Report No. 23 (Unpublished)

February 1990

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Abstract: The efficacy of two anticoagulants, warfarin (0.025% and 0.05%) and coumatetralyl (0.025% and 0.0375%), and rotenone (0.25%), a plant-derived extract, as toxicants for control of wild boar, *Sus scrofa*, were evaluated in a series of pilot field trials. Both warfarin and coumatetralyl gave excellent results against wild boar on most trials. Wild boar refused to eat rotenone baits on one trial, than ate 4 kg. on a second trial but gave no signs of mortality. Problems were experienced in the anticoagulant poisoning of non-target animals, primarily Indian crested porcupines, *Hystrix indica*, and golden jackals, *Canis aureus*. To avoid these non-target species, several bait delivery systems were evaluated. The two most satisfactory were the use of small (60 x 60 cm), modified, wooden hog feeders and the use of small (15-20 g) paraffinized baits placed into furrows and lightly (4 to 8 cm) covered with soil. A description of the several pilot field trials, baits used, and the several bait delivery systems is given.

INTRODUCTION

Wild boar (*Sus scrofa*) is an important pest of crops in both barani (rainfed) and irrigated crop lands in Pakistan (Beg and Khan 1982, Brooks et al. 1989, Smiet et al. 1979). From the farmers viewpoint, they are a nearly impossible vertebrate pest to deal with. They are wily and smart and are large and strong. They can injure or kill humans when they are frightened or attacked. They are very difficult to keep out of food crops and the farmers have no really good methods to protect their crops from damage.

Among lethal methods of control used in the past, shooting remains an expensive method and few farmers possess shotguns. So most attention has been paid to methods of poisoning, using highly toxic insecticides, like Aldicarb (Temik) (Khan et al. 1980) or extremely toxic rodenticides, such as Fluoroacetamide and Sodium Fluoroacetate (Shafi and Khokhar 1986). These materials, while no doubt extremely effective when used by professionals, are not

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suitable for use by farmers, and when used may be extremely hazardous to livestock and wildlife in the area poisoned (O'Brian et al. 1986, Rathore, 1986). They also tend to produce a bait- or poison-shyness in the animals that ingest sublethal doses. These survivors will not eat the poison baits again so they are useful usually only for one or two nights' exposure.

Searching for alternative toxicants, we considered the use of anticoagulant materials, several of which have been shown to be quite toxic to domestic and feral pigs (Dobson 1973, Hone and Kleba 1984). Warfarin appears to have good potential as a pig poison (Hone and Mulligan 1982). Several studies have shown that warfarin is highly toxic to pigs; a chronic LD_{50} of 0.05 mg/kg over 7 days (Buck 1978), chronic oral LD_{50} of 0.4 mg/kg over 5 days (Crispin et al. 1975), and Worthing (1979) listed a lethal dose of 1 mg/kg over 5 days.

Likewise, Dobson (1973) indicated that coumatetralyl at dosages ranging from 0.1 to 1.0 mg/kg created hemorrhages in 8 pigs, 3 of which survived the lowest dosages because of vitamin K_1 therapy. All the others died on the 8th day from consuming 0.25 to 1.0 mg/kg of coumatetralyl for 7 days. He concluded that a total intake of less than 2 mg/kg should be lethal provided this is given over a period of 7 days.

Rotenone, the plant extract from *Derris elliptica* and other *Derris* spp., was suggested by Matschke (Personal comm.) as a candidate acute toxicant for wild boar. According to a report by Kingscote et al. (1951), rotenone is toxic to pigs. Extrapolating from the data they presented, it appears the LD_{50} could be from 5 to 10 mg/kg.

The evaluation of these toxicants and several baits and bait delivery systems in a series of pilot field trials is given in this report. The results of a previous preliminary report (Brooks, et al. 1988) are included for completeness.

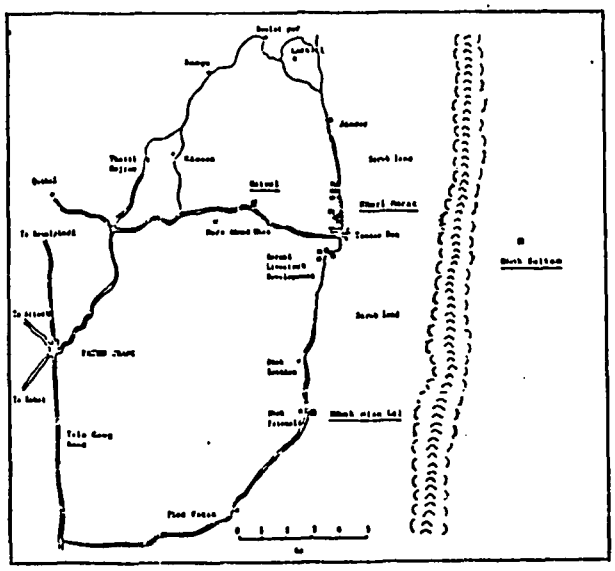

Fig. 1. Sketch map of the Kheri Morat field trials area. Underlined sites are given in text.

METHODS

Study Area: The study area was located on the grounds of the Punjab Barani Livestock Research Farm and adjacent farming areas at the base of a small range of mountains approximately 15 km south east of the town of Fateh Jhang (Fig. 1). The plains sloping up

to the base of the mountains are covered with a scrub forest dominated by trees: *Acacia modesta* (Acacia), *Geranium wallichianum, Populus nigra* (Poplar), *Olea cuspidata* (Olive), *Dalbergia sissoo* (Shisham) etc; shrubs: *Adhathoda vasica, Dodonia viscosa, Acacia nilotica* etc; and grasses: *Cynodon dactylon, Dicanthium annulatum, Desmostachya bipinnata* etc. Beyond the scrub forest, about 0.5 to 1 km from the base of the mountain, are crop fields where sorghum, millet, wheat, maize and other fodder crops are grown. Wild boar live in the mountains or near their base and forage into the crop fields. Other baitings were done in wheat fields near the village of Ratwal, about 4 km west of the previous bait sites, and at a small village, Dhok Sultan, to the south opposite Kheri Morat over the small mountains. Eleven trials were carried out in these areas in a period of 27 months.

A short trial was conducted in Faisalabad District, central Punjab. The Salarwala Forest, lying about 30 km from Faisalabad city, is an area of acacia, (*Acacia modesta*) and mesquite (*Prosopis julifloria*) forest or scrub, intermixed with stands of marsh grasses (*Saccharum munja*) in low-lying areas. The forested area is bounded by irrigation canals on three sides and crop fields on the fourth. The entire forested area is surrounded by croplands on the opposite sides of the canals.

<u>Toxicants</u>: Two anticoagulants, warfarin and coumatetralyl, were evaluated. Warfarin was supplied as the technically pure (99.9%) material as manufactured by Bell Laboratories, Madison, Wisconsin, USA. Coumatetralyl was supplied as the 0.75% concentrate by Bayer, West Germany. It is colored with a blue warning dye.

Rotenone was supplied as brittle extract of cube root, containing rotenone at 40% and 60% other cube extractives. The manufacturer was Roussel Bio Corporation, Englewood Cliffs, New Jersey, USA. The material consisted of lumps, crystals, and powder in a yellow-orange color. It was fairly soluble in acetone.

Sodium fluoroacetate was used in one instance of furrow baiting. The technical material, supplied by Rentokil Laboratories Ltd., Felcourt, England was 90% pure. It was applied to an oat grain bait in an aqueous solution and grain was then sun-dried before using.

<u>Baits</u>: In the first field trial baits were made from wheat flour (atta) mixed into a dough to which was added 4% molasses (gur), called WFM for short. Anticoagulants were added to this in the appropriate concentrations. Colored dyes were added to provide a warning that the baits were not human foods. The dough masses were separated and rolled into small balls, each weighing about 80 to 100 gm.

Other baits used were whole wheat grain and whole oat grain to which was added 4% crude brown sugar (shakkar) and 1% vegetable oil called WSO for short. Anticoagulants were added to these baits in the required concentrations.

In the first rotenone trials, the material was dissolved in acetone and applied to whole wheat grain along with 4% molasses and 1% vegetable oil, (WSO) to give a final concentration of 0.25% of the active ingredient. The grain was sun-dried to evaporate the acetone. In the second trial, the rotenone was finely ground, sieved to eliminate larger particles and applied to whole wheat along with 4% crude brown sugar and 1% vegetable oil (WSO), to give a final concentration of 0.25% active ingredient. This concentration was derived from the approximate lethal dose as given by Kingscote et al. (1951) of 5 to 10 mg/kg. About 200 to 500 g of bait should be lethal to a 50 kg wild boar at this toxicity.

Bait Delivery Systems: We evaluated six bait delivery systems in the field trials. These were in order of testing:

1. Wheat Flour Dough Balls (WFM) Placed on the Ground: Bait balls were placed in late afternoon where wild boar activity was evident. The ground was smoothed and dusted around each set of bait balls so as to record footprints of the animals visiting the site. The bait sites were visited again in early morning and the bait takes were recorded along with information on which animal's footprints were observed. All uneaten baits were retrieved for rebaiting in late afternoon. Fresh baits were made if needed.

2. Furrow Baiting with Whole Oats: A preliminary trial of furrow baiting was made in February 1988. Three parallel furrows of about 20 m in length and 10 cm in depth were made at each site. Whole grain oats, previously soaked in an aqueous solution of sodium fluoroacetate to give a final concentration of 0.03%, were air-dried. Approximately 2 kg of bait was laid in the 3 furrows at each site. The baits were lightly covered with about 2 cm of soil. Five sites of 3 furrows each in wheat fields being damaged by wild boar were baited for 3 nights. The area around each site was smoothed daily to check on animal tracks.

3. Wheat Grain Baits (WSO) Placed on the Ground: Whole wheat baits (WSO) incorporating either an anticoagulant or rotenone, were placed in limited amounts (5 kg at each site) on the ground at 4 sites at which wild boar had been prebaited for 4 or 5 nights. The idea was to limit the amount of bait available at any one site and for each night. Baiting was continued for up to 6 nights. The area around each bait site was smoothed daily to check on animal visits by noting footprints.

4. Wheat Grain Baits (WSO) in Plastic Bags Buried in Soil Furrows: Whole wheat baits (WSO) with anticoagulants, were plastic-bagged in 1 kg amounts. Five kg of baits were placed in soil furrows at each baited site. Baiting was continued for up to 6 nights at each baited site. Bait bags were lightly covered with

soil. The idea was to have the wild boar locate and dig up the baits but to keep them hidden from porcupines and jackals.

5. **Wheat Grain Baits (WSO) in Wooden Modified Hog Feeders**: Wheat grain baits (WSO) were placed in wooden modified hog feeders, 60 x 60 cm square, with four slanting wooden doors on the top (Fig. 2). These were sited in an area of heavy wild boar activity used as a resting or hiding area. Each hog feeder was filled with 15 to 20 kg of bait. The area around each hog feeder was smoothed daily to check animal visits from footprints. Baits were replenished as needed. Baiting continued until wild boar visits stopped.

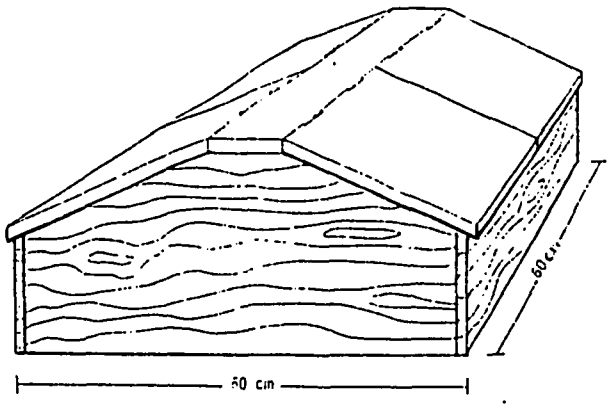

Fig. 2. Modified wooden hog feeder.

6. **Paraffinized Grain Baits in Soil Furrows**: Cracked wheat grain baits with 4% crude brown sugar and anticoagulants were mixed with 20% paraffin w/w and molded into small bite-size baits weighing 15 to 20 g each. Soil furrows were dug 1 m in length and 10 cm deep. Judging by the number of animals visiting each site, one furrow was dug for each animal on subsequent visits. Into each furrow were laid 10 of the paraffin baits and these were lightly covered with soil. The area was smoothed around the furrows and animal numbers and species were noted each morning. Baiting continued until there were no further visits by wild boar.

Dead Animals: During the course of, and following, each pilot field trial, the area was searched for dead animals. Farmers, bird trappers and wood cutters were alerted to report any dead animals also. In this way, many animals dead from the toxicants were located. A careful search was made for avian scavengers that might have fed upon the animal carcasses. No attempt was made to bury dead animals except in the one case where sodium fluoroacetate was used.

RESULTS

Results of the first three trials were given in Brooks *et al*. (1988) but are summarized here.

Field Trial 1 (October/November 1987, Kheri Morat)

This first use of anticoagulants (3 days of warfarin, the rest of coumatetralyl, 0.025%, because warfarin was in short supply) resulted in a typical bait consumption curve covering a 15-day period (Fig. 3). The baits used were WFM. During this trial, much

of the earlier bait consumption, until about the 10th day, was due to jackals and porcupines, which fed earlier in the evening than did the wild boar. Mortality in wild boar was first seen on the 8th day, and 2 more on the next day. Total mortality: 19 wild boar, 6 porcupines, 6 jackals.

Field Trial 2 (March 1988, Near Ratwal Village)

On this trial, animals were baited with WFM until feeding stopped, which took 10 days (Fig. 4). The anticoagulant used was warfarin, 0.025%. The baiting curve was typical, rising to a peak on the 5th day. Total mortality: 11 wild boar, 1 porcupine, 1 jackal.

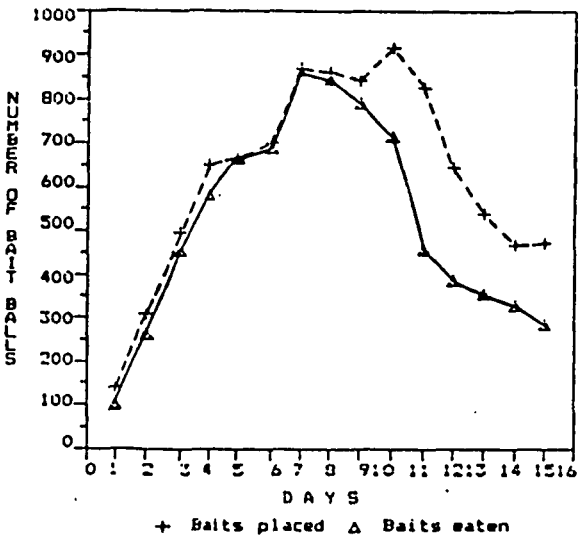

Fig. 3. No. of baits placed and eaten on first field trial.

Field Trial 3 (February 1988, Near Ratwal Village)

This was the first baiting in soil furrows. Three parallel furrows were dug at 5 sites, each about 20 m long and 10 cm deep. Dyed whole oat baits treated with 0.03% sodium fluoroacetate were placed in the furrows and lightly covered with 2 cm of soil. A total of 10 kg of baits were placed at the five sites. Wild boar visited 4 of the 5 sites in 3 nights but took baits only from 2 sites. No tracks of other animals were seen at the furrows. Total mortality: 2 wild boar.

Field Trial 4 (February 1989, Kheri Morat)

This trial used coumatetralyl at 0.0375% concentration in the WFM bait. Baits were placed on the ground surface in and around wheat fields that were being visited and damaged by wild boar. The trial lasted 16 days. Bait consumption peaked on the 6th day and stopped on the 15th day

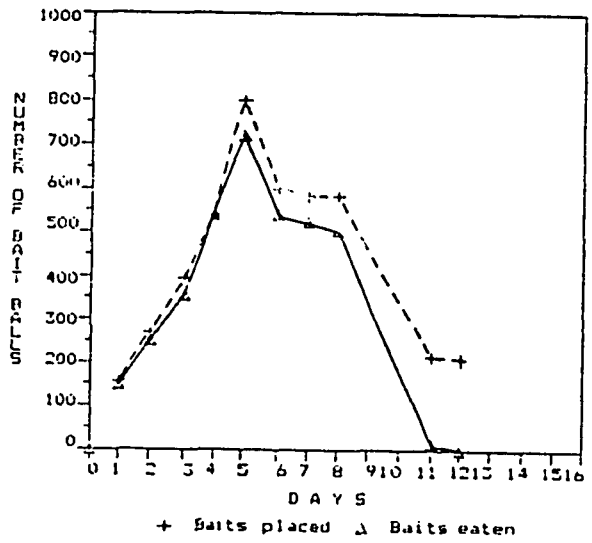

Fig. 4. No. of baits placed and eaten on second field trial.

(Fig. 5). Total mortality: 14 wild boar, 15 non-target animals (porcupines, jackals, dogs).

Field Trial 5 (February/March 1989, Kheri Morat)

Baiting (WFM) was carried out for 9 days; consumption reached a peak on the 8th day, then dropped precipitously. The toxicant was 0.0375% coumatetralyl. Baits were placed on the ground. Total mortality: 4 wild boar.

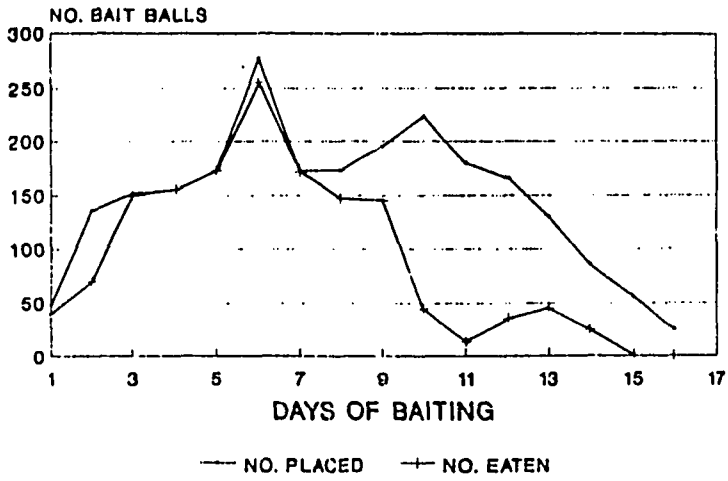

Fig. 5. No. of baits placed and eaten on fourth field trial.

Field Trial 6 (February/March 1989, near Ratwal Village)

Baiting was done in wheat fields being damaged by wild boar. The bait was WSO containing 0.0375% coumatetralyl. Baits were placed on the ground surface. Baiting lasted 11 days until feeding stopped (Fig. 6). Total mortality: 4 wild boar, 2 porcupines. This was the second time that jackals were not observed to visit the bait sites.

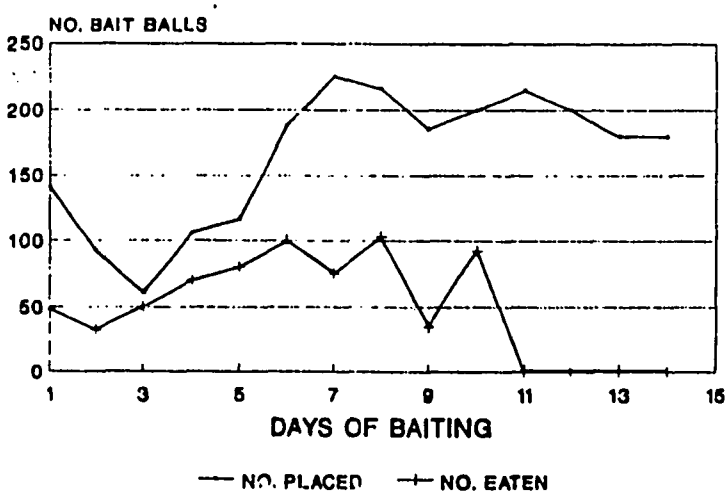

Fig. 6. No. of baits placed and eaten on sixth field trial.

Field Trial 7 (March 1989, Dhok Mian Lal)

The bait was WSO containing 0.05% warfarin. Baits were placed on the ground surface in and near wheat fields being damaged by wild boar. Baiting was done for only 6 nights. Total mortality: 6 wild boar, 3 non- target animals (porcupine, wild cat). The dead wild boar were found on the opposite side of the small range of mountains, about 4 to 5 km away from the bait sites.

Field Trial 8 (July 1989, Dhok Sultan)

Rotenone, 0.25% a.i., dissolved in acetone and then sun-dried, in WSO baits, was placed in 5 kg amounts at 4 sites for 2 nights. Wild boar approached but did not eat the baits. Most sites showed no disturbance of the baits. Previous pre-baiting with WSO at these same sites for 6 nights resulted in almost complete takes each night. The 5 kg placements were an attempt to limit bait consumption by the animals. Results: no feeding and no mortality of any species.

Field Trial 9 (July 1989, Kheri Morat)

Rotenone, 0.25% a.i. in WSO, but dusted on instead of dissolved in acetone, was placed in 10 kg amounts at 3 sites. At one site, 4 kg of bait was consumed the first night. Another two nights exposure resulted in no further consumption. Result: an estimated 13 animals (3 adults, 10 young) were visiting the baited sites; none died.

Field Trial 10 (July/August 1989, Dhok Sultan)

Baiting was done with WSO containing 0.05% warfarin. Baits were placed in 1 kg amounts in plastic bags. Five bags were buried in soil furrows at each site and lightly covered with soil. Four sites were baited. In 6 nights, the entire 20 kg of bait placed out each night was dug up and consumed by wild boar. Bait bags were ripped open and the contents sometimes scattered. Porcupines also were visiting the sites. After 6 nights, baiting was stopped for 10 days. There was still minor wild boar activity in the area so the same 4 sites were again baited in the same manner. During the next 4 nights, all baits were consumed for 2 nights, 10 kg on the third night and only 5 kg on the last night. Results: an estimated 32 wild boar were visiting the sites (12 adults and 20 young). Fifteen wild boar (6 adults and 9 young) and 6 porcupines were found dead.

Field Trial 11 (November/December 1989, Salarwala Forest, Faisalabad)

This was the first baiting to use the wooden, modified hog feeders. Three feeders, originally, were placed in the forested area. Four more were added after the 8th day. These attracted porcupine and jackals from the first day but wild boar only after one week. We believe, however, that only wild boar succeeded in feeding from the bait boxes. The bait was WSO, containing 0.025% warfarin. Baiting continued over a 35-day period, after which all feeding stopped (Fig. 7). Evidence indicated that upto 27 wild boar visited the 7 feeders in one night, and upto 10 porcupines and 6 jackals. Porcupines and jackals stopped visiting by the 23rd night following heavy use by wild boar. Total mortality: 4 wild boar, others probably dead in inaccessible areas; no non-target species were found dead.

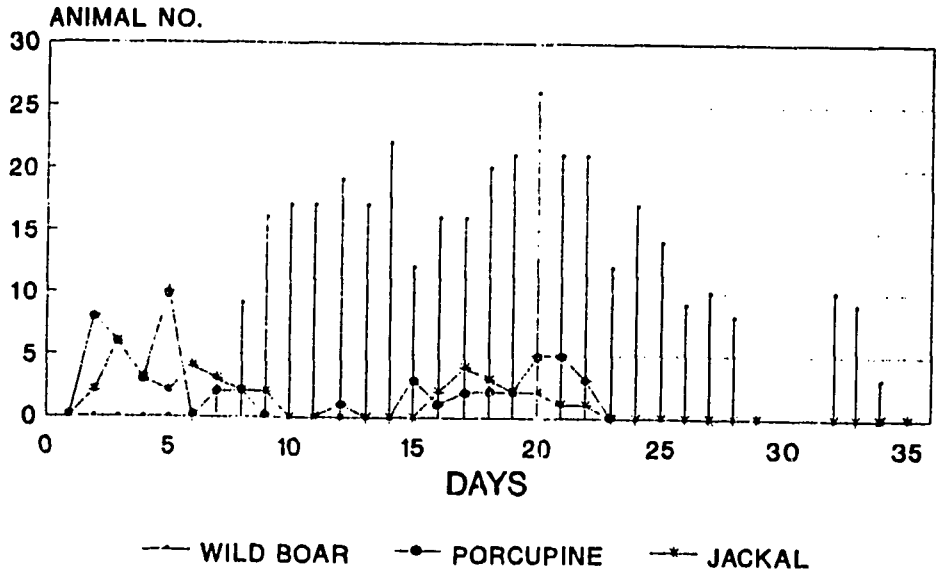

Fig. 7. No. of animals visiting modified hog feeders in Salarwala forest.

Field Trial 12 (December 1989/January 1990, Kheri Morat

This was the first furrow baiting-using a modified WSO bait intermixed with 20% paraffin. The toxicant was 0.025% warfarin. The WSO bait, using cracked wheat instead of whole grains, was made into small, bite-sized paraffinized baits, weighing 15 to 20 g each. These were placed 10 each in a soil furrow 1 meter long and 10 cm deep. These baits were covered lightly with soil. Originally only 3 furrows were made at each site. Judging by wild boar visits, one furrow was added for each animal exceeding 3 that visited the site. Upto 35 furrows were finally baited at 5 sites. The bait consumption is shown in Fig. 8. Results: no dead wild boar or any other animals were found. There was minor sign of porcupines at a few sites but because the baits were small, almost all were eaten by wild boar. Why there was no observed mortality we can not explain. The bait blocks were fed to 7 caged *Rattus rattus* and killed them all within 9 days.

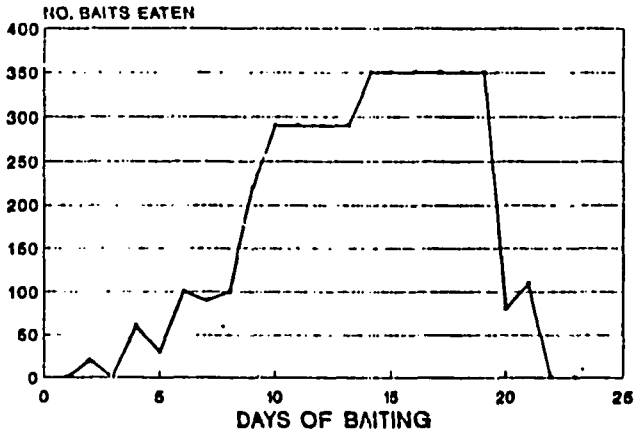

Fig. 8. No. of paraffinized baits dug up from soil furrows and eaten.

DISCUSSION

The use of anticoagulant bait materials to control wild boar populations gave very satisfactory results. Wild boar respond to anticoagulant baits in a pattern similar to that of domestic rats. The bait sites must first be located by the animals. Then bait consumption increases daily until a peak is reached, anywhere from the 5th to the 8th day. Bait consumption then declines rapidly as the animals become affected and start dying. The great advantage of anticoagulant baits over acute toxicants is that they apparently do not create a bait shyness. Nor do the animals vomit the baits, as they are known to do when poisoned with sodium monofluoroacetate (O'Brien et al. 1986), and presumably, fluoroacetamide.

The major disadvantages of anticoagulant baits are 1) they are slow to act, meanwhile crop damage continues and farmers become impatient, 2) they require a very large amount of baits when poisoning wild boar (a large boar can easily eat 5 kg of bait at one time), and 3) they are attractive to and kill non-target animals, especially porcupines, jackals and dogs.

We attempted to overcome some of these disadvantages in the design of the bait delivery system. The amounts of baits made available were restricted in trials 10 and 12. In field trial 10, the amounts of baits were limited to 5 kg at each site per night. As a consequence, only 20 kg were eaten nightly for 6 nights, a total of 120 kg. Follow-up baiting to finish the poisoning used only another 55 kg. On trial 12, the amount of baits per furrow were limited to 10, which equals 150 to 200 g. This amount of warfarin baits, if consumed by one animal nightly for 5 nights, should be lethal. Limiting the size of each bait to 15 to 20 g meant that they were easily consumed by wild boar without scattering or wasting the bait, thus not providing a residue for porcupines or jackals to feed upon.

The wooden, modified hog feeders as bait stations for wild boar were used to completely exclude porcupines and jackals from the baiting cycle. Their use looks promising in areas where the boars eventually accept their presence. They need much more evaluation, however, before being recommended. We do not know that jackals cannot learn to open the feeding doors. We are not sure that wild boar may not scatter the contents onto the ground nearby.

Modified wooden hog feeders, baited with anticoagulant baits, may offer promise in poisoning wild boar in places where they could be permanently and securely installed. Air bases and forestry plantations are chronically infested with wild boar. At these situations, hog feeders, placed along pathways or near resting areas, would eventually be found and utilized by wild boar. They could be checked for bait replenishment once or twice a week. If they did not receive attention in one area for several months, they could be moved to other areas where fresh activity was seen. Use of the hog feeders should be an easy and relatively inexpensive means of keeping the resident wild boar population in check.

Furrow baiting was first suggested by Michael Fall (pers. comm.), who observed it was used as a method to poison rabbits. It appears to have excellent promise as a method to poison wild boar. As O'Brien (1986) observed, use a method based upon either the size of the pest or on special behavior patterns, such as digging in the ground with the snout.

Bait materials do not appear to be a problem. The crude brown sugar (shakkar) or the molasses (gur) are good attractants for wild boar. Whole grain baits are equally as attractive as wheat dough baits and far easier to mix. The whole grain baits are eaten by porcupines, however.

Rotenone was a keen disappointment. The acetone-applied rotenone was rejected by the wild boar and might even make a good repellent. Wild boar did eat the material when it was ground to a fine powder and applied to molasses-sweetened wheat, but there was no sign that it killed any animals. Why the Canadians found it to be so toxic to domestic pigs (Kingscote et al. 1951) and we found it failed to kill is not understood. Perhaps the rotenone used 40 years ago contained some extractive materials toxic to pigs that are not present in the material we used.

Conclusions

Further pilot field trials are needed before any toxicant and baiting method may be recommended for wild boar control. Modified hog feeders do not work everywhere, particularly not in the Kheri Morat area. It appears that the animals remain wary of them for weeks. This may be due to living in a more stable habitat than the wild boars in irrigated croplands. Anything new in the environment tends to create a neophobic reaction. But in areas where they are accepted and utilized by wild boar, more pilot field trials are called for.

Furrow baiting, which may be more acceptable to farmers, needs much more evaluation. Paraffinized baits may not be the best form of bait materials to use. Pelletized baits should be evaluated. But it seems obvious that small, bite-sized baits work well and eliminate the scattering of baits that occurs when whole grain baits are used. Plastic-bagging of baits did not work because they were ripped open and the contents scattered widely <u>after</u> they were dug out of soil furrows.

Field trials need more careful monitoring. A programme to measure wild boar, porcupine and jackal activity pre-and post-poisoning was drawn up and initiated in January 1990. Two transects 0.5 km apart, were laid out, each about 2 km in length along the base of some small hills. Ten bait stations were established on each transect and at each site 1 kg of WSO bait was placed as an attractant. The soil was smoothed and a fine dust sieved onto an area of 1 m radius surrounding each bait site. The transects were planned to be run for 5 nights. In this first attempt, we measured activity for only four nights before the field trial had to be

canceled. Wild boar, porcupine, jackal, desert hare and domestic dogs visited the sites during the 4 nights. Further attempts like this are needed to quantitatively measure the impact of the poisoning schemes on the several animal populations.

Anticoagulants may not be the answer in developing baits that farmers can use, because of the several disadvantages mentioned earlier. But there is no reasonable acute toxicant that can be evaluated. Bromethalin might be a candidate material but we lack information on its toxicity to pigs or wild boar. In the meantime, we will continue to use anticoagulants to determine if the amounts of baits can be limited and whether the bait delivery systems used really do eliminate porcupines and jackals from the baiting cycle.

Acknowledgements

We thank the Director, Punjab Barani Livestock Development Project, Kheri Morat, for permission to conduct the field trials on their grounds and for the provision of temporary housing for the staff. We thank Mr. Arshad Khan, for his kind permission to carry out field trials and the experimental furrow baiting in his wheat fields near Ratwal village. We thank Mohammad Salim, Mohammad Mahboob and Waheed Ahmad for their help in the conduct of these field trials in the Kheri Morat area. We thank Shafqat for recording the field observations in the Faisalabad area. For our own staff help in the field we express our appreciation to Liaqat Ali, Yousaf Khan, Mohammad Ilyas and Mohammad Nawaz.

This study was financially supported by the U.S. Agency for International Development under the Project "Food Security Management, Vertebrate Pest Control, PASA IPK-0491-P-IF-5017-05". We appreciate the support of the National Agricultural Research Centre, Islamabad and the Pakistan Agricultural Research Council for providing laboratory and office space at NARC.

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