CAPSICUM OLEORESIN AS AN ELEPHANT REPELLENT: FIELD TRIALS IN THE COMMUNAL LANDS OF ZIMBABWE

FERREL V. OSBORN,[1] Mid Zambezi Elephant Project, 37 Lewisam Avenue, Chisipite, Harare, Zimbabwe

Abstract: Elephants (*Loxodonta africana*) destroy subsistence crops and threaten the livelihoods of rural farmers across Africa. In an effort to formulate a nonlethal repellent and a method of application, tests were conducted with a capsicum oleoresin spray in the communal lands of Zimbabwe. The time taken to repel elephants from fields by farmers using methods currently available was compared with a capsicum oleoresin repellent. Elephants were repelled from fields significantly faster by the capsicum oleoresin spray than by traditional methods. A number of issues regarding crop loss due to elephants are discussed.

JOURNAL OF WILDLIFE MANAGEMENT 66(3):674–677

Key words: capsicum oleoresin spray, crop raiding, elephant, human–animal conflict, *Loxodonta africana*, peppers, repellents, Zimbabwe.

Crop damage by wild elephants is a major conservation issue for both African and Asian (*Elephas maximus*) elephants. Currently, rural farmers employ the traditional practices of using drums and fire to drive elephants away, or fencing them out of agricultural fields. Wildlife managers have tended to use electric fencing, disturbance shooting (firing gunshots in the air), or killing problem elephants. These approaches have been unsatisfactory because they are either expensive or ineffective. Wildlife managers want to limit the number of elephants shot for crop protection. Therefore, a pressing need exists for a reliable, low-cost, and effective elephant-repellent system. This series of tests was undertaken to compare current traditional methods with a capsicum oleoresin repellent in the communal lands of Zimbabwe.

Repellents based on resin from *Capsicum* spp. peppers have been used to alter animal behavior for a variety of species, including bears (Hunt 1985), ungulates (Andelt et al. 1992), dogs, and humans (Bullard 1985). The resin contains capsaicin, a chemical found in fruits of *Capsicum* spp., which is the agent that makes them taste hot by stimulating nociceptors of the trigeminal system (Mason et al. 1991, Rasmussen 1994). The irritating quality of this stimulation produces a burning sensation that animals find unpleasant.

The success of atomized capsicum oleoresin with bears prompted this exploration of its possible use as an elephant repellent. Elephants were shown to respond to a capsicum oleoresin aerosol during tests in the Hwange National Park in Zimbabwe (Osborn and Rasmussen 1995). These first tests were designed to ascertain whether the spray had any effect on elephants and, if so, to establish the range of reaction. These tests also helped to identify potential logistical modifications needed for application of the spray as a deterrent and to develop an experimental protocol for further field trials.

STUDY AREA AND METHODS

The study area was in the Sebungwe region of Zimbabwe, in and around the Sengwa Wildlife Research Area (SWRA) in western Zimbabwe (located between lat 28°05′–28°01′S and long 18°01′–18°03′E). The communal lands surrounding the SWRA are a mosaic of fields, woodlands, and scattered homesteads (Anderson and Walker 1974). The mean annual rainfall is 668 mm ($n = 30$ years), and the mean annual temperature is 22 °C with a range from a maximum of 40 °C in October to a minimum of 4 °C in July. The vegetation generally is dry, deciduous savanna woodland. The boundary between the farms and the SWRA is considered a hard edge because fields abut the forest with no buffer zone (Guy 1989).

I compared the effectiveness of different methods to repel elephants by measuring the length of time elephants took to retreat from fields adjacent to the SWRA during 1995–1996. I assessed 3 categories of traditional deterrents: (1) one person guarding at the edge of a field with a small fire (this person might have a dog and chase elephants by yelling and banging on tins); (2) two to three people guarding with slingshots, drums, dogs, and throwing burning sticks; and (3) four to seven people guarding with several dogs, whips, drums, and multiple large fires. (Farmers

[1] E-mail: mzep@africaonline.co.zw, fvosborn@elephantpepper.org, mid_zam_ele@hotmail.com

aggressively pursued elephants by throwing burning sticks and making loud noises with drums and whips.) These categories were determined from a classification of observations of farmers actively defending their fields.

The traditional methods were compared to tests with capsicum oleoresin spray. The formulation used for the tests was a commercially available 10% capsicum oleoresin that was estimated to be approximately 250,000 Scoville units (Counter Assault Tactical Systems 1996). The systems used to deliver the capsicum oleoresin were a 1-kg can fitted with a spray nozzle, and a larger system that consisted of a 10-l container fitted with a trigger and nozzle mechanism. Five tests with the spray during daylight showed that the initial spray distance was 10 m and the fine mist cloud of atomized resin was still irritating to humans over 75 m in a light wind.

Test Protocol

The moment the first elephant entered a field was considered the zero point. The time between this point and the moment the repellent was applied was recorded. For all the methods tested, the duration of various behaviors was recorded by the primary investigator using a low-light monocular and a stopwatch. The time to retreat was defined as the period between the moment of the application of a repellent and the time that the elephant, or group of elephants, took to exit the field. The reactions of the elephants to the different repellents were classified as (1) alarm (head raised, ears fanned out), (2) vigorous head shaking, (3) loud exhalations of air, and (4) charge (toward testers). The distance between the elephant and the testers or farmers ranged between 20 and 40 m. All tests were conducted between 1830 and 0630 in low-light conditions.

For the capsicum oleoresin tests, a light wind was essential for transferring the resin cloud from the testers to the elephants. I recorded 4 categories of wind: (1) no wind, (2) light (1–6 km/hr), (3) gusty (7–12 km/hr), and (4) strong (≤13 km/hr). Successful tests occurred in a light to gusty wind.

Testers positioned themselves upwind of the raiding group, then waited for a 5-min control period. This period would have allowed elephants to either retreat from the presence of the testers or to continue feeding on crops. Depending on the wind velocity and the distance between the elephants and the testers, a period of 30 sec to 2 min elapsed between the triggering of a 2-sec spray and the reactions of the elephants.

Table 1. The number of reactions by elephants to 3 categories of traditional deterrents and capsicum spray repellent in communal lands of Zimbabwe, 1995–1996. In some tests, more than 1 behavior was recorded.

Reaction	Level 1[a] (n = 15)	Level 2[b] (n = 11)	Level 3[c] (n = 15)	Capsicum spray (n = 18)
1 (Alarm)	9	11	15	18
2 (Head shake)	3	3	7	12
3 (Exhalation)	0	1	3	16
4 (Charge)	2	3	9	0

[a] One person guarding at the edge of a field.
[b] Two to three people guarding with slingshots, drums, dogs, and burning sticks.
[c] Four to seven people guarding with several dogs, whips, drums, and multiple large fires.

RESULTS

In a number of tests, 2 or more reactions were exhibited (e.g., 1: alarm, and 2: charge). In response to traditional level 1 deterrent (1 person), elephants did not visibly respond to the actions of the farmer in 9 out of the 15 encounters. The number of times elephants charged farmers at level 3 (larger groups of farmers; $n = 9$) was in sharp contrast to the reactions to capsicum oleoresin spray ($n = 0$; Table 1).

The results for the traditional methods illustrate that elephants chased by individual farmers took longer to leave fields than elephants chased by groups of farmers working together (Fig. 1). The time between stimulus presentation and the end of the time to retreat (the point at which ele-

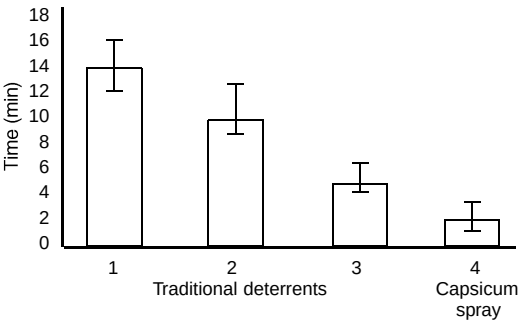

Fig. 1. Tests of 4 methods (3 traditional methods and capsicum spray) to repel elephants in communal lands in Zimbabwe, 1995–1996. The number of minutes between the time of stimulus and end of time for elephants to retreat are shown. The 3 traditional deterrents are 1 person guarding at the edge of a field (1), 2–3 people guarding with slingshots, drums, dogs, and burning sticks (2), and 4–7 people guarding with several dogs, whips, drums, and multiple large fires (3). Error bars indicate SE.

phants left the field) were compared between level 3 traditional repellent (large groups of people aggressively chasing elephants) and capsicum spray. This interval was significantly shorter during capsicum tests $_{(b)}$, than when traditional methods $_{(a)}$ were used ($U = 2.5$, $n_a = 15$, $n_b = 18$; Mann-Whitney U-test, $P < 0.001$).

While responses varied from test to test, a similar pattern of behavior was observed throughout the capsicum oleoresin spray trials. Elephants did not visibly respond to the sound of the spray device and continued to feed until the capsicum spray reached them. In 12 tests, some individuals in a group of crop raiders momentarily stopped feeding and froze when the chemical was fired, but elephants did not retreat from a field in response to the sound of the spray during any test. Elephants generally reacted to the capsicum spray as follows: (1) The first elephant to come into contact with the spray immediately stopped feeding and raised its head in alarm. (2) An audible exhalation of air, then a rumble or roar followed this reaction. (3) The rest of the group froze until the next animal in line inhaled the spray. (4) The elephants then emitted a series of excited trumpets, rumbles, and roars, followed by a hurried and disoriented exit from the field in the opposite direction from which the spray came. The intensity of reactions varied, probably due to the amount of capsicum oleoresin inhaled.

DISCUSSION

The comparison among the traditional deterrents showed that the larger the group of people, the more effective farmers were at repelling crop raiders. This result may be due to the fact that larger groups of farmers tended to be bolder and more aggressive toward raiding elephants. The larger the group of farmers and the greater their aggression, the less time elephants occupied a given field, which resulted in less crop loss. The length of time elephants remained in a field in response to level 3 deterrent was, however, still long enough to cause substantial damage. This shows that some improvement in traditional methods can be made to lessen crop loss by organizing farmers to repel elephants.

The data indicated that capsicum spray repelled elephants from fields more quickly than traditional deterrent methods. In no cases did elephants charge after inhaling the spray. Their retreat from the fields was swift. Due to the difficulty of re-identifying elephants at night, it was not possible to assess the longer-term deterrence properties of the resin. Farmers believed that elephants were more easily repelled using traditional methods after being exposed to the capsicum oleoresin spray, although this was not tested.

Elephants habituate to the sounds of people shouting, drums beating, and guns firing (Osborn 1998). However, conditioning through the use of aversive stimuli (e.g., capsicum oleoresin spray) when the elephant is engaged in the undesirable behavior may be sufficiently disturbing to cause the raider to associate adversity (e.g., watering eyes, burning sensation in the trunk mucosa, trigeminal pain) with the particular behavior (e.g., crop destruction). Capsicum oleoresin also may act as a secondary repellent. If the resin is the primary stimulus that causes a reflexive withdrawal, the resin also can act as the unconditional stimulus to further avoidance of the conditional stimuli. This may mean that capsicum oleoresins also can act as secondary repellents. The possibility that an elephant may associate a novel sound (e.g., whistles or horns) with adverse reactions (pain) of the resin also is worthy of evaluation. Periodic reinforcement of the sound with oleoresin may be necessary as an elephant learns that the single stimulus (sound) is a false threat.

Information from wildlife managers and field observations during this study suggest that crop-raiding may be learned by young males from a limited number of older bulls (Osborn and Welford 1997). These bulls, by their successful example, show younger males how and where to raid. Elephants that initiate destructive behavior could be targeted for behavior modification. If a relatively small number of bulls are inciting others to engage in destructive behavior, altering the actions of only a few individuals could control problem populations. If the elephants that initiate crop-raiding could be taught to avoid agricultural areas, a serious economic problem could be ameliorated.

The economic considerations of the application of these techniques are of great importance. Currently, electric fencing is widely seen as the only nonlethal option for reducing crop damage (Taylor 1999), but these fences generally are funded by foreign donors at great expense. Most crop damage in Zimbabwe occurs between February and May, followed by 8 months of relatively low levels of human–elephant conflict. Considering these factors, a combination of chemical repellents and the use of traditional methods may become more economically viable. The cap-

sicum spray that was tested is relatively expensive (US$5 per discharge) and was imported from the United States. While this is costly, the value of subsistence agriculture cannot be measured in purely economic terms. Often, the affected crop is the only source of food and income for rural families. The time spent defending crops and obtaining food to replace that lost to elephants must be considered. Further refinement of the capsicum repellent system, with manufacture in Africa, is necessary to make it safer and more economical for farmers.

MANAGEMENT IMPLICATIONS

Wildlife managers are reconsidering the indiscriminate shooting of crop-raiders due, in part, to the decline of elephants in some parts of Africa. Reducing crop damage by elephants involves changes in the behavior of farmers and technical advancements in repellent technologies. There is a pressing economic and social need for a reliable, low-cost, easy-to-use elephant repellent. These tests were an attempt to develop a new approach for defending crops from elephants. Traditional methods of deterrence can be effective, if organized and varied. Capsicum oleoresins, or other chemical repellents that are administered by farmers, may augment or present a viable option to electric fencing and traditional methods of repelling elephants. If elephant repellents can be developed and utilized by farmers, this could become an important tool for rural Africans.

ACKNOWLEDGMENTS

I thank the Department of National Parks and Wildlife Management, Zimbabwe, for permission to conduct this research. Thanks to J. Birochack, D. Cumming, K. Eltringham, K. Mariba, R. Martin, R. Taylor, G. Parker, B. Rasmussen, L. Welford, and 3 anonymous reviewers. This study was funded by the U.S. Fish and Wildlife Service and World Wide Fund for Nature/Zimbabwe.

LITERATURE CITED

ANDERSON, G. D., AND B. H. WALKER. 1974. Vegetation composition and elephant damage in the Sengwa Wildlife Research Area, Rhodesia. Journal of the Southern African Wildlife Management Association 4:1–14.

ANDELT, W. F., D. L. BAKER, AND K. P. BURNHAM. 1992. Relative preference of captive cow elk for repellent-treated diets. Journal of Wildlife Management 56:164–173.

BULLARD, R. W. 1985. Isolation and characterization of natural products that attract or repel wild vertebrates. Pages 65–94 *in* T. E. Acree and M. Soderlund, editors. Semiochemistry flavors and pheromones. Walter de Gruyter, New York, USA.

COUNTER ASSAULT TACTICAL SYSTEMS. 1996. Capsaicin content and pungency of oleo-resin. Internal report, Valley Forge, Pennsylvania, USA.

GUY, P. R. 1989. The influence of elephants and fire on a *Brachystegia* spp. and *Julbernardia* spp. woodland in Zimbabwe. Journal of Tropical Ecology 5:215–226.

HUNT, C. L. 1985. Descriptions of five promising deterrent and repellent products for use with bears. U.S. Fish and Wildlife Service Report 3. Grizzly Bear Recovery Coordinator, Missoula, Montana, USA.

MASON, J. R., N. J. BEAN, P. S. SHAH, AND L. CLARK. 1991. Taxon-specific differences in responsiveness to capsaicin and several analogues correlates between chemical structure and behavioral aversiveness. Journal of Chemical Ecology 17:2539–2552.

OSBORN, F. V. 1998. The ecology of crop-raiding elephants in Zimbabwe. Dissertation, University of Cambridge, Cambridge, United Kingdom.

———, AND L. E. L. RASMUSSEN. 1995. Evidence for the effectiveness of an oleo-resin capsicum against wild elephants in Zimbabwe. Pachyderm 20:15–22.

———, AND L. A. WELFORD. 1997. Living with elephants: a manual for wildlife managers in the SADC region. USAID/SADC TCU Publication 5. U.S. Agency for International Development, Lilongwe, Malawi.

RASMUSSEN, L. E. L. 1994. Sensory and communication systems. Pages 207–217 *in* S. K. Mikota, E. L. Sargent, and G. S. Ranglack, editors. Medical management of the elephant. Indira Publishing House, West Bloomfield, Michigan, USA.

TAYLOR, R. D. 1999. A review of problem elephant policies and management options in southern Africa. Human–Elephant Conflict Task Force, International Union for the Conservation of Nature and Natural Resources, Nairobi, Kenya.

Received 10 February 2000.
Accepted 29 January 2002.
Associate Editor: Clark.