Indian Journal of Entomology 85(1): 6-10 (2023) DoI. No.: 10.55446/IJE.2022.525

EVALUATION OF AN ODOUR DETERRENT TO BLUE BULL *BOSELAPHUS TRAGOCAMELUS* AND MONKEY *RHESUS MACAQUE* FROM AGRICULTURAL FIELDS

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ABSTRACT

An experiment was conducted to evaluate two deterrents to deter blue bull *Boselaphus tragocamelus* and monkey *Rhesus macaque* from crop fields through randomized block design experimental trials in different parts of Nepal from July 2019 to May 2021. The odour deterrent tri methyl amine @15ml/ 700 m² and microbial fermented fish solution @4ml/ l were evaluated among 150 plots each with 50 replications including control. Significant results were obtained where >90% farmers responded that tri methyl amine repelled blue bull and monkey for >14 days. This might be due to its strong ammonia like fishy odour which was unpleasant to these animals and might had been found irritant and offensive. Similarly, many farmers replied that the microbial fermented fish solution also protected their crops from blue bull for ≥ 30 days.

Key words: Blue bull, *Boselaphus tragocamelus*, monkey, *Rhesus macaque*, wild boar, *Sus scrofa*, human-wildlife conflict, tri methylamine, odour deterrent, fermented fish

Nepalese farmers are severely afflicted with wild animals and the conflicts between them have been increased in recent days (Joshi et al., 2020; Paudel and Shrestha, 2018; Khanal et al., 2018; Thapa, 2016). The animal pests cause crop loss of million dollars each year and the damage may vary from 10-60% (Joshi et al., 2020; Pandey and Bajracharya, 2015). The extent of damage depends upon the cropping patterns, crop type, crop stage and cropping season (Schley et al., 2008; Cai et al., 2008). Because the protection of fields will remain essential in the future, thus it is important to address wildlife and human conflicts with appropriate techniques (Manral et al., 2016). Blue bull (*Boselaphus tragocamelus*) is a devastating pest of agriculture, mostly found in plain parts of southern Nepal (Koirala et al., 2020; Khanal et al., 2018; Thapa, 2016). They destroyed 14.48% and 10.38% of standing vegetables and pulses accounting $68,633 in Rupendehi district from March 2015 to March 2016 (Khanal et al., 2017). Blue bull could cause >50% crop damage in India (Meena et al., 2014). Physical barriers such as electric fences have been found promising, but their widespread uses are limited due to costs of construction, maintenance and no government subsidy (Hayward and Kerley, 2009; Pérez and Pacheco, 2006; Thapa, 2010).

Monkey is also a serious crop raider for hills and agricultural farms residing near the forests in plain parts of Nepal (Poudel and Shrestha, 2018; Sharma and Acharya, 2017). The annual crop damage by monkey was 183.46 kg ($75.10)/ household in Jaidi Baglung (Poudel and Shrestha, 2018) and >$267 economic loss was reported in Tallakodi Pokhara where maize (31%) was most raided crop followed by potato (30%) in 2015 (Sharma and Acharya, 2017). Similar to Nepal, the average economic loss was Rs.150 crore/ annum in Himachal state, India (Reddy and Chander, 2016) and 10-20% of total household income was lost each year in Rwanda near forest fragment area (Guinness and Taylor, 2014). Successful crop protection measures have not been identified yet except active guarding with domesticated dogs, beating with sticks and throwing stones over monkey (Bhatta and Joshi, 2020; Gehring, 2010; Uddin and Ashan, 2018).

Farmers use several strategies to protect their crops from devastating wild animals worldwide but none of them had provided complete protection because of varied nature of the animals and the taxa involved (Kolowski and Holekamp, 2006). Protective measures like modification in cropping patterns, cultivation of medicinal and ornamental plants are suggested to mitigate crop raiding (Manral et al., 2016; Guinness and Taylor, 2014). But they could cause significant reductions in food crops produced, thereby potentially increase food insecurity (Akankwasah, 2010; Vedeld et al., 2012). Blue bull, monkey and wild boar have widely developed olfactory organs. They use olfactation for orientation, foraging, intra specific social interactions and for avoidance of natural enemies (Schlageter and

Wackernagel, 2012). This background information reveals the fact that odour deterrent might be a promising means of deterring wild animal pests from agricultural fields. Thus, it was hypothesized that odour deterrent work against wild animal pests. In the present study, the efficacy of an odour deterrent chemical tri methyl amine (TMA) was investigated to deter free ranging blue bull, monkey, and wild boars from the crop fields.

MATERIALS AND METHODS

The experiment was conducted in randomized complete block design. Two treatments tri methyl amine (TMA) (Sun et al., 2018) and microbial fermented fish (MFF) solution were tested in 150 plots each with 50 replications in 2019-20 and 36 plots with 12 replications including control in 2020-21. A single farmer's field of ideal size 700 m^2 was considered as a plot and each plot worked as a replication. The control plots were selected where no deterrents placed and were >500 m far from the experimental plots. The study area consisted four districts of Nepal; Kathmandu (27.7172°N, 85.3240° E), Sindhupalchok (27.9512°N,85.6846°E), Sarlahi (26.9627° N, 85.5612°E) and Sunsari (26.6276°N, 87.1822° E). The study sites were chosen based on earlier complains by the farmers where blue bull, and monkey had high interference. The crops used were cabbage, cauliflower, potato, sweet potato, wheat, coriander, onion, chilli, brinjal, maize, pea, sugarcane, mustard, pigeon pea and okra.

A small bottle of size 60-100 ml was taken and about 12-15 ml TMA poured in it, and the cover of both bottles were made tight to prevent the spread of smells. The small bottle was placed in the center of the experimental field and a hole (0.1-0.2 mm dia) on the cover of the bottle was made to spread the odour slowly. The MFF was sprayed @4ml/liter of water. Four doses 5, 10, 15, and 20ml of TMA and four doses 3, 4, 5, and 6 ml of MFF solution were considered and distributed to farmers. Based on their perceptions, the dose was determined. There were no restrictions for the entry of wild animals in the experimental fields. Microbial fermented fish solution was prepared from helicopter catfish (*Wallago attu*) which was chosen because of its easy availability and fast degradability. About 1 kg fish was weighted and cut into pieces which were placed in a plastic bucket where 2 l of tap water and 200 ml of decomposer was also poured and mixed well. The container was covered and left for 70-80 days to ferment at room temperature (15-20^{o}C). When the fishes partially decomposed and started to emit odour at high level, it was sieved through cotton clothes in which 3 gm/ l fine chili powder was mixed, and again sieved and used as biorepellent. The decomposer used to enhance fish fermentation was claimed to contain natural microorganisms with trade name: EM-1 (Effective Microrganism-1), Balaju, Kathmandu, Nepal. The selected farmers were interviewed to know the status of wild pests in their farms before and after using the deterrents. Similarly, the estimation of damage of crops before and after using the deterrents were also reported and the collected data were subjected to construct ANOVA to know the level of significance for different variables through MSTAT software program. The number of wild pests visited in the experimental plots was considered as independent variables whereas the damages of crops were taken as dependent variables.

RESULTS AND DISCUSSION

The deterrent effects of tri methylamine and microbial fermented fish solution to deter blue bull and monkey from the crop fields were found highly significant compared with control (Table 1). The average crop damage before using TMA was 44% and it decreased to 3.6% with the use of deterrent. Similarly, crop damaged before using MFF was 34.9% and it reduced to 8.4% after spray. But the controlled trial crops were damaged maximum in 2019-20. In the same way, the crop damage before use of TMA and MFF solution were 35 and 38.75%, respectively and crop damaged after using the deterrents were 0 and 5%, respectively in 2020-21. The fields might be protected due to strong ammonia like fishy odour of TMA which was unpleasant to the blue bulls, and monkeys. The odour might had been found irritant and offensive and could had lost their orientation ability during field visit. But in control trials, blue bull ravages the fields with frequent trampling of crops causing severe loss. The techniques of using odour deterrents have been practiced since long time. Farmers use insecticides like phorate, phenyl solution, and thimet as deterrents which has strong fouling smell and could control blue bulls for a couple of days (Meena et al., 2014; Sitati and Walpole, 2006). Indigenous methods like use of audio/video shining tapes, scarecrows, beating of bells, live fencing, use of animal excreta, and fire crackers have been practiced widely but they do not work as expected (Bhatta and Joshi, 2020; Ansari, 2017). Similarly, etorphine hydrochloride, xylazine hydrochloride combined with ketamine is also used as chemical capture for blue bull (Tripathi and Rao, 2016).

TMA is a sensory pain causing deterrent which

Table 1. Effects of deterrents tri methyl amine and microbial fermented fish solution over animal pests- blue bull, monkey, and wild boar (2019-20, 2020-21)

SN	Treatments/ year	Animal pests in the field before using deterrents		Animal pests in the field after using deterrent		Farmer's crop damage before using deterrent (%)		Farmers crop damage after using deterrent (%)	
		2019/20	2020/21	2019/20	2020/21	2019/20	2020/21	2019/20	2020/21
1	Tri-methyl amine	5	3	0	0	44.00	35.00	3.60	0
2	Microbial fermented fish	6	4	0	1	34.90	38.75	8.40	5
3	Control	5	4	5	5	43.10	34.58	34.60	55
Grand mean		5	3.78	2	1.889	40.66	36.11	15.53	20.13
Coefficient of variation (%)		45.46	40.15	93.46	89.19	47.33	41.98	123.49	41.88
Least significant difference at σ 0.05		0.98	1.25	0.65	1.39	7.63	12.57	7.61	6.99
p value		0.0135*	0.0433	0.0000*	0	0.0376*		0.0000*	0

*indicates significance; animal pests expressed in whole numbers by minimizing to decimals; crop damages expressed in %

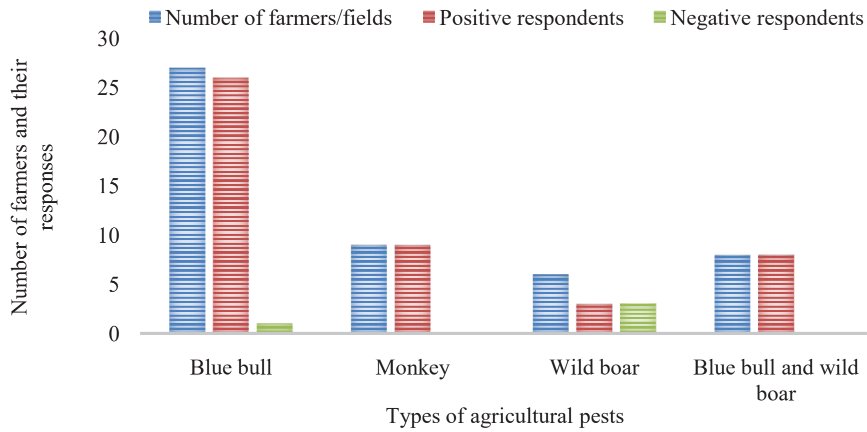

Fig. 1. Responses of farmers who used tri methyl amine. Positive respondents= wild animals leave the fields without damaging crops; negative respondents= wild animals damage crops (2019-20)

was found effective for blue bull and monkey but did not show adequate efficacy over wild boar. Farmers reported that wild boars did not respond exactly and continued to trample the fields where deterrents were placed. It meant one type of odour deterrent might not be effective for another type of wild species (Kolowski and Holekamp, 2006; Pandey and Bajracharya, 2015). Hence, still extensive trials are needed to confirm the results. An odour repellent "Wildschwein-Stopp" extensively tested to repel wild boars from the field was found ineffective (Schlageter and Wackernagel, 2012); but low dose warfarin baits proved effective to control pig problems (Poche et al., 2018). Farmers who used the odour deterrent for >two times at two weeks interval found that the blue bulls and monkeys got deterred for longer durations. Castor oil, egg solution, predator odours are also used for repelling blue bulls and monkeys but they are effective for shorter durations (Ansari, 2017; Meena et al., 2014; Tripathi and Rao, 2016; Parker and Osborn, 2006; Schlageter and Haag Wackernagel, 2011). Similarly, gonadotropin baits are seldom used for controlling monkeys (Tripathi and Rao, 2016). The deterrents causing pain are considered more effective than those causing fear or sickness, and thus chemical deterrents are widely used to protect a variety of crop species from wildlife damages (Schlageter and Wackernagel, 2012; Mason, 1997). Other methods based on acoustic, gustatory, and optic deterrence have not yielded satisfactory long-term results (Agyeman and Baidoo, 2019; Schlageter and Wackernagel, 2011; Sitati and Walpole, 2006).

Blue bulls did not damage the crops where MFF sprayed. Crops were safe and protected for about >30 days. The MFF solution had significant effects to deter blue bulls from the crop fields. MFF was also found equally effective to repel bulls and oxen. Since the MFF had strong fishy odour, it was disliked by herbivorous animals (Aryal et al., 2016; Meena et al., 2014). The effect of this biodeterrent was reported to be >5 weeks. Mixed responses about the effective durations of odour deterrent were obtained from the farmers who used TMA to deter blue bulls. The effective duration of odour deterrent varied but the duration was almost similar for monkey (Fig. 1). About 15ml TMA was found appropriate for ≥700 m^2 area to deter blue bulls and monkeys for ≥12-14 days. The increase in amount of TMA indicated the voluminous spread of odour to the fields which was highly irritants to blue bull and monkey and reduced the chance of damage of crops and vegetables. Similarly, 4 ml MFF/ l of water was found more effective to repel blue bull for ≥30 days. Several other factors also determine the effectiveness of odour deterrent such as the target species, functionality of deterrent, time of placement, type of crop, and season etc. (Pandey and Bajracharya, 2015; Schlageter and Wackernagel, 2012). Tri methylamine is a sensory pain-causing chemical which was found highly effective to deter the wild animals during the experimentation. Therefore, this chemical compound can be used as a deterrent to avoid blue bull and monkey from the farmer's fields.

ACKNOWLEDGEMENTS

Author thanks farmers for permitting their fields to conduct the trials, and National Plant Breeding and Genetics Research Center and Nepal Agricultural Research Council, Khumaltar, Lalitpur, Nepal

FINANCIAL SUPPORT

No external funding was received for this work.

CONFLICT OF INTEREST

The author declares no conflicts of interest.

REFERENCES

Agyeman Y B, Baidoo S. 2019. Farmer's perception of the effectiveness of strategies for managing wildlife crop depredation in Ghana. International Journal of Biodiversity and Conservation 11(6): 165-174.

Akankwasah B. 2010. The effect of crop raiding on household food security in the Albertine Rift: A case study of Queen Elizabeth National Park, western Uganda. Human Dimensions of Wildlife 15(1): 45-54.

Ansari N A. 2017. Status of mammals with special reference to population estimation of Nilgai (*Boselaphus tragocamelus*) and suggest mitigation measures to prevent crop damage in and around Surajpur reserve forest, Uttar Pradesh, India. Journal of Entomology and Zoology Studies 5(4): 1085-1091.

Aryal M, Panthi S, Bhatta M, Magrati T P, Shrestha A K, Shrestha P B, Karki A. 2016. Population status, distribution and potential threats of the blue bull *Boselaphus tragocamelus* (Mammalia: Cetartiodactyla: Bovidae) along the Tinau river of Rupendehi district Nepal. Journal of Threatened Taxa 8(14): 9638-9642.

Bhatta M, Joshi R. 2020. Analysis of human wildlife conflict in buffer zone area: A case study of Sukhlaphanta National Park, Nepal. Grassroots Journal of Natural Resources 3(3): 28-45.

Cai J, Jiang Z G, Zeng Y, Li C W, Bravery B D. 2008. Factors affecting crop damage by wild boar and methods of mitigation in a giant panda reserve. European Journal of Wildlife Research 54: 723-728.

Gehring T M, VerCauteren K C, Landrey J C. 2010. Livestock protection dogs in the 21st century is an ancient tool relevant to modern conservation challenges. Bio Science 60: 715-721.

Guinness S Mc, Taylor D. 2014. Farmer's perceptions and actions to decrease crop raiding by forest-dwelling primates around a Rwandan forest fragment, Human Dimensions of Wildlife 19(2): 179-190.

Hayward M W, Kerley G I H. 2009. Fencing for conservation: restriction of evolutionary potential or a riposte to threatening processes. Biological Conservation 142: 1-13.

Joshi G, Neupane B, Dahal D, Shrestha S, Dhakal P, Jandug C M B, Gautam D. 2020. Assessment of human wildlife conflict in Kailali district of Nepal. Journal of Animal Diversity 2(3): 24-36.

Khanal S, Aryal A, Morley C G, Wright W, Singh N B. 2018. Challenges of conserving blue bull (*Boselaphus tragocamelus*) outside the protected areas of Nepal. Proceedings of the Zoological Society 71: 352-362.

Koirala P, Neupane B, Silwal T, Dhami B, Regmi S, Dahal D. 2020. Distribution of blue bull (*Boselaphus tragocamelus*) and its conservation threats in Bardia National Park, Nepal. Journal of Forest and Natural Resource Management 2(1): 50-60.

Kolowski J M, Holekamp K E. 2006. Spatial, temporal and physical characteristics of livestock depredations by large carnivores along a Kenyan border reserve. Biological Conservation 128: 529-541.

Manral U, Sengupta S, Hussain S A, Rana S, Badola R. 2016. Human wildlife conflict in India: A review of economic implication of loss and preventive measures. Indian Forester 142(10): 928-940.

Mason J R. 1997. Repellents. In: Wagner K K, Nolte DL (eds) Wildlife damage management for natural resource managers. Western Forestry and Conservation Association, Olympia, pp. 11-16.

Meena R P, Meena B L, Nandal U, Meena C L. 2014. Indigenous methods developed by farmers to curb the menace of blue bull (*Boselaphus tragocamelus*) in district Rajsamand, Rajasthan, India. Indian Journal of Traditional Knowledge 13(1): 208-215.

Pandey S, Bajracharya S B. 2015. Crop Protection and its effectiveness against wildlife: A case study of two villages of Shivapuri National Park, Nepal. Nepal Journal of Science and Technology 16(1): 1-10.

Parker G E, Osborn F V. 2006. Investigating the potential for chili (Capsicum species) to reduce human-wildlife conflict in Zimbabwe. Oryx 40: 343-346.

Perez E, Pacheco L F. 2006. Damage by large mammals to subsistence crops within a protected area in a montane forest of Bolivia. Crop Protection 25: 933-939.

Poche R M, Poche D, Franckowiak G, Somers D J, Briley L N, Tseveenjav B, 2018. Field evaluation of low dose warfarin baits to control wild pigs (*Sus scrofa*) in North Texas. PLoS ONE 13(11): e0206070. DOI: https://doi.org/10.1371/journal.pone.0206070

Poudel G, Shrestha T K. 2018. Crop depredation by monkey outside protected area in Nepal; Cost, condition and perceptions. The Indian Forester 144(10): 929-935.

Reddy A R M, Chander J. 2016. Human monkey conflict in India: some available solution for conflict mitigation with special reference to Himachal Pradesh. Indian Forester 142(10): 941-832.

Schlageter A, Wackernagel D H. 2011. Effectiveness of solar blinkers as a means of crop protection from wild boar damage. Crop Protection 30: 1216-1222.

Schlageter A, Wackernagel D H. 2012. Evaluation of an odour repellent for protecting crops from wild boar damage. Journal of Pest Science 85(2): 1-7.

Schley L, Dufrene M, Krier A, Frantz A C. 2008. Patterns of crop damage by wild boar (*Sus scrofa*) in Luxembourg over a 10-year period. European Journal of Wildlife Research 54: 589-599.

Sharma S, Acharya S. 2017. Human-*Rhesus macaque* conflict at Pumdivumdi Tallokodi, Pokhara, West Nepal. Banko Janakari 27(2): 46-50.

Sitati N W, Walpole M J. 2006. Assessing farm-based measures for mitigating humane elephant conflict in Transmara District, Kenya. Oryx 40: 279-286.

Sun J, Mausz M A, Chen Y, Giovannoni S J. 2018. Microbial trimethylamine metabolism in marine environments. Environmental Microbiology 21(2): 513-520.

Thapa K. 2016. Park-People interaction and public perceptions towards Parsa Wildlife Reserve, Nepal. Journal of Forest and Livelihood 14(1): 41-52.

Thapa S. 2010. Effectiveness of crop protection methods against wildlife damage: A case study of two villages at Bardia National Park, Nepal. Crop Protection 29: 1297-1304.

Tripathi R S, Rao V. 2016. Vertebrate pest management in agriculture. In: Agrawal P K, Verghese A, Radhakrishna S, Subaharan K (ed.) Human animal conflict in agropastoral context: Issues and policies. Indian Council of Agricultural Research, New Delhi.

Uddin M M, Ahsan M F. 2018. Do Rhesus monkeys (*Macaca mulatta*) damage the unpalatable crops during conflict with human? A case study from Rampur village of Narsingdi District in Bangladesh. Journal of Wildlife and Biodiversity 2(2): 1-5.

Vedeld P, Jumane A, Wapalila G, Songorwa A. 2012. Protected areas, poverty, and conflicts: A livelihood case study of Mikumi National Park, Tanzania. Forest Policy and Economics 21: 20-31.

(Manuscript Received: December, 2021; Revised: April, 2022;
Accepted: April, 2022; Online Published: May, 2022)
Online First in www.entosocindia.org and indianentomology.org Ref. No. e21265