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# Effectiveness of LED lights on bomas in protecting livestock from predation in southern Kenya

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## SUMMARY

Various interventions have been employed to mitigate livestock predation by lions and other carnivores. Livestock owners have typically employed lethal and/or non-lethal measures with varied successes and failures. Resolving the human-carnivore conflict is key to the survival of carnivores and ensuring local livelihoods and safety. Here we assess the effectiveness of placing LED lighting systems at bomas (livestock enclosures) in order to deter predator attacks at night in two group ranches surrounding Amboseli National Park, southern Kenya. Both the number of predatory attacks and the number of livestock killed were significantly lower after the LED lighting system was installed, compared to the period before the LED system was installed for the same boma, or compared to control bomas without LEDs. LED lights reduced the number of attacks on livestock in bomas by almost threefold, and reduced the number of livestock killed by over four times compared to the levels recorded before the LED lights were installed. The results provide clear evidence that the LED system, as installed at bomas in the study regions, was an effective means of reducing night-time predation on livestock, at least in the short term (six months) during which effectiveness was monitored.

## BACKGROUND

Human-wildlife conflict is a growing issue worldwide, that negatively impacts human lives, livestock and wildlife. In East Africa, human-carnivore conflicts are among the most serious threats to lion *Panthera leo* populations (IUCN 2006). Conflicts mainly arise from attacks on livestock and perceived threats to human lives, resulting in retaliatory killings of carnivores such as lions (Frank *et al.* 2005). Predation may cause up to 20% per capita income loss, compromising the livelihoods of local pastoral communities (Holmern *et al.* 2007). For instance, in Serengeti, pastoralists reported an annual loss of a fifth of their annual income from livestock to predation (Wang & Macdonald 2006). In South Africa, losses resulting from livestock predation were approximately 22 million USD annually (Statistics South Africa 2010).

Livestock predation may prompt either retaliatory killings or deterrent and preclusive measures (Ray *et al.* 2005). More often, livestock owners have employed cheap but deadly lethal control methods like poisoning, spearing, trapping and snaring to reduce livestock predation (Mitchell *et al.* 2004, Treves & Naughton-Treves 2005). Measures such as poisoning are highly indiscriminate, and can have impacts across the whole ecosystem through secondary poisoning. Moreover, predators may learn with time to avoid traps and snares (Knowlton *et al.* 1999, Bamford *et al.* 2007). In the long run, lethal predator control measures become expensive and have often been found to be ineffective in mitigating losses from predation (Mitchell *et al.* 2004).

In general, human-wildlife conflict mitigation measures should be cost-effective, and minimize impacts on wildlife, livestock and local livelihoods (Marker *et al.* 2010). A recent review study assessed the effectiveness of different interventions applied worldwide to reduce the conflict between humans and large carnivores (Eklund *et al.* 2017). This comprehensive review found mixed evidence for the effectiveness of interventions. Some were found to effectively reduce depredation by large carnivores, but several interventions were ineffective (Kolowski & Holekamp 2006). Interestingly, the same study reported that experimental and quasi-experimental studies on this topic are very rare in the literature (Miller 2016, Treves *et al.* 2016). This finding highlights the need to produce more robust evidence, based on solid study designs on the effectiveness of interventions aimed at mitigating human-carnivore conflict.

Therefore, this study aims to assess the effectiveness of a LED lighting system applied to livestock enclosures (hereafter referred to as bomas) in two group ranches adjacent to Amboseli National Park, southern Kenya. This study monitored predation at bomas before and after the LED systems were installed, and at control bomas without LEDs only during the six months after LED installation at the treatment bomas. The effectiveness of the LED system was measured by comparing the number of attacks and the number of livestock killed at each boma.

## ACTION

**Installing the LED lighting system**: The experiment was carried out at two study ranches, Olgulului-Ololorashi and Kimana, which are among the six group ranches surrounding the Amboseli National Park. The park lies within the Amboseli ecosystem, southern Kenya, at the foot of Mt. Kilimanjaro covering an area of 392 km$^2$. The ranches occur in arid and semi-arid lands. Rainfall is distinctly bi-modal and annual rainfall has a mean of 430 mm and varies between 132 and 553 mm/yr. The temperature fluctuates between 14 ºC and 30 ºC. The plant communities of the ranches are mainly bushland, open grassland and some woodland. The Amboseli ecosystem

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**Figure 1.** Installing LED lights at a boma: (a) fixing bulbs to a pole, (b) fixing a boma with connecting wires

supports a variety of wildlife, including a large diversity of resident ungulates, and a large population of lions. Other dominant predators are spotted hyenas *Crocuta crocuta*, leopards *Panthera pardus* and cheetahs *Acinonyx jubatus*. Because of recent volcanic activity, the top soils in the Amboseli Ecosystem are shallow and unproductive. The land is therefore suited for wildlife conservation, tourism and pastoralism. The current land tenure has led to conflicting use between pastoralism, agriculture and wildlife conservation.

To install the LED systems, we randomly selected 20 bomas within each of the two study ranches (Olgulului-Ololorashi and Kimana), totalling 40 bomas. In each ranch, ten bomas were randomly selected for the installation of an LED lighting system, and ten were kept as controls. All bomas were used as protective enclosures for cattle and already had lion-proof fences, which, however, do not guarantee full protection against lion attacks at night.

One watt wire system LED bulbs were strategically placed on poles approximately 10 m apart around the boma facing outwards. The bulbs were connected to one another and to the main power source (battery) which was powered by a solar panel through the study period (December 2013 to May 2014). This enhanced flickering of the lighting system at night, which illuminated the immediate surroundings of the boma (Figure 2). During the day, the lighting system was disconnected from the battery to allow the solar panel to charge the battery. To maximise the flickering of the LED system at night a maximum of fourteen bulb stems were used for each solar powered battery. In cases where the cattle boma was very large, more than one LED system was installed i.e. two batteries and two solar panels (Figure 1). Throughout the installation process, the cattle owner was instructed in detail how to operate the lighting system (i.e. how to connect and disconnect the lighting systems to allow the battery to recharge during daytime).

To quantify predation frequency, we collected information on the number of attacks and the number of livestock killed at each study boma. These data were gathered by questioning the user of the boma, and were collected for the period of six months before and six months after the installation of the LED system for the bomas where the system was installed. For control bomas, data were collected for the six month period post-installation only.

**Data analysis:** We used generalized linear mixed models with Poisson distribution and log link function (package lme4 in R version 3.0.3) to quantify the effect of LED lighting systems on the number of attacks and the number of livestock killed at bomas. We built two models with similar structure (see below), with response variables being the number of attacks per six months or the number of livestock killed per six months. Each of the two models included as predictor variables *treatment* (here intended in a broad term, including three categories, treatment boma before LED lighting system installation, treatment boma after LED lighting system installation, control boma; hereafter named "LED before", "LED after", "control") and *site* (with two categories: Kimana or Olgulului). Because the same boma where LED lights were installed was considered twice in the analyses (predation recorded for the period before and after led installation), we included boma identity as a random term in each model.

We started by testing the significance of the interaction between treatment and site, in order to quantify whether the effect of LED lights on predation (in terms of number of attacks and number of lost livestock) varied between the two sites. If this interaction was not significant, it was dropped from the model, which then included only two main effects predictors, namely site and treatment (in addition to the random term). We quantified the statistical difference between each pair combination of the three classes of the treatment variable (namely LED before, LED after, control) by running *post-hoc* tests with Tukey adjustment for multiple comparisons (package *multicomp* in R). Next, we derived the least square mean of the response variable (i.e. the predicted mean and standard error of number of attacks or livestock lost) for each of the three classes of the treatment variable (package *lsmeans* in R).

**Figure 2**. Flickering LED lighting system on a boma at night.



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## CONSEQUENCES

**Effectiveness of the LED lighting system:** We found that the use of LED lights as a predator deterrent reduced the number of attacks and livestock killed over a period of six months after installation at the 10 bomas in each of the two sites studied (Figure 3). Both number of attacks on livestock ($\chi^2$ = 131.8, d.f. = 2, p < 0.001) and number of livestock killed ($\chi^2$ = 227.0, d.f. = 2, p < 0.001) differed significantly between bomas with LED lights installed and either control bomas, or bomas before LED lights were installed. Specifically, both the number of predatory attacks and number of livestock killed were significantly lower after the LED lighting systems were installed in the homesteads compared to the period before the LED system was installed for the same boma or compared to the control group (Figure 3). The number of attacks per boma in a six month period was reduced from approximately 2.5 in bomas without LED systems to less than one in bomas with the LED system. Similarly, the number of livestock killed per boma over a six month period fell from over 2.5 animals killed in bomas without LED systems to 0.6 at bomas with LED systems (Figure 3). The impact of LED lighting systems in reducing the number of attacks and livestock killed was similar at both sites, as indicated by the non-significant interaction between treatment and site in both models (statistics for the interaction in the attack model: $\chi^2$ = 1.95, d.f. = 2, p = 0.38; and in the number of livestock killed model: $\chi^2$ = 4.45, d.f. = 2, p = 0.11). The overall number of attacks (z = 1.68, p = 0.09) and number of livestock killed (z = 1.31, p = 0.19) were similar at both sites.

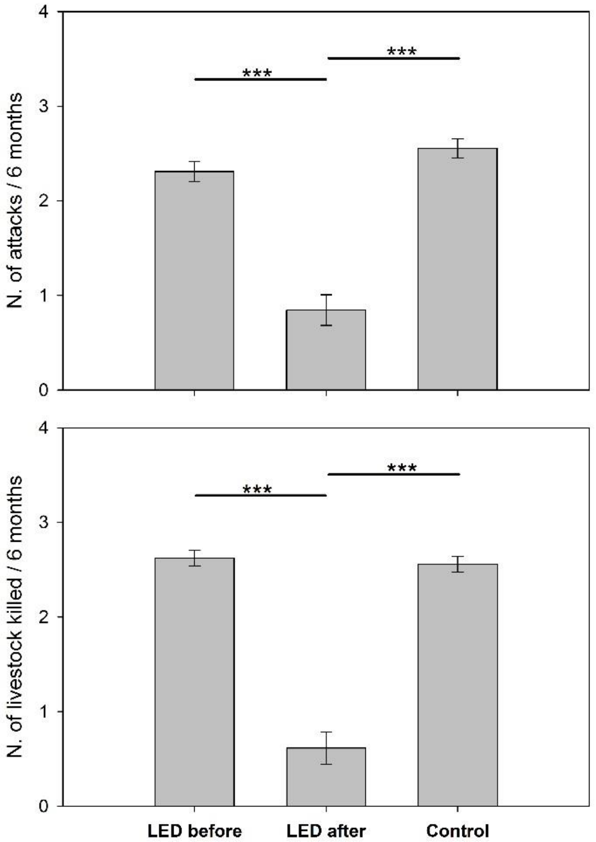


**Figure 3**. Least square mean (with S.E.) of number of attacks (top) and number of livestock killed (bottom) at bomas which were part of the LED lighting system treatment for the period before (LED before) and after (LED after) the LED lighting system installation at the boma (n = 20), and at control bomas (n = 20) in the same sites. The horizontal lines with the three stars above them join classes that were significantly different (p < 0.001) from each other after *post-hoc* testing with Tukey method adjustment. The values reported refer to incidences recorded over a period of six months.

## DISCUSSION

Bomas installed with LED lights had significantly lower numbers of both predatory attacks and livestock killed compared to the period before the LED system was installed for the same boma or compared to the control group. LED lights reduced attacks to livestock in bomas by almost three fold, and reduced the number of livestock killed by over four times from the levels recorded before the LED lights were installed. This is a clear indication that the LED system was effective in reducing livestock predation by carnivores, at least for the period in which predation was monitored (i.e. during the six months following the LED system installation).

Despite the fact that the LED system successfully reduced depredation and predator attacks, livestock killings still occurred in bomas installed with the LED system. It is possible that some of the attacks recorded when the LED system was installed may have been due to interruptions in supply either due to technical problems or alternative use of the electricity system. Overall the results of this study have indicated that the LED system was effective in reducing livestock predation at bomas in addition to conventional 'lion-proof' fencing. To maximise effectiveness it is essential that the system is used and maintained to ensure uninterrupted electricity supply to the LEDs.

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