Hawk-kite as a scaring method for avian pests in Kenyan rice fields

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Abstract

The human population is increasing globally, and so are the human-wildlife interactions and conservation conflicts. One source of conservation conflict is the crop damage caused by wildlife. Crop damage is negatively affecting farmers, but also the wildlife due to lethal methods used to reduce the damage. In Kenya, birds are a great threat to the rice production and chemical spraying is used to reduce the damage. To decrease the use of chemicals, other less harmful methods, such as scaring, are needed. In this study, the efficiency of a scaring kite, mimicking a bird of prey (hawk-kite), was tested in south-central Kenya. Rice was used as a bait and the number of birds visiting bait stations at sites with and without hawk-kites were compared. Also, to get a better understanding of the current situation and the challenges with damaging birds, farmers producing rice were interviewed.

The hawk-kite almost halved the number of birds visiting the bait stations. Also, the birds did not seem to habituate to the kites, at least not over a 4-day period. Moreover, the interview confirmed that grain-eating birds is the major threat to the rice production and that many farmers are positive to the chemical sprays due to lack of better options. However, it seems like the hawk-kite has potential to be used as a scaring method in rice fields in Kenya, but the efficiency is likely dependent on the kite-type, weather conditions, bird species and food availability. Moreover, when scaring birds for periods longer than four days, habituation may still be a challenge. Since the hawk-kite was found to decrease the number of birds in bait stations, they could provide a better alternative to the chemical sprays in the rice fields, which in turn would lead to more sustainable food production for the increasing human population.

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1. Introduction

The human population is constantly increasing and so is the demand of land and food production (Godfray et al., 2010; World Bank Group, 2023b). This in turn leads to fragmentation and reduction of natural habitats (Ghimire & Barraclough, 2013) and consequently, an increase in human-wildlife interactions as well as crop damage and conservation conflicts (Hemminger et al., 2022; König et al., 2020; Montràs-Janer et al., 2019; Redpath et al., 2013). Crop damage caused by wildlife is a worldwide challenge and causes economical losses for farmers (Messmer, 2000; Mukeka et al., 2019; Nyhus, 2016). The losses are not only direct (reduced harvest), but also indirect in the form of lost opportunities due to changes done by farmers in order to reduce the damage (e.g. change to less damage prone crops that provides less yield) (Kega et al., 2015) Additionally there is a cost of damage-control agents needed (Chambers et al., 2010). Furthermore, it seems like specialist species are more sensitive to the intensification of the agricultural landscape, while some generalist species adapts to human-made landscape and even benefit from it (Hemminger et al., 2022). This might result in increased crop damage caused by the thriving species but also negative effects on more vulnerable species due to competition and other interactions (Hemminger et al., 2022; Muñoz-Sáez et al., 2020). It is of importance to improve the food production to the increasing human population (Godfray et al., 2010), but at the same time this must be done in a way that allows coexistence with the wildlife (Carter & Linnell, 2016). For instance, the methods for reducing crop damage should aim to cause as little harm to the wildlife as possible.

Both lethal and non-lethal methods are used to reduce crop damages caused by wildlife. For example, hunting and culling are used to control wildlife population size (Boyce, 1991; Ueno et al., 2010). These methods are most effective on a large scale basis (de Mey & Demont, 2013), since if performed over a small area other individuals may quickly recolonise the area (Conover, 2001). In addition, culling does not only have a lethal-, but also a scaring effect which Månsson (2017) found to be the case for greylag goose (*Anser anser).* Some other methods for lethal control are trapping and use of poisoning (e.g. lethal spraying of birds during night roost) (Mullié et al., 1999). However, using lethal control may be a threat to small populations and especially the latter method which might have negative effects on nontarget species (Mullié et al., 1999). In other words, lethal methods are seldom good options when striving for a coexistence with the wildlife.

In contrast to lethal control, scaring is a less harmful strategy to reduce crop damage. According to the optimal foraging theory, animals will approach a foraging strategy to gain the highest nutrition benefit (Krebs et al., 1974; Pyke, 1984). However, they also need to avoid predation and if an area seems too risky to visit, they might avoid feeding there even if the food availability is high (Gallagher et al., 2017). The fear can be triggered by different auditory, odour or visual cues. A disadvantage with fear provoking stimuli is the habituation to the scaring methods (Koehler et al., 1990). Due to this, scaring devices are most suitable to use during shorter periods of time, for example when the crop is extra vulnerable (Conover, 2001; Koehler et al., 1990). Moreover, there are factors that can delay the habituation. For instance, if the scaring device is imitating the animal's real predator it will be hard for the animals to differentiate it from the actual danger (Conover, 2001). Also, if a visual scaring device is in constant movement, it will look more realistic and thereby prolong the scaring effect (Conover, 2001). Hence, these factors are beneficial to be taken into consideration when designing and using scaring devices.

One scaring device that both mimic a natural predator and moves is a kite in the shape of a bird of prey (hereafter hawk-kite). The hawk-kites are designed to scare birds and according to Conover (2001), birds mostly depend on vision when avoiding predators. In a study by Conover (1984), it was found that hawk-kites (attached to a helium balloon to make it fly even with no wind) were more efficient to reduce crop damage (caused by blackbirds in cornfields) than both the usage of the chemical Avitrol FC and propane exploders. The hawk-kites were also relatively cost efficient compared to the chemicals. Other studies have also seen a scaring effect of different types of kites (Haque & Broom, 1985; Nakamura, 1997) and these findings are good reasons for evaluating the efficiency of hawk-kites in agricultural land where pesticides are often used.

Thanks to an exchange program between Swedish University of Agricultural Science and University of Embu in Kenya, financed by the Linnaeus-Palme programme, this study was conducted in Kenya. Kenya is a country facing similar problems as other parts of the world with a continually increasing human population (about sevenfold population size in 2021 compared to 1960 (World Bank Group, 2023a)) and there is therefore a need of expanding the food production. Rice is the country's third most important cereal after maize and wheat (Mati, 2010), but according to Oerke (2006) 15% of the rice worldwide is lost due to animal pests. In Kenya, grain-eating birds, such red-billed quelea *(Quelea quelea)* and Village weaver (*Ploceus cucullatus)* are some of the main pests causing great losses to the rice production (Cheke & Sidatt, 2019; Muhunyu, 2012). To prevent damage to the rice, the Kenyan Ministry of Agriculture perform large-scale eradications by night roost sprays with fenthion, a nerve agent that is poisonous to the birds but also to other non-target species and humans (Cheke & Sidatt, 2019; Kega et al., 2015; Odino & Ogada, 2021). The roost spray is not only harmful at local level but may also be spread into waterbodies, negatively affecting the aquatic life (Mullié et al., 1999). Moreover, it affects insects that get exposed to the sprays and also animals eating the affected birds (Mcwilliam & Cheke, 2004). Hence, the usage of fenthion as a pesticide could negatively affect the biodiversity and the human health (Odino & Ogada, 2021). Therefore, the goal should be to minimize the usage of roost sprays.

To be able to minimize the usage of roost sprays, the farmers need other methods to decrease the bird damage to rice. For instance, one can use protective nets to hinder the birds. Another way is to use sacrificial crops (i.e. fields where the birds can feed undisturbed) to lure away the birds from the rice fields, but this needs to be managed on a regional level and is not very popular among the farmers since they do not like to feed their pests (Kega et al., 2015). A traditional and common way to reduce crop damage is to have humans present in the fields making noises and throwing rocks at the birds (Oduntan et al., 2015). But, these three methods are costly and human scaring is also very labour intensive (Cheke & Sidatt, 2019; Hiron et al., 2014).

Since there is currently no obvious solution for reducing damage on rice caused by birds in Kenya, this challenge needs to be further studied. The method needs to be 1) cheap, 2) environmentally friendly, 3) not too labour intensive, and 4) decreasing the number of birds in the fields. The hawk-kite fulfils the first three requirements and the objective of this study was to see whether the hawk-kites also fulfils the fourth aim, i.e. decreasing the number of birds, when used in small-scale rice farms in Kenya. Since habituation is a common problem when using scaring methods, this was also tested. Furthermore, to get a deeper understanding of the current situation for Kenyan rice farmers an interview was conducted.

2. Method

2.1 Study area

The initial plan was to conduct the entire study in one place, but due to thefts of field equipment (such as wildlife cameras and memory cards) there was a need of changing location after one week. Therefore, the study was conducted at two locations: Mwea irrigation scheme and University of Embu.

2.1.1 Mwea irrigation scheme

The study was first set up in Mwea irrigation scheme (hereafter Mwea), located in Kirinyaga county, south-central Kenya (approximately 100 km northeast from Nairobi), and it was also here the interviews were held. Approximately 86% of all the rice produced in Kenya comes from farms in this area (Muhunyu, 2012). The water for irrigation in Mwea is obtained from the two rivers *viz* Nyamindi and Thiba, and the regulation is partly provided by the government through the National Irrigation Board (Muhunyu, 2012). The rain periods are between March-May (long rains) and October-December (short rains) and averagely, there is an annual precipitation of 950 mm (Kihoro et al., 2013). Most of the rice is produced between August and December but also during the less productive period of February to June (Mukiama & Mwangi, 1989).

Furthermore, the farming is mainly small scale and in Nyangati, the village where this study was conducted, farm sizes ranged between 0.2-2.4 hectares. Almost all farmers had rice as their main crop with maize as the second most common crop. A great challenge for rice production in the area are grain-eating birds, especially the red-billed quelea and Village weaver that feeds on flowering and mature rice which causes big losses to the farmers (Kega et al., 2015; Muhunyu, 2012). The quelea is the most abundant bird in Africa and both feeds and breeds in colonies as big as of several millions of individuals (Dallimer, 2000; Ruelle & Bruggers, 1982). They are also migratory and move to areas where rain has been falling and where grains are available (Newton, 1998).

2.1.2 University of Embu- campus

The campus of the University of Embu (hereafter Embu) is located in Embu county, approximately 15 km northeast of Nyangati village and 115 km northeast from Nairobi, and it was here most of the data was collected during the study. The Embu area consists of a mix of farmland, forest and ponds. Both wild birds and mammals occur in the area. Crops such as maize, beans, kales and lemongrass are cultivated. Compared to Mwea, the landscape is not as open and has more trees and bushes around the fields. Also, there is no rice cultivation in and around Embu.

2.2 Data collection

2.2.1 Kite study

The scaring method tested was the use of kites flying in the wind to mimic a bird of prey (hawk-kites). The hawk-kites had a silhouette of a raptor, were black in colour and had two eyes drawn in red at the downfacing side. They were attached to a 6 m long telescopic pole and 3 m long string.

Mwea

The kite study was started in Mwea on 6th of February and the plan was to perform a before-after-control-impact (BACI) study (Green, 1979), in other words, compare the status before using the experiment treatment with the status when the experiment treatment is used. Wildlife Cameras (Denver WCT-8010) were placed at the edges of 12 different fields (but sometimes the field was surrounded by other fields, i.e. the area was open). The cameras were set to take 1 image/minute. Since there was no flowering- or ripe rice at this time of the year (which attracts birds), bait stations with brown unhusked rice was placed at the fields. To avoid chicken from getting into the farms to eat the bait, the rice was placed 1 m above ground on temporary built tables. The cameras were taken down during the nights but were recording data between dawn and dusk, approximately 6.00-19.00. After 2 days hawk-kites were placed at 6 of the fields (randomly chosen), 4 m from the bait stations, while the rest of the fields remained as controls (see Appendix 1, Figure S1, which shows a site setup with a hawk-kite). The treatments were planned to be switched between the fields, but due to thefts of the cameras' memory cards the study in Mwea was interrupted. Nevertheless, images from 11 sites were recorded during the first 2.5 days and from 5 sites during 4.5 additional days.

Embu

Since it was not possible to conduct the study in Mwea, it was moved to Embu. As there were no ripe crops in the area, bait stations were also used here to attract birds to certain spots. When using baits, it became easier to position the cameras and the sites were more comparable to each other. Before placing the bait stations, a bait preference test was done where green maize, white boiled rice and brown unhusked rice were placed side by side at different places in Embu. After 4 days it was determined which bait that had been eaten the most. All types of baits were used and when the sites were visually checked there was no clear difference in the preference of baits, and thereby it was decided to use the brown rice which mimic the crop available in rice fields the most and that also is cheapest and easiest to handle (no boiling needed). The bait preference test was only conducted to make sure that the bait stations would attract the birds and no statistical test was done on them.

Three scoops (appr. 2 dl) of brown unhusked rice were placed on the ground at 16 places in Embu. After 5 days, the 12 sites that seemed to have had the highest bird activity were chosen to be included as test sites. To track the visits of birds, these sites were then equipped with a wildlife camera (Denver WCT-8010) placed 2 meters from the bait. The cameras were set to take one image every third minute between 06.00-19.00 o'clock i.e., from dusk till dawn.

At 6 of the sites, a hawk-kite was placed approximately 4 meters from the bait station. The remaining 6 sites had no scaring device and functioned as control sites. The choice of which sites should have the hawk-kite was randomised, but if two sites were located close to each other (visible from each other), both had the same treatment. Each day (with one day exception) the sites were refilled with bait and the status of the kites were checked. If a kite was malfunctioning (e.g., fallen, twisted around the pole due to heavy rain and wind), the time was noted and the kite fixed. After 4 days the site treatments were switched (control sites received the hawk-kites and vice versa). To get full days of data, the switch of treatment occurred after 19.00 and at the same time the memory cards in the cameras were changed.

These 8 days of hawk-kite and control treatments were carried out from 15th -22nd of March (period 1). The setup was repeated at the same sites (with exception of 2 sites that were exchanged due to lack of bird-visits in period 1) from 23rd - 30th of March (period 2). From 3rd-10th of April (period 3), the set up was repeated at 4 new sites and 2 already used sites (where data had not been collected earlier due to malfunctional kites). All sites except one, site 15 (Table 1), were placed on farmland with different types of crops (e.g. maize, lemongrass, kale) or open soil prepared to be sowed. Site 15 was instead placed at grassland. The sites were placed along the edges of the fields with bushes and other high vegetation nearby.

2.2.2 Interview study

To get a deeper understanding of the current situation in Mwea, an interview study about crop damage and scaring methods among the local farmers was performed. The interviewed persons were the owners of the farms where cameras had been placed and in total 11 farmers participated. An interpreter was used to translate English to Swahili during the interviews. Also, three other students helped to accomplish some of the interviews, where two of them spoke Swahili. The farmers were asked one by one, but in some few cases, they may have overheard another person answering the questions before themselves. The main purpose of the interview was not to collect quantitative data, but to provide knowledge to deepen the discussion part of this study. Thus, the questions were formulated to get qualitative data and a summary was written by finding similarity patterns among the answers (LeCompte, 2000). The questions were about which species were most destructive, the estimated harvest losses due to crop damage, the framers scaring routines etc. The full set of questions can be found in Appendix 2.

2.3 Data analysis

2.3.1 Image analysis and data handling

In total 33 784 images were collected during the study in Mwea (one image every minute) and 54 768 in Embu (one image every third minute). All the images from the cameras were checked and the number of images with and without presence of birds for each day and site were noted (examples of images can be found in Appendix 1, Figure S2-S5). Due to occasional malfunction of the kites, days when it was uncertain if the kite had been working throughout the day were excluded. Furthermore, some of the data from control sites was missing due to camera issues and thefts. In Mwea only control data was received.

Among the images with presence of birds, 200 images were randomly chosen from both control sites and the kite sites in Embu and as well as from Mwea area (only control sites), thus 600 images in total. These images were used to identify species using the bait stations and to count the total number of grain-eating birds in each image. If an image was blurry (often the case during rainy mornings) it was replaced with a new one. The image analysis was not statistically tested.

2.3.2 Statistical analysis

Since there was no data from hawk-kite sites in Mwea the statistical analysis of scaring effect and habituation was only conducted for the sites in Embu. The scaring effect was tested by comparing the mean number of images with presence of birds per day and period at sites with and without hawk-kites. Since the data (mean number of images) was normally distributed, a paired t-test was performed. All the sites were randomly paired so that a site with hawk-kite treatment was paired with a site having control treatment (no hawk-kite) during the same period. In total there were 3, 4 and 3 pairs during period 1, 2 and 3 respectively. In total 15 unique sites were used. However, 5 sites were re-used during period 1 and 2 (see Table 1). As sample size was restricted, random factors could not be included to account for this issue, but it was assumed that the data collected from different periods was independent as many conditions changed between the periods, e.g. weather, vegetation, bird density in the area etc. The mean number of images of birds was poled in a bar chart.

Secondly, it was also of interest to see if the birds got habituated to the kite during the 4-day period. Therefore, an ANOVA was performed with day-number as factor for all the sites when having the hawk-kite treatment and the control- treatment respectively. This was also poled in a bar chart. All the statistics was carried out in SPSS version 28.0 (IBMCorp, 2023).

Table 1. An overview of which sites that were used during which periods in University of Embu campus. "HK" means that the site had a hawk-kite and "C" stands for control site. "X" means the site was set up but that the data could not be used due to malfunctional hawk-kite, camera issues or no matching data in the pair (only the case for control data)." –" means the site was not set up during the current day. The boxes represent the pairs used in the paired t-test. The crossed-out sites (1,2 and 12) did not contribute with any data.

Period	Date	~~1~~	~~2~~	3	4	5	6	7	8	9	10	11	~~12~~	13	14	15	16	17	18
1	15-mar	X	X	X	X	X	X	-	X	X	X	X	X	X	-	-	-	-	-
1	16-mar	X	X	X	X	X	X	-	X	X	X	X	X	X	-	-	-	-	-
1	17-mar	X	X	X	X	HK	C	-	X	X	X	X	X	X	-	-	-	-	-
1	18-mar	X	X	X	X	HK	C	-	C	HK	X	X	X	X	-	-	-	-	-
1	19-mar	X	X	HK	C	X	X	-	HK	C	X	X	X	X	-	-	-	-	-
1	20-mar	X	X	HK	C	X	X	-	X	X	X	X	X	X	-	-	-	-	-
1	21-mar	X	X	HK	C	C	HK	-	X	X	X	X	X	X	-	-	-	-	-
1	22-mar	X	X	HK	C	X	X	-	HK	C	X	X	X	X	-	-	-	-	-
2	23-mar	-	-	X	X	X	C	HK	X	X	X	X	X	X	X	-	-	-	-
2	24-mar	-	-	X	X	X	C	HK	X	X	HK	C	X	X	X	-	-	-	-
2	25-mar	-	-	X	X	X	X	X	X	X	HK	C	X	X	X	-	-	-	-
2	26-mar	-	-	C	HK	X	X	X	X	X	HK	C	X	X	X	-	-	-	-
2	27-mar	-	-	X	X	X	HK	C	HK	C	C	HK	-	X	X	-	-	-	-
2	28-mar	-	-	X	X	X	HK	C	X	X	C	HK	-	X	X	-	-	-	-
2	29-mar	-	-	X	X	X	X	X	X	X	C	HK	-	X	X	-	-	-	-
2	30-mar	-	-	X	X	X	X	X	X	X	C	HK	-	X	X	-	-	-	-
3	03-apr	-	-	-	-	-	-	-	-	-	-	-	-	HK	C	HK	C	C	HK
3	04-apr	-	-	-	-	-	-	-	-	-	-	-	-	HK	C	HK	C	C	HK
3	05-apr	-	-	-	-	-	-	-	-	-	-	-	-	HK	C	HK	C	C	HK
3	06-apr	-	-	-	-	-	-	-	-	-	-	-	-	HK	C	HK	C	C	HK
3	07-apr	-	-	-	-	-	-	-	-	-	-	-	-	C	HK	C	HK	HK	C
3	08-apr	-	-	-	-	-	-	-	-	-	-	-	-	C	HK	X	X	HK	C
3	09-apr	-	-	-	-	-	-	-	-	-	-	-	-	C	HK	C	HK	HK	C
3	10-apr	-	-	-	-	-	-	-	-	-	-	-	-	C	HK	C	HK	HK	C

3. Results

3.1 Species composition and flock size of birds

At Embu 12 different species of grain-eating birds were found, 6 of these and one additional species were also found in Mwea (Table 2).

Table 2. The appearance of different species of birds in Embu at the control sites (C) and at sites with hawk-kites (HK) and in Mwea (only control sites). "X" indicates that the species was found. The species written in bold are different kinds of weaver birds.

Species	Embu C	Embu HK	Mwea C
Holub's golden weaver *(Ploceus xanthops)*	X	X	X
Village weaver *(Ploceus cucullatus)*	X	X	X
Baglafect weaver *(Ploceus baglafecht)*	X	X	X
Wite-browed sparrow- weaver *(Plocepasser mahali)*	X	X	X
Grosbeak weaver *(Amblyospiza albifrons)*	X	X	-
Chestnut weaver *(Ploceus rubiginosus)*	X	-	-
Unknown weaver	-	-	X
Fire finch *(Lagonosticta spp.)*	X	X	X
Parrot-billed sparrow *(Passer gongonensis)*	X	X	X
Yellow bishop *(Euplectes capensis)*	X	X	-
Yellow-necked spurfowl *(Pternistis leucoscepus)*	X	X	-
Red-collared widowbird *(Euplectes ardens)*	X	X	-
Pin-tailed whydah *(Vidua macroura)*	X	X	-
Common bulbul *(Pycnonotus barbatus)*	X	X	X
Unknown bird	X	-	X

In Embu the most common species group was weavers (control: 78%, hawk-kite: 86%; Fig. 1) (including the genus *Ploceus spp., Amblyospiza spp.* and *Plocepasser spp.*). Among the weavers, the village weaver (*Ploceus cucullatus*) was the most frequent visitor to the sites (control: 78%, hawk-kite: 81%; Fig. 1). Even in Mwea (only control) the weavers were the most common type of bird (60%). The most common species was the white-browed sparrow-weaver (74% of all the weavers).

In Embu, the flock size varied from 1 to 24 birds with a mean of 2.8 at the control sites and from 1 to 26 with a mean of 3.3 at the sites with kites. In Mwea it varied from 1 to 5 birds with a mean of 1.4.

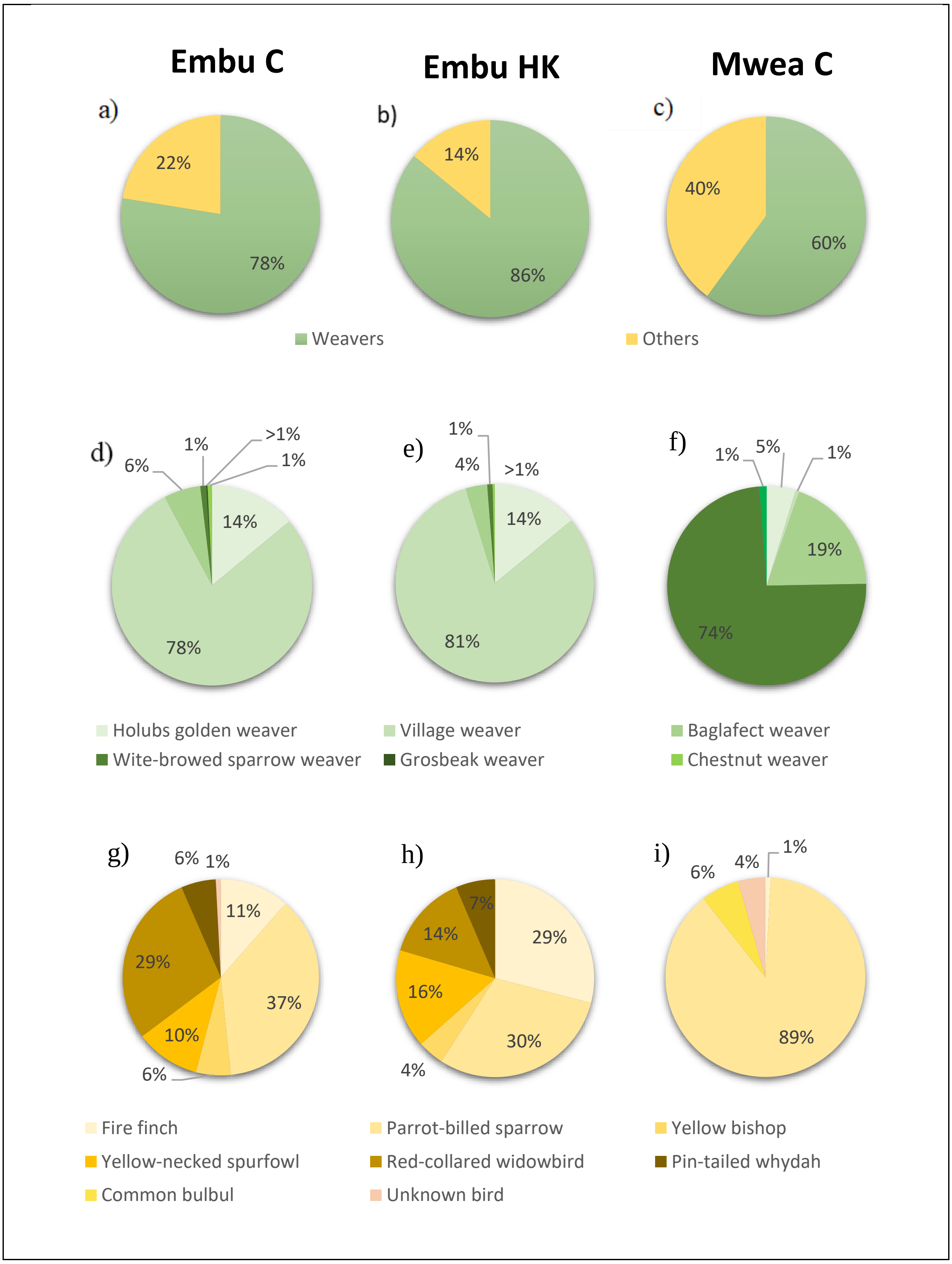

Figure 1. Proportion of different bird categories/species counted on the images in the two different study areas (Embu and Mwea) and treatments (control and scaring hawk-kite). a-c categorises the birds into weavers (including the genus Ploceus spp., Amblyospiza spp. and Plocepasser spp.) and others (anything except weavers). d-f specify the species of the weavers and g-i the species of the other birds.

3.2 Effect of hawk-kite

In total there were 612 images with presence of birds in Mwea (only from control sites) and in Embu 1988 images with birds at sites with hawk-kite and 3510 images at control sites. On average, the number of images with birds where significantly fewer at sites with hawk-kites ($\bar{x}$=41.05, SE=8.60) than at sites with no hawk-kites ($\bar{x}$=74.03, SE=7.52), t(9)=5.06, p<0.001 (see Fig. 2). The hawk-kites were reducing the number of images with birds by 44.5%.

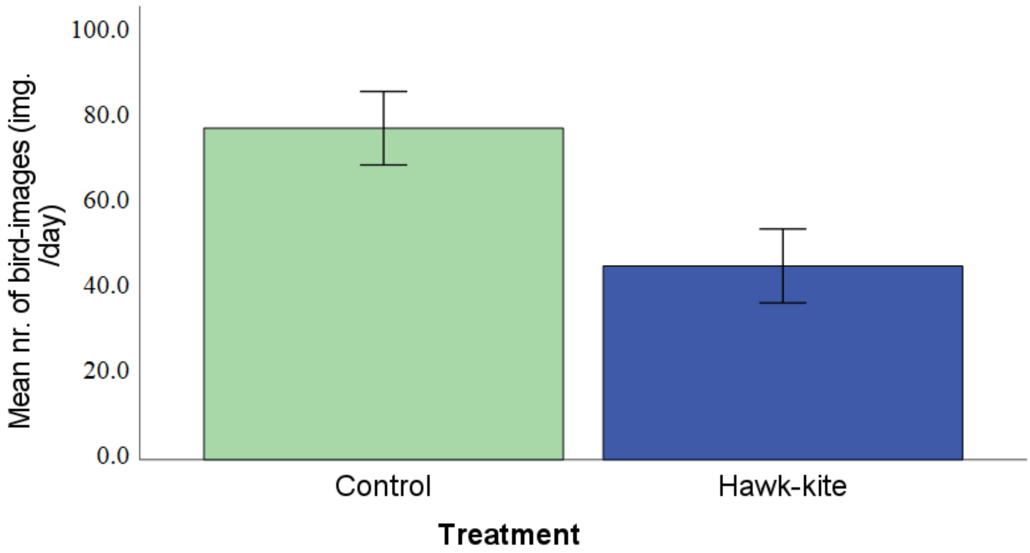

Figure 2. A bar chart illustrating the difference between the mean number of images with the presence of birds due to treatment of the sites in University of Embu. The control treatment resulted in M=74.03, SE=7.52 and hawk-kite treatment M=41.05, SE=8.6

3.3 Habituation

There was no significant difference between the number of bird-visits over the four days with scaring ($F(3,42)=0.88$, $p=0.46$, Fig. 3).

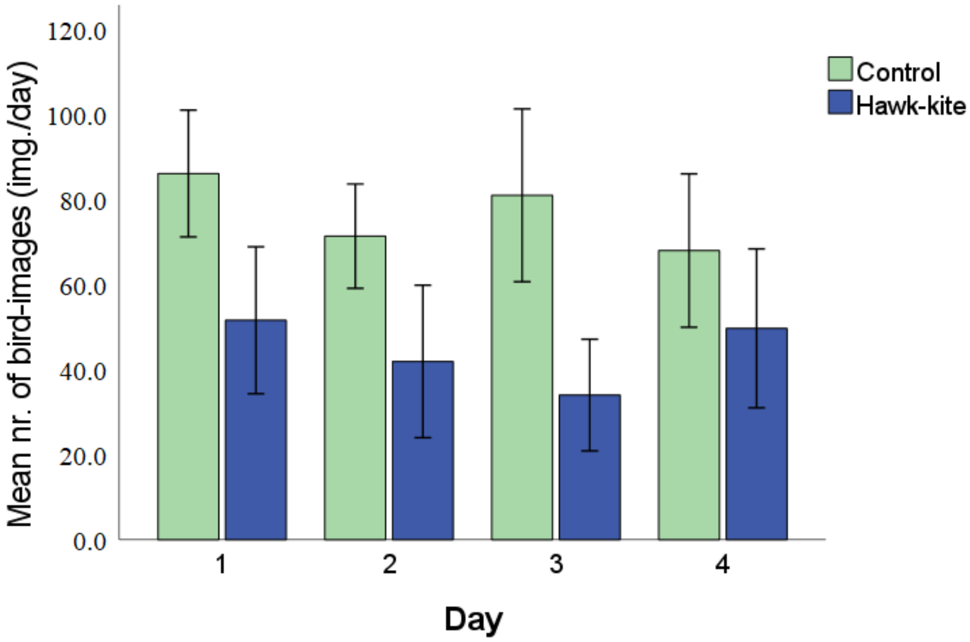

Figure 3. A bar chart illustrating the mean number of images of birds per day due to treatment (hawk-kite or control) and day of treatment of sites in University of Embu. The chart is showing +/- 2 SE bars.

3.4 Interview

Below is a summarized version of the answers from the 11 farmers that took part in the interview (questions 1-12 in Appendix 2).

(1) The most common crop in Mwea is rice and it is also the crop that the farmers experience the most damage on. Another crop that is damaged to a high extent by wildlife is maize. Some farmers also mentioned problems with crop damage on tomatoes, beans, kale, millet, sorghum and pigeon peas.

(2) When asked which animal causes the most crop damage the farmers answered birds. Some specified that it is mainly weavers (especially red-billed queleas) and mannikins causing damage. According to the farmers, the second most destructive type of animal were rats.

(3) The farmers reportedly experience some crop damage in rice already while sowing (ca. February and August, but some farmers sow at different times to lower the risk of damage), but most damage occurs from flowering to harvest of the rice (ca. May-June and November-December).

(4) Most of the farmers said they see more crop damage close to trees and bushes where the birds can perch and find shelter.

(5) The respondents consider crop damage by wildlife to constitute a big problem (options: no, little, medium, big).

(6) If no scaring of the birds were conducted during flowering to harvest (1.5 month, two times a year), some farmers believed they would lose their entire harvest. But also when the birds were scared, the farmers still had harvest losses. The estimated loss while scaring the birds away varied between 4-50% among those interviewed.

(7&8) According to the farmers, the birds are most active in the morning (between 6-11am) and late afternoon (15-18) and thereby some take a break from the scaring at noon, while other said they must stay in the fields during the entire day (6-18).

(9) To scare the birds most people use a slingshot or a stick (1.43 USD/year) to throw mud or stones. Other methods are shouting, making noise with metal plates and placing scarecrows. Some farmers also employ people to help with the scaring (2.86 USD/day*3 month).

(10&11) The farmers experienced that the birds left after scaring but returned within 1-5 minutes if the field was left without being attended to. Most of the farmers experience that the birds come back being bolder and that the birds get used to the scaring methods (habituated).

(12) When asked about recommendations to give to other farmers they said that one should use slingshots and metal plates but also increase human presences in the fields. Some also mentioned that the large-scale roost spray against red-billed quelea is the most effective method and in general they had a positive attitude for it being used.

4. Discussion

This study showed that the hawk-kite almost halved the number of images with birds visiting the bait stations. Also, the birds did not seem to habituate to the kites, at least not over a 4-day period. Moreover, the interview-study confirmed that grain-eating birds are a great challenge to rice production in Mwea and that many farmers are positive to the large-scale roost sprays due to lack of better non-lethal methods.

According to the results, the hawk-kite significantly reduced the number of images of birds feeding on the rice, which in turn indicates that the kite has a scaring effect. This result is in line with similar studies, such as Nakamura (1997) who used a kite with 2 drawn eyes and found that it had a scaring effect on rufous turtle doves (*Streptopelia orientalis*) feeding on soybeans. Moreover, the farmers in the interview study said that the birds usually habituate to their scaring methods. There was no evidence of any habituation to the hawk-kites over a 4-day period, but a longer period is needed to rule out that the birds do not habituate to the hawk-kites at a later stage. In another kite-study, Haque and Broom (1985) could not see any signs of habituation over a 3-month period. But their kite differed from the one used in this study since it did not mimic a bird of prey (it had a red colour) and was approximately 55 m up in the sky (compared to 6 m in this study). In contrast, Conover (1979) saw some habituation to his hawk-kite attached to a helium balloon over a 7 day period and also that the habituation time varied between different bird species. The habituation time for the hawk-kite used in this study is thereby uncertain.

Given the interview answers in this study, the most common scaring method today is to have humans present in the fields. In a questionnaire survey about bird damage to rice in Senegal, de Mey et al. (2012) found that 80% of the responding farmers used children to scare birds from the rice-fields which led to high numbers of missed school days. According to Muhunyu (2012), children take part in bird-scaring in Kenya as well. Nevertheless, another option is to employ people to do the work, though this is very expensive. In Mwea, Kenya, Kihoro et al. (2013) showed that the costliest part of rice cultivation is employing people to scare birds, which is needed during one and a half months before harvesting the rice. If the hawk-kite could reduce the number of children working in the fields and lower the need of employing people, that would be a great win for the Kenyan farmers.

Furthermore, the scaring effect of the hawk-kite was not 100%, but almost 45%. Although, the sample size and duration time of this study was limited, the result goes in line with the study by Conover (1979) who got a similar result with 40% scaring effect of birds feeding on blueberries when using hawk-kites attached to helium balloons. A higher scaring effect would be more preferred, but at least the hawk-kite shows signs of being able to lower the crop damage to some significant extent. Also, scaring methods seldom give a total protection (Elliott & Bright, 2007; Ruelle & Bruggers, 1982; Santilli et al., 2012). The farmers who participated in the interview said they could lose 4-50% of their harvest even though many of them stay out in the fields during the entire days to scare the birds away. Therefore, the kites seem to have a potential to be used as a compliment to other scaring methods. Besides, employing a greater variety of scaring methods would probably delay the time for habituation (Conover, 2001; Koehler et al., 1990). However, a study over the cost-effectiveness should preferably be conducted before recommending the hawk-kite to the local farmers.

The aim was to test if the hawk-kite is an effective scaring-method at small-scale rice farms in Kenya, but it was not possible to perform the study at actual rice fields. Still, rice was used as bait to attract the same types of birds feeding on the rice fields. From the results, weavers were the most common type of bird both in Embu and Mwea. Six out of seven species found in Mwea was also found in Embu, but the composition of species differed between the areas. However, the data from Mwea was collected from fewer sites and over a shorter time which lowers the probability of detecting different species. Also, the bird-visits per site were generally fewer in Mwea compared to Embu, probably since there was no time for the birds to get used to the sites before the data was collected (in Embu they had time due to the bait preferences test). Besides, the farmers indicated that red-billed quelea is a big issue to the rice-production in Mwea, but the queleas were not found during this study period. This is because the queleas are migratory and reside to the area when the rice is flowering. So, the actual distribution of species in Mwea during the flowering might look a bit different compared to the one found in this study.

Since the red-billed quelea is the major challenge to rice production it is important to know how they respond to the hawk-kite. The quelea is a type of weaver which most of the birds found in this study also were. Furthermore, there was no clear difference between the species distribution at control sites and hawk-kite sites which suggest that the kite works on several types of grain-eating birds (even though it was not statistically tested). But, compared to many other birds, the queleas have a different behaviour since they migrate and can occur in very large flocks which possibly influences their response to the scaring devices as flock size can affect behaviour related to risk avoidance such as vigilance (Westcott & Cockburn, 1988). Further studies should therefore preferably be done during the flowering period and on queleas for more accurate result.

In this study weather conditions, for instance wind, were not considered. If there was no wind, the kite was just hanging without movement which probably did not scare the birds as effective as when flying. To avoid this problem helium balloons are often attached to the kites (Conover, 1984; Hothem & DeHaven, 1982; Seamans et al., 2002). Still the balloons are easily broken during strong winds and need to be filled with new helium 2 times a week, which make them costly and more labour intensive (Conover, 1984; Seamans et al., 2002). The goal of this study was to find a cheap and less labour-intensive method suitable for small-scale farmers, hence the balloons were not an option in this case. Furthermore, the landscape in Mwea is more open than in Embu which suggests it would be windier and that the hawk-kites might work better than in Embu. As a further study it would be of interest to see how wind conditions influence the efficiency of the hawk-kite. Maybe if the wind pattern is known throughout a normal day, the farmers could go out scaring manually while the wind is calm, but instead rely on the kite when the wind is stronger.

Conclusion

It seems like the hawk-kite has a potential to be used as a scaring method for birds in Kenya, at least as a compliment to other methods. But from this study it is not known how the efficiency and the habituation rate depend on the kite-type, weather conditions, bird species and food availability. Thereby it would be preferable to conduct further studies on the actual rice fields during periods when the birds are causing the most damage. Also, it would be of interest to know the range of the effect of the kite i.e. the maximum distance in which birds are scared. By providing alternative methods for keeping birds out of the rice fields the farmer would spare time and money (less employees needed) and possibly lower the rate of children staying home from school to help scare birds. It is also important to decrease the use of roost sprays and other chemicals in the agricultural sector. Learning more about other methods is taking a step towards lowering the need of using roost sprays and manual scaring by humans. This will in turn lead to a more sustainable food production for the increasing human population and result in a higher quality of life for the Kenyan rice farmers.

References

Boyce, M. S. (1991). Migratory behavior and management of elk (Cervus elaphus). *Applied Animal Behaviour Science*, *29*(1-4), 239-250. https://doi.org/10.1016/0168-1591(91)90251-R

Carter, N. H., & Linnell, J. D. (2016). Mainstreaming coexistence with wildlife: Reply to Gallagher. https://doi.org/10.1016/j.tree.2016.08.007

Chambers, R. G., Karagiannis, G., & Tzouvelekas, V. (2010). Another look at pesticide productivity and pest damage. *American Journal of Agricultural Economics*, *92*(5), 1401-1419. https://doi.org/10.1093/ajae/aaq066

Cheke, R. A., & Sidatt, M. E. H. (2019). A review of alternatives to fenthion for quelea bird control. *Crop Protection*, *116*, 15-23. https://doi.org/10.1016/j.cropro.2018.10.005

Conover, M. R. (1979). Response of birds to raptor models. https://canadianbirdstrike.ca/wp-content/uploads/2018/02/Conover_1979.pdf

Conover, M. R. (1984). Comparative effectiveness of avitrol, exploders, and hawk-kites in reducing blackbird damage to corn. *The Journal of Wildlife Management*, 109-116. https://doi.org/10.2307/3808458

Conover, M. R. (2001). *Resolving human-wildlife conflicts: the science of wildlife damage management*. CRC press. https://www-cabdirect-org.ludwig.lub.lu.se/cabdirect/abstract/20033147482

Dallimer, M. (2000). *Migration patterns of the redbilled quelea (Quelea quelea) in southern Africa: genetics, morphology and behaviour* University of Edinburgh]. http://hdl.handle.net/1842/13550

de Mey, Y., & Demont, M. (2013). 19 Bird Damage to Rice in Africa: Evidence and Control. *Realizing Africa's Rice Promise*, 241. https://doi.org/10.1079/9781845938123.0241

de Mey, Y., Demont, M., & Diagne, M. (2012). Estimating bird damage to rice in Africa: evidence from the Senegal River Valley. *Journal of Agricultural Economics*, *63*(1), 175-200. https://doi.org/10.1111/j.1477-9552.2011.00323.x

Elliott, C., & Bright, E. (2007). *Review of the bird pest problem and bird scaring in South west Nigeria*. https://ageconsearch.umn.edu/search?ln=en&p=REVIEW%20OF%20THE%20BIRD%20PEST%20PROBLEM%20%20AND%20BIRD%20SCARING%20%20IN%20SOUTH%20WEST%20NIGERIA%20&f=&sf=&so=d&rg=10

Gallagher, A. J., Creel, S., Wilson, R. P., & Cooke, S. J. (2017). Energy landscapes and the landscape of fear. *Trends in ecology & evolution*, *32*(2), 88-96. https://doi.org/10.1016/j.tree.2016.10.010

Ghimire, K. B., & Barraclough, S. L. (2013). *Agricultural Expansion and Tropical Deforestation: Poverty, International Trade and Land Use*. Routledge. https://doi.org/10.4324/9781315870533

Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., Pretty, J., Robinson, S., Thomas, S. M., & Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. *science*, *327*(5967), 812-818. https://doi.org/10.1126/science.1185383

Green, R. H. (1979). *Sampling design and statistical methods for environmental biologists*. John Wiley & Sons. https://www-cabdirect-org.ludwig.lub.lu.se/cabdirect/abstract/19820729140

Haque, A. F., & Broom, D. (1985). Experiments comparing the use of kites and gas bangers to protect crops from woodpigeon damage. *Agriculture, ecosystems & environment*, *12*(3), 219-228. https://doi.org/10.1016/0167-8809(85)90113-6

Hemminger, K., König, H., Månsson, J., Bellingrath-Kimura, S. D., & Nilsson, L. (2022). Winners and losers of land use change: A systematic review of interactions between the world's crane species (Gruidae) and the agricultural sector. *Ecology and Evolution*, *12*(3), e8719. https://doi.org/10.1002/ece3.8719

Hiron, M., Rubene, D., Mweresa, C. K., Ajamma, Y. U., Owino, E. A., & Low, M. (2014). Crop damage by granivorous birds despite protection efforts by human bird scarers in a sorghum field in western Kenya. *Ostrich*, *85*(2), 153-159. https://doi.org/10.2989/00306525.2014.937368

Hothem, R. L., & DeHaven, R. W. (1982). *Raptor-mimicking kites for reducing bird damage to wine grapes* Proceedings of the Vertebrate Pest Conference, https://escholarship-org.ludwig.lub.lu.se/uc/item/9932206x

IBMCorp. (2023). *IBM SPSS Statistics for Windows*. In (Version 28.0) [Computer program]. IBMCorp.

Kega, V. M., Gikonyo, E. W., Muriithi, C. W., Macharia, J., & Muthoni, L. (2015). Rice cultivation manual. *Kenya Agricultural and Livestock Research Organization (KALRO) Secretariat, Kenya*. https://www.kalro.org/files/Rice-Cultivation-Manual.pdf

Kihoro, J., Bosco, N. J., Murage, H., Ateka, E., & Makihara, D. (2013). Investigating the impact of rice blast disease on the livelihood of the local farmers in greater Mwea region of Kenya. *Springerplus*, *2*, 1-13. https://doi.org/10.1186/2193-1801-2-308

Koehler, A. E., Marsh, R. E., & Salmon, T. P. (1990). Frightening methods and devices/stimuli to prevent mammal damage--a review. https://digitalcommons.unl.edu/vpc14/50

Krebs, J. R., Ryan, J. C., & Charnov, E. L. (1974). Hunting by expectation or optimal foraging? A study of patch use by chickadees. *Animal behaviour*, *22*, 953-IN953. https://doi.org/10.1016/0003-3472(74)90018-9

König, H. J., Kiffner, C., Kramer-Schadt, S., Fürst, C., Keuling, O., & Ford, A. T. (2020). Human–wildlife coexistence in a changing world. *Conservation Biology*, *34*(4), 786-794. https://doi.org/10.1111/cobi.13513

LeCompte, M. D. (2000). Analyzing qualitative data. *Theory into practice*, *39*(3), 146-154. https://doi.org/10.1207/s15430421tip3903_5

Mati, B. M. (2010). System of rice intensification (SRI): growing more with less water. *Promoting the adoption of SRI in Kenya*. http://sri.cals.cornell.edu.ludwig.lub.lu.se/countries/kenya/KenyaBancyGDLNVC091109.pdf

Mcwilliam, A. N., & Cheke, R. A. (2004). A review of the impacts of control operations against the red-billed quelea (Quelea quelea) on non-target organisms. *Environmental Conservation*, *31*(2), 130-137. https://doi.org/10.1017/S0376892904001213

Messmer, T. A. (2000). The emergence of human–wildlife conflict management: turning challenges into opportunities. *International Biodeterioration & Biodegradation*, *45*(3-4), 97-102. https://doi.org/10.1016/S0964-8305(00)00045-7

Montràs-Janer, T., Knape, J., Nilsson, L., Tombre, I., Pärt, T., & Månsson, J. (2019). Relating national levels of crop damage to the abundance of large grazing birds: implications for management. *Journal of Applied Ecology*, *56*(10), 2286-2297. https://doi.org/10.1111/1365-2664.13457

Muhunyu, J. G. (2012). Is doubling rice production in Kenya by 2018 achievable? *Journal of Developments in Sustainable Agriculture*, *7*(1), 46-54. https://doi.org/10.11178/jdsa.7.46

Mukeka, J. M., Ogutu, J. O., Kanga, E., & Røskaft, E. (2019). Human-wildlife conflicts and their correlates in Narok County, Kenya. *Global Ecology and Conservation*, *18*, e00620. https://doi.org/10.1016/j.gecco.2019.e00620

Mukiama, T. K., & Mwangi, R. W. (1989). Field studies of larval anopheles arabiensis Patton of mwea irrigation scheme, Kenya. *International Journal of Tropical Insect Science*, *10*, 55-62. https://doi.org/10.1017/S1742758400003349

Mullié, W. C., Diallo, A. O., Gadji, B., & Ndiaye, M. D. (1999). Environmental hazards of mobile ground spraying with cyanophos and fenthion for quelea control in Senegal. *Ecotoxicology and Environmental Safety*, *43*(1), 1-10. https://doi.org/10.1006/eesa.1998.1744

Muñoz-Sáez, A., Heaton, E. E., Reynolds, M., & Merenlender, A. M. (2020). Agricultural adapters from the vineyard landscape impact native oak woodland birds. *Agriculture, ecosystems & environment*, *300*, 106960. https://doi.org/10.1016/j.agee.2020.106960

Månsson, J. (2017). Lethal scaring–Behavioral and short-term numerical response of greylag goose Anser anser. *Crop Protection*, *96*, 258-264. https://doi.org/10.1016/j.cropro.2017.03.001

Nakamura, K. (1997). Estimation of effective area of bird scarers. *The Journal of Wildlife Management*, 925-934. https://doi.org/10.2307/3802202

Newton, I. (1998). *Population limitation in birds*. Academic press. https://doi.org/10.1016/B978-0-12-517365-0.X5000-5

Nyhus, P. J. (2016). Human–wildlife conflict and coexistence. *Annual review of environment and resources*, *41*, 143-171. https://doi.org/10.1146/annurev-environ-110615-085634

Odino, M., & Ogada, D. (2021). The Intentional Use of Pesticides as Poison in Kenya: Conservation and Ecohealth Impacts. In *Wildlife Biodiversity Conservation: Multidisciplinary and Forensic Approaches* (pp. 421-438). Springer. https://doi.org/10.1007/978-3-030-64682-0_16

Oduntan, O., Shotuyo, A., Akinyemi, A., & Soaga, J. (2015). Human-wildlife Conflict: A View on Red-Billed Quelea (Quelea quelea). *International Journal of Molecular Evolution and Biodiversity*, *5*. https://doi.org/10.5376/ijmeb.2015.05.0002

Oerke, E.-C. (2006). Crop losses to pests. *The Journal of Agricultural Science*, *144*(1), 31-43. https://doi.org/10.1017/S0021859605005708

Pyke, G. H. (1984). Optimal foraging theory: a critical review. *Annual review of ecology and systematics*, *15*(1), 523-575. https://doi.org/10.1146/annurev.ecolsys.15.1.523

Redpath, S. M., Young, J., Evely, A., Adams, W. M., Sutherland, W. J., Whitehouse, A., Amar, A., Lambert, R. A., Linnell, J. D., & Watt, A. (2013). Understanding and managing conservation conflicts. *Trends in ecology & evolution*, *28*(2), 100-109. https://doi.org/10.1016/j.tree.2012.08.021

Ruelle, P., & Bruggers, R. (1982). Traditional approaches for protecting cereal crops from birds in Africa. https://digitalcommons.unl.edu/vpc10/37/

Santilli, F., Azara, S., Galardi, L., Gorreri, L., Perfetti, A., & Bagliacca, M. (2012). Evaluation of an aerial scaring device for birds damage prevention to agricultural crops. *Rivista Italiana di Ornitologia*, *82*(1-2). https://doi.org/10.4081/rio.2012.139

Seamans, T. W., Blackwell, B. F., & Gansowski, J. T. (2002). *Evaluation of the Allsopp Helikite as a bird scaring device* Proceedings of the Vertebrate Pest Conference, https://doi-org.ludwig.lub.lu.se/10.5070/V420110024

Ueno, M., Kaji, K., & Saitoh, T. (2010). Culling versus density effects in management of a deer population. *The Journal of Wildlife Management*, *74*(7), 1472-1483. https://doi.org/10.1111/j.1937-2817.2010.tb01274.x

Westcott, D. A., & Cockburn, A. (1988). Flock size and vigilance in parrots. *Australian Journal of Zoology*, *36*(3), 335-349. https://doi.org/10.1071/ZO9880335

World Bank Group. (2023a). *Kenya*. Retrieved 2023-06-20 from https://data-worldbank-org.ludwig.lub.lu.se/country/kenya

World Bank Group. (2023b). *Population, total*. World Bank Group. Retrieved 2023-06-20 from https://data-worldbank-org.ludwig.lub.lu.se/indicator/SP.POP.TOTL?end=2021&start=1960&view=chart

Popular science summary

Have you ever lost your strawberries to greedy birds? That is irritating, but what if it was not only your strawberries, but your livelihood that the birds were feeding on in front of your eyes? This is the reality for many farmers worldwide. For instance, 15% of all the rice produced globally is estimated to get lost due to birds. In Kenya, where rice is one of the most important crops and the human population is increasing, this is a big issue.

Several methods are used to reduce the crop damage to the rice in Kenya, but all of them come with disadvantages. The red billed quelea, is causing most of the damage and is often eradicated by spraying entire flocks with a nerve agent called fenthion. These sprays are not only toxic to the birds, but also harmful to humans and other non-target species. To be able to minimize the usage of the sprays, the farmers need other methods to decrease the damage to rice. A common way is to have humans present in the fields making noises and throwing stones at the birds, but it is very labour intensive and not unusually children take part in this work which could lead to missed days in school.

Today there is no obvious solution available for reducing damage on rice caused by birds in Kenya and this field needs to be further studied. Since scaring is in general less harmful than lethal methods, this study wanted to test the scaring-efficiency of a kite mimicking a bird of prey (hereafter hawk-kite). This was done by having bait stations with rice and comparing the number of visits of birds at sites with and without hawk-kites. The initial plan was to perform the study at actual rice fields in Mwea (a place in Kenya known for its rice production), but due to thefts of equipment the study was moved to University of Embu campus. However, to get a deeper understanding of the current situation interviews were also held with farmers in Mwea.

This study showed that the hawk-kite almost halved the number of birds feeding on rice at the bait stations. Moreover, the interview confirmed that grain-eating birds is a major threat to the rice production in Mwea and that many farmers are positive to the fenthion sprays due lack of better options. It seems like the hawk-kite has potential to be used as a scaring method at rice fields in Kenya, at least as a compliment among others. It does not give a hundred percent protection against damage, but neither do other methods. The more scaring devices that can be used, the less losses for the farmers. Hopefully it will also lower the need of using fenthion sprays and manual scaring by humans, which in turn will lead to a more sustainable food production for the increasing human population and result in a higher quality of life for the Kenyan rice farmers.

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Appendix 1

Bellow a picture of the set up in the rice fields in Mwea is presented (Fig. S1), and some examples of images with birds taken by wildlife cameras from both Mwea and Embu (Fig. S2-S5).

Figure S1. Picture of the study setup in Mwea which also gives a view of the rice fields in the area. At the pole a wildlife camera is attached and at the provisional table the bait (brown unhusked rice) is placed.

Figure S2. An image of 2 parrot-billed sparrows (Passer gongonensis) at a bait station in Mwea.

Figure S3. An image of 10 village weavers (Ploceus cucullatus) feeding at a bait station at University of Embu campus.

Figure S4. An image of 2 fire finches (Lagonosticta spp.) feeding at a bait station at University of Embu campus.

Figure S5. An image of 2 Holub's golden weavers (Ploceus xanthops) and 2 village weavers (Ploceus cucullatus) feeding on a bait station at University of Embu campus. In the background a pole of a hawk-kite can be seen.

Appendix 2

Below, the questions (1-12) asked during the interview of the 11 farmers are presented.

1. "Which crops/fruits usually get damaged/eaten by wildlife? Could you rank them from most to least crop damage?"

2. "Based on your experience, which type of animals/species causes crop damage and which animal causes the most crop damage? Could you rank them from most to least crop damage?"

3. "During what months/season does most of the crop damage caused by wildlife occur? What is the state of the crops at that time?"

4. "Are there any parts of the farmland that are more vulnerable to crop damage than others? (For example: the edges of the fields, Further/Closer to: buildings, forest, water etc.)"

5. "Is the crop damage caused by wildlife a problem for you? In that case how big of a problem (little, medium or big)?"

6. "If you would estimate, how much of your harvest is lost to damage caused by wildlife? Could you estimate that in both weight, percentage and income lost?"

7. "At what time of the day does most of the crop damage caused by wildlife occur?"

8. "Do you have any routine to see if there is wildlife present and to scare them away? - If yes, how often per day and when? How much time do you spend scaring?"

9. "What methods do you use to scare the wildlife and what do they cost? Could you rank different methods by efficacy?"

10. “How does wildlife typically respond to your different scaring methods? (Run/fly away? Do they come back? Aggressive? etc.)”

11. “Has there been a change in how wildlife responds to the scaring methods over the years – and if yes, how?”

12. “From your experience, what would you recommend to other farmers to reduce their crop damages by wildlife?”

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