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Int. J. Biol. Chem. Sci. 16(2): 527-542, April 2022

ISSN 1997-342X (Online), ISSN 1991-8631 (Print)

International Journal of Biological and Chemical Sciences

Original Paper http://ajol.info/index.php/ijbcs http://indexmedicus.afro.who.int

Effect of bird scaring methods on crop productivity and avian diversity conservation in agroecosystems of Benin

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Received: 13-01-2022 Accepted: 20-04-2022 Published: 30-04-2022

ABSTRACT

Farmers are developing methods to scare off and reduce bird damages. The aim of this study is to explore the effect of these methods through a simple form of evaluation that allowed to highlight relationship between these methods and productivity on the one hand, and the relationship between these methods and conservation of birds in the agricultural environment according to different vegetative stages on the other hand. 713 farmers were interviewed in the agro-ecological zones of Benin. This study reveals the use of four methods. These are auditory method, visual method, exclusion method and mixed method. They are used primarily to reduce "loss and damage" and "reduce the frequency of bird visits". 96.78% of farmers agreed that these methods improve yields. Moreover, effectiveness of the methods varies according to the vegetative stages and the duration of its application. Bird species richness was also significantly and positively influenced by bird control methods (Maize: p= 5767e-3) and (Rice: p=4482e-6). Long-term studies, generalized to different forms of agricultural area, are needed for a better assessment.

Keywords: Anti-aviary control methods, growth stage of the vegetation, conservation, Benin.

INTRODUCTION

Since immemorial time, conflicts between humans and wildlife have persisted and now pose serious environmental problems to societies. (Anand and Radhakrishna, 2017). For example, humans continue to trap certain birds through various methods. However, birds are considered bio-indicators species (Lougbegnon et al., 2010; Yabi et al., 2017). One of the major elements that further accentuate this conflict is the anthropogenic destruction of structures use by species for feeding, courtship, resting or nesting sites (Lamoureux and Catherine, 2014). Some structures were anthropogenically transformed into fields of rice, corn, etc. In West Africa, out of 1100 bird species counted 36 are crop destroyers, a rate of 3.3% of the population (Bouet et al., 2017). Among the common species families, only the Sturnidae (starlings) and Ploceidae (weavers) families are known to be pests of cereal and vegetable crops (Schiffers and Moreira, 2011). The research done by Niamien et al. (2019) on sorghum

DOI: https://dx.doi.org/10.4314/ijbcs.v16i2.2

revealed nine species of crop pest birds and this depends on the growth stages. In Benin, Sikirou et al. (2018) identified some species of birds namely the double-spurred francolin (*Pternistis bicalcaratus*), Red-billed weaver (*Quelea quelea*), and Rose-ringed Parakeet (*Psittacula krameri*) as the main maize predators. From all the above, birds are perceived by farmers as major constraints in agricultural production process. As an example Elliot and Bright (2007) indicate that 75% of rice production in South East Nigeria could be consumed by birds. For Schiffers and Moreira (2011) the loss of nearly 50% of the world's agricultural production is caused by the combined effect of crop pests, plant diseases and competition with weeds. Thus, the major concerns of rice farmers are the large production losses caused by granivorous birds (Bouet et al., 2017). In addition, Blackbirds can cause economic losses to seedling and maturing rice in southern regions of North America, and for sunflower and corn in central regions (Cummings et al., 2002). In south-western Nigeria, bird damage has been identified as a major constraint to rice production. It is increasingly acquiring attention from ecologists, wildlife biologists, and wildlife managers around the world (Messmer, 2000; Anand and Radhakrishna, 2017). In general, efforts have been devoted to minimize human-bird conflicts by examining compensatory schemes for crop losses or developing technologies to reduce crop raids (Mazlina et al., 2020). These demonstrated the complexity of the relationship between bird, populations and agriculture (Ormerod and Watkinson, 2000). The multiplicity of agricultural systems and the strategic role of birds for maintaining diversity and ecological equilibrium in this system limited human action (Cassandre, 2012).

Several methods were developed to mitigate the negative impact of bird predation (Arvalis and terre inovia, 2017). Tschakert (2012) suggested strategic directions for research areas, covering adaptation in vulnerability contexts, hence the need to understand the multiple stressors, vulnerabilities on the ground, actual response and limits and barriers to adaptation. In Nigeria, farmers are often forced to adopt bird scaring techniques like nets at high cost (as high as 50% of production costs) (Clive and Bright, 2007). Chemical repellents sometimes can provide a nonlethal alternative for reducing wildlife impacts to agricultural production (Werner et al., 2005).

Agroecosystems are part of hot spots in biodiversity (Codjia et al., 2003; IRD, 2013). In Malagasy, species inventories in two contiguous ecosystems (conserved forest and agroecosystems) revealed the presence of 70% of the recorded species in the agroecosystems (IRD, 2013), with a great diversity in birds. However, populations of farmland birds have declined since the second half of the 20^{th} century both in Europe and North America (Reif, 2013). This has both direct and indirect effects on human well-being as nature provides numerous benefits such as ecosystem services to people (Millennium Ecosystem Assessment, 2005). Studying bird declines in relation to bird control methods is thus important to set the conditions for eff ective biodiversity conservation in farmland.

By focusing on the analysis of bird control methods, this study aims not only to contribute to operationalize these methods in literature, but also to highlight the major constraints that characterize them and that have so far been neglected in analysis of agricultural production process in Benin and which consideration by agricultural policy makers could promote the expansion of methods that reduce negative effects on agricultural production process. Strictly, the aim of this study is to analyze the effect of bird control methods on the productivity and conservation of bird richness in agroecosystems.

MATERIALS AND METHODS

Study area

The Republic of Benin covers 114,763 km² and is located between 6°13'55" and 12°24'26" N latitude and, 0°46'19" and 3°50'58" E longitude (Adam and Boko, 1993). Benin is subdivided into eight agro-ecological zonations according to the relevant crops production in each zone (PANA, 2007). The majority of these zones produce several crops that attract birds. As a result, farmers developed several methods to limit the damage caused by some birds.

Sampling design

A total of eight municipalities were sampled for this study (Figure 1), based on one municipality per agro-ecological zone, and the most relevant crops in each zone (maize and rice) generally appreciated by birds. These municipalities also record the highest productions for the selected crops. Consequently, they are more prone to human-bird conflicts due to the damage caused by birds in search of resources.

The studied agrosystems are composed of several crops always visited by birds. It is the case of cereal production systems dominated by small to large plots (500 m^2 to some hectares), with generally short cycles of 3 months. They are in places associated in polyculture systems with other crops like peanut and bean. In these production systems, bird control is a daily challenge during the entire production period and farmers invest more energy to limit bird predation. Using a stratified sampling technique, villages that practice the target crops of this study were selected from the different agro-ecological zones. The sample size of the interviewees (713 farmers) was defined using Dagnelie's (1998) formula and distributed by a proportionality ratio according to the size of the population. Subsequently, snowball sampling was used to select the people to be interviewed from the important communities in these different villages until the calculated sample size is reached. The interviews were conducted with this predefined number of farmers. Dagnelie's (1998) formula is as follows:

$$N = \mu^2_{1-\alpha/2}\frac{p(1-p)}{d^2}$$

$\mu^2_{1-\alpha/2}$ = 1.96 represents the normal distribution value at a threshold of 0.05; d is the expected margin of error for any parameter to be estimated from the survey and is equal to 0.08, p is the proportion of farmers in the study area that use at least one surveillance technique. This proportion was obtained after a quick survey conducted on 50 individuals that were randomly investigated. This quick survey enabled us identifying farmers who never used a surveillance technique.

After the interviews, a selection of twelve farmers per agro-ecological zone was made. The aim was to monitor production process like the effects of the different anti-aviary control methods used on the productivity and conservation of bird in the field. The selection was based on a stratified set of criteria, with at least one hectare of the target crops of this study being available, and then whether or not to use the anti-aviary control methods. Farmers located in the same area (same village) are then sufficiently informed about the contents of our study and collaboration clauses are defined (participation by location in the installation of control methods and compensation, even if only partial, by location for the control sites). In each of the target municipalities, large agricultural areas were identified. Representative portions of these areas were then delineated in a stratified manner. The control areas were then selected in proportion to the agricultural area identified for each of the speculations.

Data collection

Survey of farmers

This study was conducted from March 2018 to May 2020, and a questionnaire was administered to the 713 farmers through “Kobocollect” application on smartphones. Data collected included bird species, description and mode of action on agroecosystems, control methods adopted against, extent of the bird damage to farmers' crops. Initially, farmers listed the most frequent birds in their fields that are potential responsible of the damage recorded in terms of loss and destruction. To do this, the farmers describe the species one by one and then take out the guide and identify the birds that most closely match their description so that they can point out the species. They were then asked to rank the extent of bird damage on a scale of 1 to 5, with 1 representing the least severe damage (Saraswat et al., 2015). We ask them to describe the mode of action of the species mentioned. This interview also provided information on the motivations for installing bird control techniques and their perceptions of the effects of these techniques on the bird conservation and crop productivity. They finally provide details about the different techniques and their effectiveness according to crops growth stages.

Inventory of bird species in the different systems

On the production sites of the farmers selected, on the basis of the above predefined criteria, the avifauna was counted taking into account the different control methods used. The method applied to collect data on avifauna is simple stratified point sampling (SPS) based on 20-minute points counts (Cordonnier, 1976; Spitz, 1982; Prodon, 1988; Lougbégnon, 2008). The inventory data made it possible to assess the specific richness of each method of bird control method.

Data analysis

Anti-avian methods and productivity

Data were collected in the different forms of agroecosystems considered in the delimitation measures. Rice and maize were chosen for this study because of their frequent damage. In the ripening phase, the different crops were harvested and then transported in bags, the quantities of which were known in advance. Nevertheless, these crops were weighed to have a better idea of their quantity. And then, to test the effect of control methods on productivity, yield data from monitoring farmers using control methods and those not using (control sites) bird control methods (with the same proportion of land under cultivation) were collected. These data allowed using a non-parametric Wilcoxon test to compare average yields from agroecosystems using bird control methods and agroecosystems considered as control sites.

Anti-avian methods and conservation

Control method identified in the field have been categorized into four control techniques. The four methods are: Auditory methods, Exclusion method, visual method and mixed method (Table 1). To check which of the methods best contribute to the conservation of avian wildlife we performed a non-parametric Kruskall-Wallis analysis after Shapiro-Wilk's normality test. The control methods were compared using the non-parametric pairwise wilcoxon test. All tests are significant at the 5% level.

Relationship between the positioning of bird control methods, vegetative stages and damage location

Chi-Square independence test was used to test the dependent relationship between positioning of birds control methods in agroecosystems and damages location.

To test the significance of the effect of control methods on crop (Rice and maize) productivity, we used Wilcoxon's non-parametric test after normality test with Shapiro-Wilk test.

Bird's surveillance methods, damage location and vegetative stages in some agroecosystem

When farmers were asked about the intensity of the damage and its location, 93 percent mentioned sowing and milky stages. During these different stages, damage is generally recorded at precise positions in relation to the positioning of the techniques used in the targeted agroecosystems. Thus, we suspected a relationship between the vegetative stages, the location of damage and the types of methods used.

To verify this relationship, we carried out a Chi² test between the positioning of damage in agroecosystems and the types of methods used. Then, a correspondence factorial analysis was carried out in order to find out the possible relationships that would exist between the vegetative stages, the location of the damage and the types of methods commonly used. All Analyses were performed with R software.

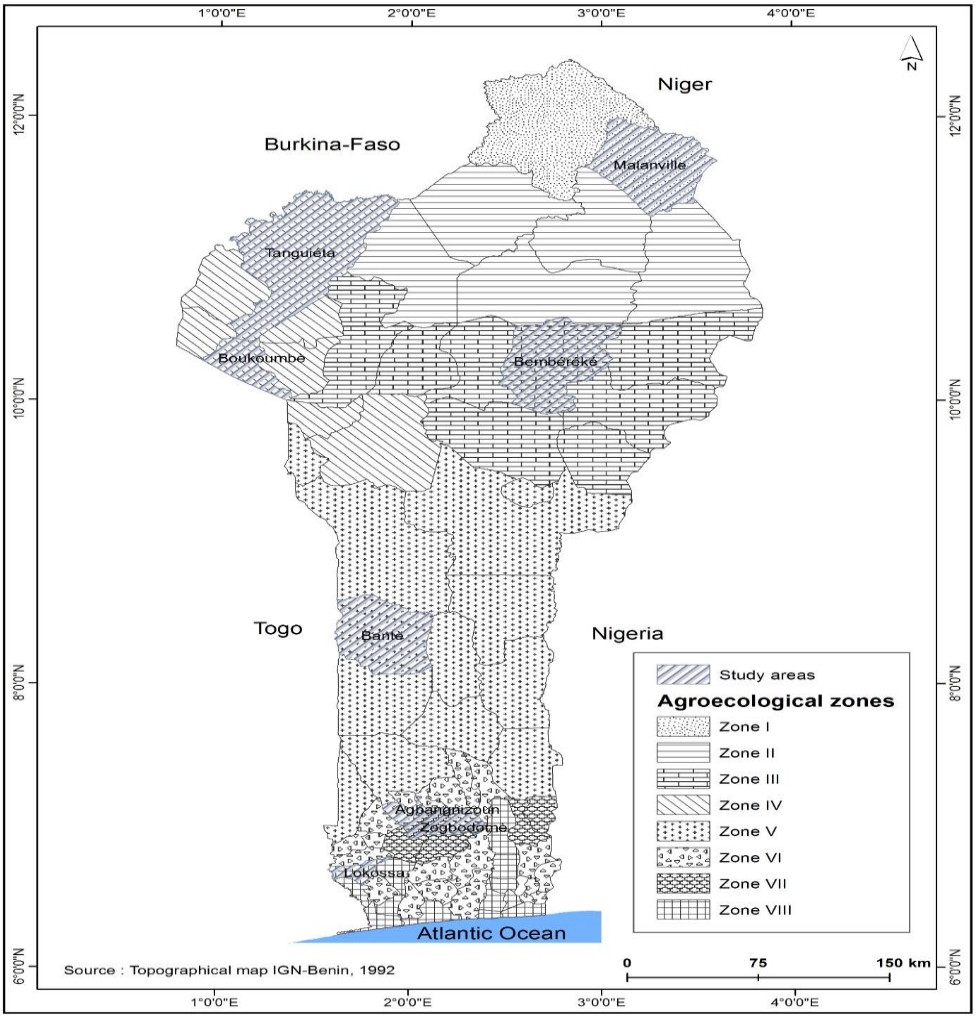

Figure 1: Map of Benin Republic showing the eight agro-ecological zones and the communes sampled for survey.

Table 1: Techniques used to control birds in crop fields.

Techniques	**Descriptions**	**Examples**
Auditory method	Consists of emitting sounds and noises in order to keep birds away from agroecosystems.	Use of cassette tapes that in contact with the wind, repel birds with the resulting noise; use of old sheet metal with spikes; monitoring with noise to keep the birds away
Exclusion method	It consists in excluding birds from the field, it is a direct control method.	Technics of seeding with avicides: which consists of using insect repellent for seeding; surveillance: which consists of walking the field and capturing or killing birds; Use of nets: (for high-value crops, nets are usually placed above crops) and

		traps for capturing birds and the use of fire to burn bird nests.
visual methods	It consists in playing on sight in order to keep the birds away	The traditional scarecrow. Tire bands and tape recorders also create visual disturbances for birds in contact with the sun, as they are reflective bands.
mixed method	It consists of combining different methods listed above in the quest for effectiveness in the removal of avian fauna. In practical terms, it is a method that makes great demands and often requires more resources.	all of the above in combination

RESULTS

Diversity of Bird and control method

Control methods and description

As shown in Table 1 the bird control methods used in Benin are varied and are applied in various forms. These methods are classified into four main categories: auditory methods, visual methods, exclusion methods and mixed methods.

Some birds and control methods

- Birds cited by farmers

Fourteen birds' species have been cited by farmers (Table 2). Some of these species are insectivorous (feed on a large number of pests insect) and act as natural and effective insecticides. On the other hand, there are also some species of omnivorous birds that attack crops, especially planted seeds, flowers, fruits or different forms of cereals (Sorghum, rice...) especially at the harvest stage. It is therefore this category of species that motivates farmers to develop control methods in order to reduce their effect on productivity. Thus, the adoption of a form of crop protection against these bird species implies direct control, crop protection with physical objects and the use of sound and/or visual repellents. The adoption of the appropriate method depends on a series of parameters mentioned by farmers. Among these parameters, the area of the crop to be protected plays an important role. Indeed, some control methods are effective on a small scale and are not effective on a large scale. Finally, given the magnitude of the problem, if food is scarce for the birds and their populations are large, they will be willing to take great risks to feed themselves despite all the means used to keep them away. Beyond these parameters, some bird species impose their own mode of frightening.

- Birds inventory by technical used

Regardless of the method considered, birds always mark their presence in the fields. These species are present for various reasons depending on their ecology. In fields with auditory control methods, very few bird species are observed (Table 3). This could be explained by the fact that noise is a disturbing factor. The sites where the visual methods were installed are the preferred sites for the majority of birds. More than 20 species were recorded at these sites. Therefore, the auditory methods manage to frighten the different species of birds by the emission of noise to dissuade them.

-Specific richness

The mixed method technique is more diverse (H=2.30) in bird species than the other control techniques (Table 4). On the other hand, the birds are less diverse when it comes to the auditory method (H=5). In fact, 25 species were inventoried in all the techniques, i.e. 10 species in the mixed method technique compared to 5 species inventoried in the auditory method technique (Table 4).

Farmer's motivation for using Birds control methods

Farmers motivations for the installation of bird surveillance techniques include "losses and damage observed" (67.85 % citations) and crop protection (13.87 %). This was followed by other motivations related to incentives through capacity building sessions to reduce bird damage in the fields (Figure 2). In this category we have "After training" (6.44%) and "After awareness raising" (0.84%)

Effect of birds surveillance methods on productivity

Farmer's perceptions of the effect of birds control methods on productivity.

96.78 % of our respondents testified effectiveness of bird surveillance methods for feeling that these techniques have an effect on productivity (Figure 3). They said that certain combinations of techniques allow them to reduce damage. They indicate that the combination of techniques varies depending on the size of the crop (vegetative stage). However, 3.22 % of our respondents continue to look for ways to use these techniques. They indicate that the techniques have not yet been effective in their experience.

Anti-avian methods and productivity

Whatever the speculation considered, period of use of bird control methods has a positively significant influence on yield (Figure 4).

Maize

The yield of maize is significantly and positively influenced after the use of pest control means (W = 6760, p-value = 0.00000001432).

Rice

The yield of Rice is significantly and positively influenced after the use of pest control means (W = 7264, p-value = 5.142e-12). The yield is higher after the use of pest control measures (Figure 5).

Effects of bird control method on bird's conservation

Whatever the speculation considered, the species richness of birds was significantly influenced by the different techniques of bird control methods. Indeed, the visual method and it association are methods where the species richness of the avian fauna appears to be the highest in agricultural areas. This method therefore contributes to a greater conservation of bird fauna, unlike the other methods practiced by producers, as well as their combinations.

Maize

The specific richness of maize cultivation was influenced by the control methods (chi-squared = 23.198, df = 9, p-value = 0.005767). The MV_MA_ME method has the greatest influence on this richness (Figure 6).

Rice

The specific richness of the rice crop was influenced by the control methods (chi-squared = 41.262, df = 9, p-value = 0.000004482). The MA and MV_MA method has the greatest influence on this richness (Figure 7).

Positioning of birds surveillance methods, vegetative stages and location of damage in agroecosystems

Bird's surveillance methods and damage location in some agroecosystem

There is a dependency between bird surveillance techniques and location of the damage (p-value = 7.401542e-109). For each location we had a specific technique to control birds (Figure 8). MA_MV technique is more used in the field, but the technique (MV_ME) is more practiced in field and in mixed areas the MA_MV_ME technique is practiced in almost all location.

Table 2: List of species commonly encountered in the field for which the control techniques mentioned by the farmers are also listed.

Species	**Mode of action in agricultural area**	**Control methods adopted against**
Dendrocygna bicolor **Tawny Dendrocygne**	Damage to rice fields after sowing by trampling the plants	Frightening, guarding, elimination
Pternistis bicalcaratus **Double spurred francolin**	Damage to seedlings on rice, corn, sorghum...	Seed repellents, field guarding, elimination
Numida ineleagris **Helmeted guinea fowl**	Millet damage after sowing	Seed repellents, field guarding
Balearica pavonina **Crowned crane**	Trampling damage on rice	Guardianship (protected species)
Streptopelia semitorquata **Collared Turtle Dove**	Damage after sowing on maize and rice	Frightening, guarding, elimination
Streptopelia decipiens **Mourning Dove**	Damage to rice and sorghum	Frightening,
Turtur afer **Red-billed emeraudine**	Damage after sowing on rice, maize and peas	Frightening
Poicephalus senegalus **Youyou**	Damage to sorghum and maize cobs	Guarding, and repellent
Corvus albus **; Pied Crow**	Damage to sorghum ears	Guarding
Ploceus cucul Zatus **Village Weaver**	Damage to sorghum, millet, rice, wheat and maize cobs	Guarding, repellents, protection of fields with nets, Field treatment with avicides
Ploceus melanocephalus **Black-headed weaver**	Damage to ears of millet, sorghum, rice, damage to rice seedlings	Guarding, repellents, protection of fields with nets, Field treatment with avicides

Table 3: Species encountered by control method.

Methods	**Birds inventory**
Auditory method	*Ploceus cucullatus, Ploceus melanocephalus, Streptopelia decipiens, Streptopelia roseogrisea, Crinifer piscator, Actophilornis africanus, Quelea erythrops*
Exclusion method	*Bubulcus ibis, Spilopelia senegalensis, Centropus senegalensis, Corvinella corvine, Corvinella corvina, Ploceus cucullatus, Ploceus melanocephalus, Hirundo aethiopica, Psittacula Kramer, Quelea erythrops*

visual methods	*Falco biarmicus, Bubulcus ibis, Spilopelia senegalensis, oriolus larvatus, Passer griseus, Centropus senegalensis, Lonchura cucullata Lamprotornis chalybaeus, Corvinella corvina, Accipiter badius,Turdus pelios, Ptilostomus afer,Uraeginthus angolensus, Pternistis bicalcaratus, Ploceus cucullatus, Ploceus melanocephalus, Spilopelia senegalensis, oriolus larvatus, Passer griseus, Pycnonotus barbatus, Lonchura cucullata, Lonchura fringilloides, Lamprotornis chalybaeus Psittacula krameri, Hirundo aethiopica*
mixed method	*Euplectes franciscanus, Apus pallidus, Coracias abyssinicus, Hirundo rustica, Lonchura cucullata, Apus affinis, Cypsiurus parvus, Telacanthura ussheri, Motacilla clara, Viuda senegalesa*

Table 4: Summary of Shanon's index values, pielou equitability by control method.

Techniques	Richness	Shannon	Equitability of pielou
Auditory method	5	1.6094379	0.69314718
Exclusion method	8	2.0794415	0.69314718
mixed method	10	2.3025851	0.69314718
visual methods	7	1.9459102	0.69314718
pooled	25	3.1701483	0.68265428

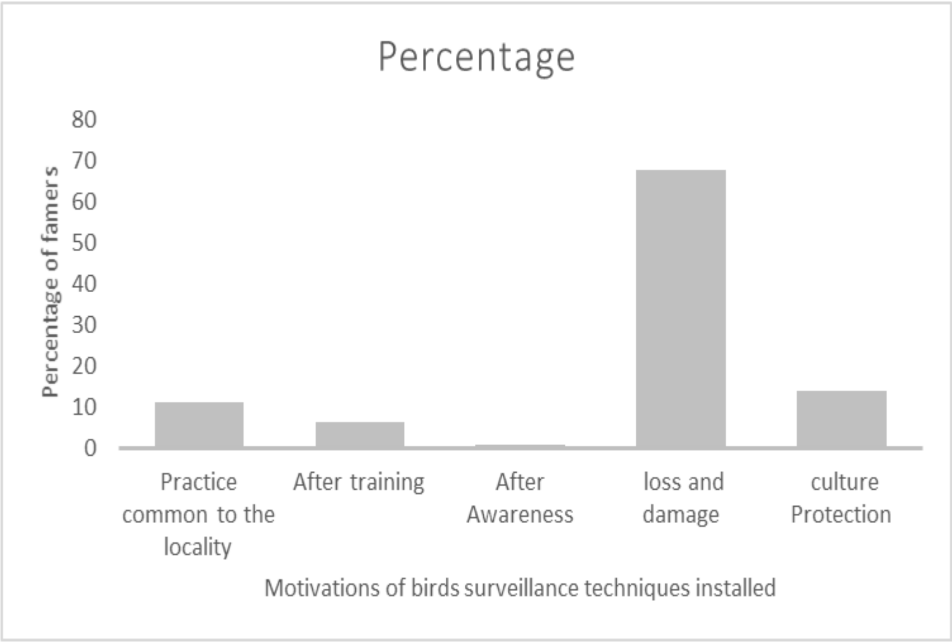

Figure 2: Motivations for installing bird control systems in agroecosystems.

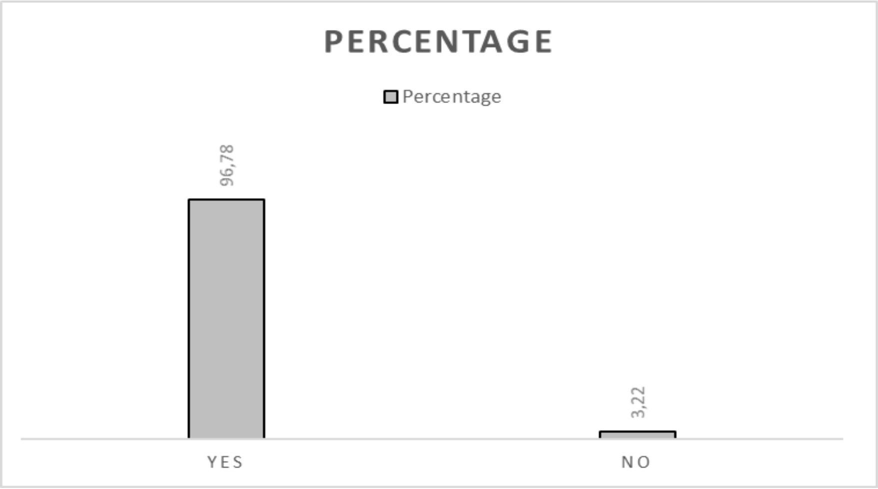

Figure 3: Rate of recognition of the effectiveness of bird surveillance techniques.

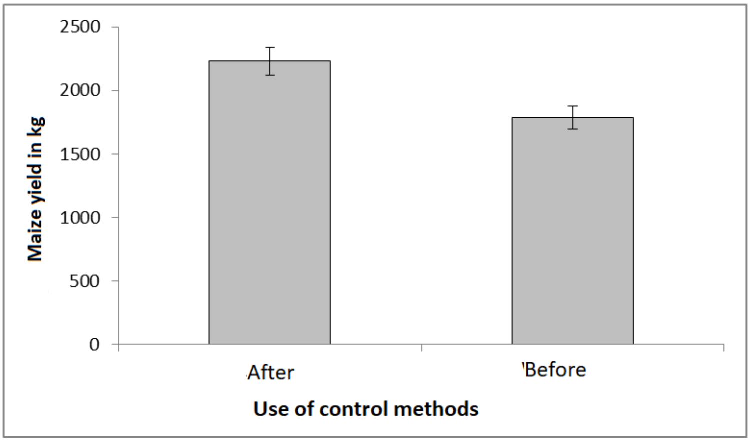

Figure 4: Average maize yield as a function of time of use of pest control methods.

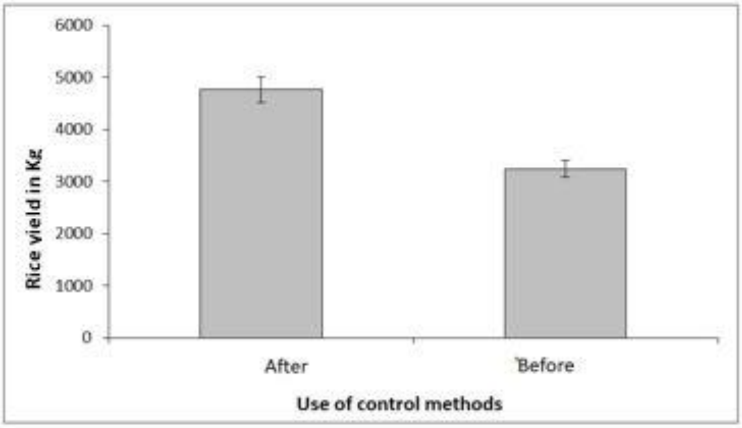

Figure 5: Average rice yield as a function of time of use of pest control methods.

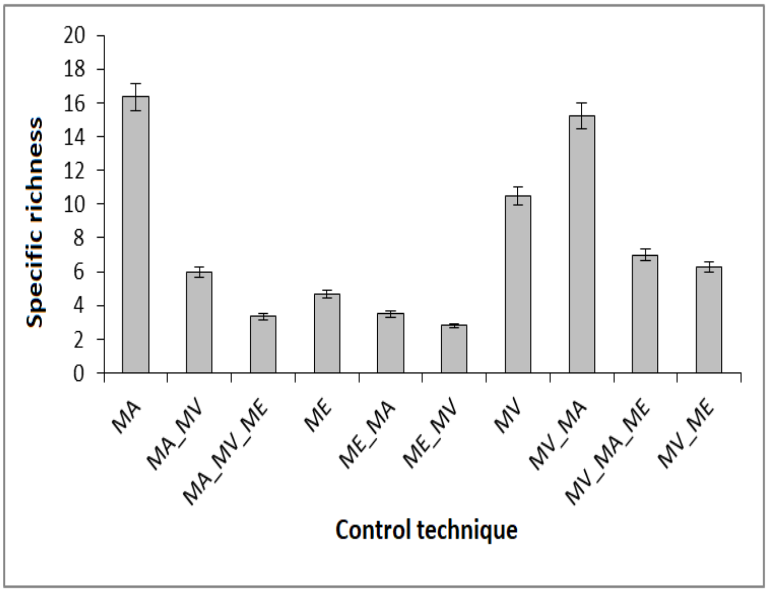

Figure 7: Specific richness of avifauna according to control methods used in the rice agroecosystem. **(Abbreviations. Full form):** MA = auditory method; ME= exclusion method; MV= visual method; MA_MV_ME= combined technique of auditory method, visual and exclusion method; MV_ME= combined technique of visual_and_exclusion_method; MA_MV= combined technique of the auditory method_visual method and.

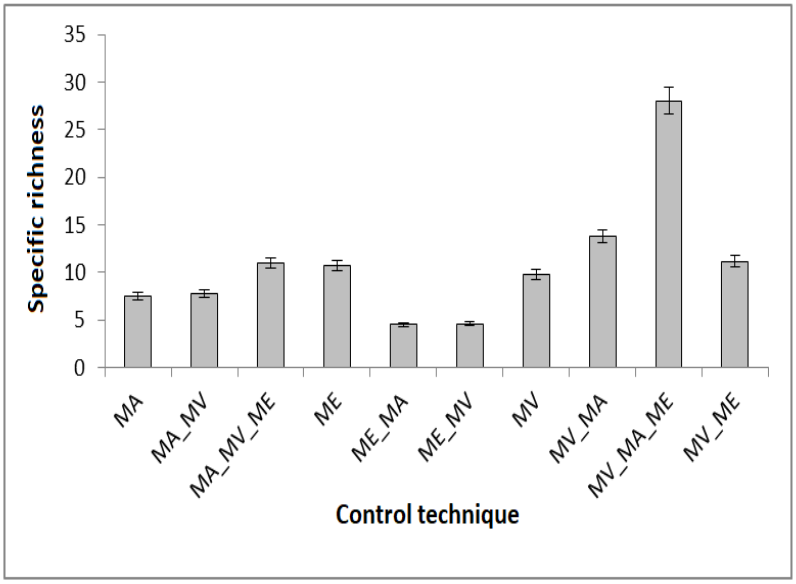

Figure 6: Specific richness of avifauna according to control methods used in maize agroecosystem. **(Abbreviations. Full form):** MA = auditory method; ME= exclusion method; MV= visual method; MA_MV_ME= combined technique of auditory method, visual and exclusion method; MV_ME= combined technique of visual_and_exclusion_method; MA_MV= combined technique of the auditory method_visual method and.

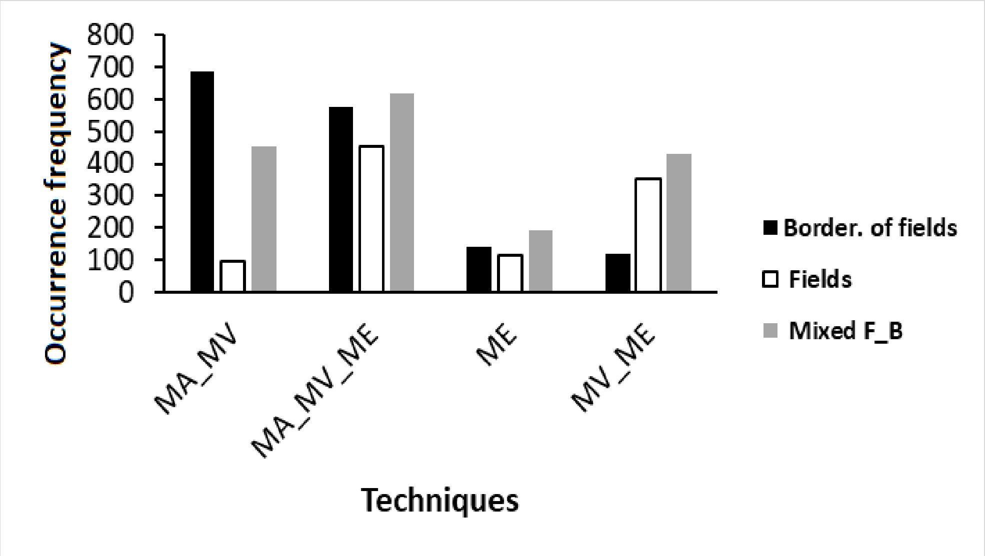

Figure 8: Relation between bird surveillance techniques and location of damage.

(Abbreviations. Full form): MA_MV_ME= combined technique of auditory method, visual and exclusion method; MV_ME= combined technique of visual_and_exclusion_method; MA_MV= combined technique of the auditory method_visual method and ME= exclusion method.

DISCUSSION

Our paper presents three major findings. Motivations related to installation of bird control techniques are diversified. The survey revealed five different motivations, namely "Crop protection", "huge losses and damages" which are major motivations, then "after sensitization", "following training" and "practices common to the locality" which are the three other motivations. Delval and Ulrich (2018) found similar motivations for using anti-aviary control methods to keep birds away from fields. They reported in their survey results that farmers support losses, but when these become significant due to overpopulation of birds in a given production area, farmers respond by installing anti-avian control techniques. They concluded that frequency of bird visits is an important motivation for installation of control techniques. This last motivation is linked to others mentioned above, since protection initiative only comes into play when frequency of visits and the samples taken by these visiting birds make it necessary. Direct relationship between different motivations resulting from survey and those identified by Delval and Ulrich (2018) is the reduction of bird's action on crops. Clergeau (2000), has indicated that all human interventions in this process of anti-aviary control can be summarized in two strategies. The first consists of the protection of sites with various methods which aim is to keep birds' away (use of scarecrows, use of noise in all its forms, use of chemical repellents, and use of netting) and the second consists of the elimination of birds. Sikirou et al. (2018) follow the same logic, indicating that these techniques just needed to be supplemented by agronomic strategies (modification of sowing dates, for example) and environmental measures (guaranteeing peace of mind for local residents, for example). Adekola et al. (2019) find that for the strategy of direct protection of sites, the different techniques used are guarding or surveillance, which is a very widespread practice in Africa and above all is irreplaceable at farmer's level; scare techniques which include scarecrows, flags, reflective strips, balloons, silhouettes of predators which are only effective for a period of time. Protection by netting and the use of repellents are techniques that they find tenacious and durable, but without any guarantee for conservation of target species. The results of this study are well in line with these various research studies.

However, the categorization of control techniques into four different methods is supported by many authors such as Carrier (2002). Even though he mentioned three methods without specifically mentioning the association of different control techniques. It should nevertheless be noted that the agronomic method that consists in modifying the sowing calendar, i.e. choosing sowing dates to coincide with the absence or low density of bird populations, is used very little or very hardly except in the Boukoumbé region where we recorded a few cases of farmers who mentioned it. The use of these agronomic processes, i.e., cultivation techniques (cutting off ears of corn; use of resistant varieties, i.e., less attractive varieties) are very little used in Benin. This is justified by the fact that the majority do not have access to this kind of information or a lack of inattention and also a lack of training with modules that evoke it. It can also be explained by the fact that man is much attached to what he masters best or what he has seen the majority practice. Therefore, these practices are not necessarily a vehicle to arouse their attention to the point of experimenting with it. Moreover, many farmers adopt a combination of techniques for the sole purpose of seeking effective protection. According to Robert (2011), partial effectiveness of control techniques is obtained when control methods are combined. It supposes that control techniques (scaring techniques) cannot only be sufficient to keep birds away; these techniques must be combined. Scaring techniques alone, for example, just move the birds from one location to another. Monitoring alone, on the other hand, is only possible if the field is small and even then, it requires a very expensive human resource (Bouet et al., 2014). A combination of these techniques is therefore indicated like best option (Mey et al., 2013). In addition, since control techniques vary among birds, a combination could affect a group of birds consisting of several species' types (Mey et al., 2013; Mofokeng et al., 2016). The results of this study reveal that there is a significant effect of control methods on crop yields. Bouet et al. (2014) reached the same conclusion.

Effect of the techniques listed on conservation varies from one technique to another. This is all the more evident as the categorization of techniques clearly indicates these. By way of illustration for the vast majority, techniques that are categorized as proprietary methods lead to the elimination of birds, while auditory and visual methods are relatively conservative of the species. They are used in the majority of cases to scare birds. Furthermore, based on the species richness of the different methods, the visual method is the one that indicates a relatively high species richness. This investigation shows that the visual method contributes best to conservation of birds in the agricultural landscape compared to the auditory and exclusive methods.

Conclusion

The study highlighted effect of anti-aviary control methods on the productivity and conservation of avian fauna in agricultural areas. Control techniques are diversified and used in several forms. These techniques were categorized into four control methods (visual method, auditory method, exclusion method and mixed method). The study shows that different methods used vary according to the producer groups. Moreover, the installation of these techniques in agroecosystems helps to improve yields. However, not all of them contribute to the conservation of avian fauna. This is the case of exclusion methods and it combination, which through certain techniques eliminate some species. The visual method and in some conditions auditory methods remains the method that best participates in the conservation of bird fauna. In view of these results, it is urgent that governor and international institutions get involved in the promotion of protective methods for the diversity of birds in the agroecosystems according to the species. Despite the validity of these results, a study on the ecology of the more cited species, in particular advanced analyses of the content of the crop or isotopic analyses should contribute to ensure more sustainably not only for the production of species but also for conservation and specific richness.

COMPETING INTERESTS

The authors declare they have no competing interests.

AUTHOURS' CONTRIBUTIONS

This article is the work of one lead author (HA) and 3 other co-authors (EPSA, PJD, SHB). HA is the author who conceptualized, wrote the research protocol, conducted the field surveys, designed the database and. EPSA coordinated the reorganization of the data and edited the first draft. PJD revised and edited the first draft. In addition, SHB contributed to the validation of the research protocol, questionnaire and survey guide, data analysis, and editing of the first draft to this one.

ACKNOWLEDGEMENTS

Funding for materiel used in the field is provided by IDEA WILD. We would like to thank the agents and managers of the Territorial Agricultural Development Agencies (ATDA) for facilitating and putting us in contact with farmers. Many thanks' to the farmers for making their fields available and for their precious help in the process of collecting data related to avian control methods and crops productivities.

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