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ASSESSING THE IMPACT OF VERTEBRATE PEST-INDUCED ON-FARM MAIZE LOSSES ON YIELDS, INCOME, FOOD SECURITY AND FARMERS' LIVELIHOOD IN IFELODUN LOCAL GOVERNMENT AREA, KWARA STATE, NIGERIA

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ABSTRAK

In developing countries, pests' damage to fields and stored crops substantially contributes to losses in farm yields and income. Studies have investigated the impact of insect pests on maize production, with inadequate attention on the impact of on-farm losses of maize from vertebrates. Consequently, this study examined types, stages, intensity, effects, and control of vertebrate pest-induced on-farm losses of maize as well as assess its effects on maize's yields and income and its impact on food security and farmers' livelihood in Ifelodun LGA, Kwara State, Nigeria. 500 Maize farmers were selected through convenient sampling from 14 randomly selected settlements in the study area. Responses were analyzed using descriptive statistics (percentages), while inferential statistics (ANOVA) was used to assess the degree of spatial variations and hypothesis testing; because of its suitability for analysis of differences among the means of more than two groups. The result shows that the majority; identified grass cutter as the vertebrate pest largely responsible for on-farm losses (38.6%), sustained on-farm losses at the fruiting stage (60.0%), described the intensity of on-farm losses as very high (58.4%), affirmed negative impact of on-farm losses from vertebrate pests on Maize's yield and income (70.8%) and upheld the negative impact of On-farm losses of Maize from vertebrate pest on food security and farmers' livelihood (75.4%). The result shows no significant variations in the perception of respondents on the negative impact of vertebrate pest-induced on-farm losses of maize on food security and farmers' livelihood across the settlements ($F(3,483) = 0.755$, $P > 0.05$). The study concluded and consequently recommended improvement in the control mechanisms of vertebrate pests to reduce on-farm losses to increase maize yields and income as well as improve farmer's livelihood and food security..

Keywords: *Food Security, Livelihood, Maize, On-farm losses, Vertebrate pests*

INTRODUCTION

Damages from pests to fields and stored crops are among the major causes of huge losses to agricultural investments in developing countries. Even though agriculture employs nearly three-quarters of Nigeria's workforce (Etim and Edet, 2013), Nigeria remains one of the largest food importers in Sub-Saharan Africa (Ojeka, 2016; Igwe, 2018); this may not be unconnected with the fact that over 80% of the Nigerian farming population is made up of small-scale farmers (Ugbor, et al., 2018). The inadequate level of crop output in developing countries could also be explained by the fact that agriculture is constrained by pests and diseases, low access to capital, market, credit and storage facilities, research and extension services, among other myriads of problems (Mpanddeli and Mpanya, et al 2014; Nsikak-Abasi, et al 2015; Ojeka, et al, 2016; Makuvaro *et al,* 2017).

There is no gain saying in the assertion that pest causes enormous havoc in agriculture. Specifically, crop pest constitutes a major constraint to agricultural production worldwide (Derke, 2006). Insect infestation has been associated with losses ranging from 5% to 15% specifically on maize crops (Upadhyay *et al,* 2023). For instance, an earlier study in India has reported that maize crops suffered losses ranging from 26-80% due to stem borer (insect pest)

during the kharif season in various agroclimatic environments (Upadhyay *et al,* 2023). In developing countries, on-farm and stored crops are vulnerable to a high degree of damage by insect and vertebrate pests. Additionally, insect infestation of stored agricultural products causes significant qualitative damage (Bharathi *et al.*, 2017). Insect pests are known to have accounted for 15.7% in India 100% of crop loss (Dahliwal *et al.,* (2015). A typical example of an insect pest that constitutes massive havoc to maize fields is locust (Wright *et al,* 2000)

Vertebrate Pests which is the focus of this study are animals with a backbone that causes damage to crops through feeding; they can be birds, mammals, and reptiles. In the course of feeding, vertebrate pest causes huge damage to both fields and harvested/stored crops; with negative consequences on yields and income obtainable from farming investments (Quamar *et al,* 2019). Vertebrate pest is known to have accounted for at least 1 billion dollars in terms of agricultural loss and environmental damage in Australia (Saunders *et al.,* 2010). Vertebrate pests (rodents and birds) of maize have been on the increase sequel to increasing hectarage cultivation and utilization potential of maize in the country (Fayenuwo *et al,* 2007). If not adequately checked could negatively impact rural livelihood and food security problems, especially in the face of the increasing population in Nigeria. Vertebrate pests in this study include birds/avid (guinea fowl, quail) mammals (grass cutters, squirrel, and monkey) causing damage to crops, especially Maize. For instance, Amusa *et al* (2005) reported that damages associated with birds and rodent vertebrates on maize fields in the Southwestern agro-ecological zone of Nigeria ranged from 20% to 59%.

Studies have shown that damages due to vertebrate pests are usually sustained during the pre-harvesting; especially from the planting till harvesting time on the farm/field and post-harvesting (storage) stages (Bhattarai and Basnet 2004; Gary, 2007; Bayam *et al.* 2016; Qamar *et al,* 2019). This study specifically focuses on vertebrate pests responsible for on-farm losses of maize (planting till harvesting time). Vertebrate pests like monkeys can cause total or almost destruction of maize crops on the field. The economic losses so sustained can lead to traumatic psychological and emotional disturbances for the farmers. The need to drastically eliminate or lessen losses through on-farm losses is highly imperative. In an attempt to overcome economic loss due to rodents and birds, farmers are known to have used rodenticides, avicides, trapping, and aversion (Sexton *et al*. 2007). The inability to effectively control pests is a major contributor to the heightened level of food insecurity in most rural farming populations. This buttresses the notion that pest is a major cause of crop failure (Quamar *et al,* 2019); with negative impacts on maize's economic chain and food security. Food security is a situation when everyone, at all times, has physical, social, and economic access to enough, safe, and nutritious food that satisfies their dietary needs and food choices for an active and healthy life (FAO, 2002). Almost two billion people experience moderate to severe food insecurity today because they lack regular access to a sufficient variety of food with adequate nutritional value, or insufficient food to feed the entire population. Apart from the on-farm losses, it is a known fact that people in developing countries lost their stored food and crops containing economic yield due to the attack of rats, mice, and pet birds (Tobin and Michael, 2004; Kumar Daud Kalita 2017). The high incidence of pest attacks on field and stored crops must have played contributory roles to the low level of crop output and income as well as diminishing the level of farmers' livelihood; this also constitutes a major setback to the achievement of goals 1 (end hunger) and 2 (end poverty) of sustainable development. There is no gain saying in the assertion that the difficulties people have in achieving their nutritional needs, especially in poor nations (Oyinloye *et al.,* 2018) connected to the decreasing output of so many crops including maize.

Maize (*Zea Mays* L) commonly referred to as corn is a member of the grass family Poaceae. It is a cereal grain of global relevance. It has long been grown by people in ancient Mexico, and Central and South America. In sub-Saharan Africa (SSA) Maize is the most commonly-grown cereal staple with a total cultivated area of more than 40 million ha as of 2017 and the most consumed staple food in households (FAOSTAT, 2018). It is estimated that more than 300 million people in SSA depend on Maize as a source of livelihood (Mqcauley and Ramadjita, 2015). As of 2018, Nigeria was the second largest producer of Maize in Africa (FAOSTAT, 2018). Maize is a major source of food for man eaten as roasted or boiled, it is also being used to make palp (solid and or liquid) or even as a food supplement for Amala (a popular Yoruba food). In addition, it is being used to make popcorn, ethanol, animal feed, and other maize products, such as corn starch and corn syrup. Despite its multi-faceted uses, the crop suffers several biotic stresses due to its vulnerability to weeds, insect pests, vertebrate pests, and pathogens irrespective of the location.

Previous studies on vertebrate pests have examined losses sustained on Maize, Guava, sugarcane and root tubers at *both field* and storage. However, information is lacking on the on-farm losses of maize particularly due to vertebrate pests despite its widespread cultivation and vulnerability to vertebrate pests in in the study area. Therefore, understanding farmers' perception of the impact of on-farm losses of maize due to vertebrate pests on maize's yields and income as well as food security and farmers' livelihood across the maize food chain is considered necessary with the aim of reducing vertebrate pests' induced havoc, improving maize production, food security, and farmers livelihood. Therefore, this study identifies the vertebrate pest responsible for on-farm losses of maize, stages of damage, intensity of damages, and control mechanisms of on-farm losses of Maize due to vertebrate pests as well as the perception of farmers on the effects of vertebrate pest-induced on-farm losses of Maize on food security and farmers' livelihood in Ifelodun LGA, Kwara State, Nigeria.
The study stated this hypothesis:

H_0: there are no significant variations in the perception of respondents on the negative impact of on-farm losses of Maize due to vertebrate pests on food security and farmers' livelihood.
H_1: there are significant variations in the perception of respondents on the negative impact of on-farm losses of Maize due to vertebrate pests on food security and farmers' livelihood.

MATERIALS AND METHODS

Data for this study were obtained from primary and secondary sources. Multi-stage sampling technique was used to select settlements and respondents for this study. First, all the settlements in the Local Government Areas (LGAs) were arranged according to their population size. Records of the 1991 population census figures of the study area obtained from the National Population Commission office, Ilorin were projected to 2017 using to 2017 using the 1.03 percent growth rate for rural areas in Nigeria (World Bank Group, 2016). Subsequently, settlements with a population of at most 19,999 are categorized as rural settlements (Madu, 2010) to generate the population estimate of various settlements in the study area. The reason for the choice of the 1991 population census figures was because it is the only population figure of the area that has the population of the study area on a community basis. 14 settlements were purposefully selected. Also, based on the average household size of 4.6 people declared in the result of the National population survey (Nigeria, 2014) the number of households in the selected settlements was computed. Second, using a convenient sampling technique, the settlements were divided into three population groups 1 (≤ 5000), 2 (5001- 15,000), and 3

(>15,000); 30, 40, and 50 respondents were selected from sampled settlements in each of the population groups 1, 2 and 3, respectively through snow-ball sampling technique (Table 1). Responses were analysed using descriptive statistics (percentages), while inferential statistics (ANOVA) was used to assess the degree of spatial variations and test the stated hypothesis due to its suitability for the analysis of differences existing among the means of more than two groups.

Table 1. Names of Sample Settlements and the Number of Respondents Selected

S/N	Settlements	Pop. as at 1991	2017 pop. at 1.03 growth rate	No of Household per settlement	Number of household head selected
1	Igbaja	11012	14374	2875	40
2	Sagbe	1692	2209	442	30
3	Omupo	6411	8368	1674	40
4	Alabe	965	1260	252	30
5	Arobaiye	1059	1382	276	30
6	Amodu Asungbolu	640	427	128	30
7	Babanloma	11059	14435	2887	40
8	Share	15359	20048	4010	50
9	Babanla	3686	4806	961	30
10	Oke-Oyan	1663	2171	834	30
11	Oreke	540	705	141	30
12	Ora	3251	4244	849	40
13	Oro-ago	8333	10877	2175	40
14	Oke-ode	6734	8790	176	40
	Total				500

The questionnaire was purposively administered to selected adult maize farmers (18 years and above), who have been in maize cultivation for at least two years (believed to have enough experience to answer long-time durational questions as far as Maize cultivation is concerned) in the selected settlements. The study made use of a set of questionnaires divided into sections largely composed of closed questions. The questionnaire largely employed Likert Scales such as 3-scale and 4-scale; such as high, very high, low, and very low in an attempt to determine respondent's view on types and degree of effects of vertebrate pest on maize production in the study area. Also, Yes or No options was equally used. A total of 500 copies of questionnaires were administered in the entire study area.

Study Area

The study was carried out in Ifelodun local government area, Kwara State, Nigeria. It is situated between latitude 8º 20' 0" N - 9º 0' 0" N and Longitude 4º 20' 0" E - 5º 20' 0" E in the North Central part of Nigeria by geo-political division (Figure 1). Ifelodun Local Government Area (LGA) was created in 1976 with the headquarters in Share. The LGA has a border with Asa, Edu, Isin, Irepodun, Ilorin South, Moro, and Oyun local Government areas as well as the Yagba West local government area of Kogi state. In terms of area coverage, Ifelodun local government area is the largest LGA in Kwara State with an estimated land area of 3,435 km. It has an estimated population of about 206.042 (NPC, 2006; KWSMI, 2002). Ifelodun local government area is located in the tropical climate area, characterized by wet and dry seasons with harmattan intervening from December to January. The wet season takes off in late March/early April and stops in late October/early November. Annual rainfall ranges

from 1000 mm to 1500 mm, and mean temperature ranges from 25º C to 30º C (Oyegun, 1983; Olaniran, 2002). The study area is in the transitional zone of climate and vegetation, as such, neither has extreme drought nor rainfall. The vegetation type is largely made up of guinea and derived savanna (Oyegun, 1983). Common trees in the area are locust bean, acacia, and shear butter.

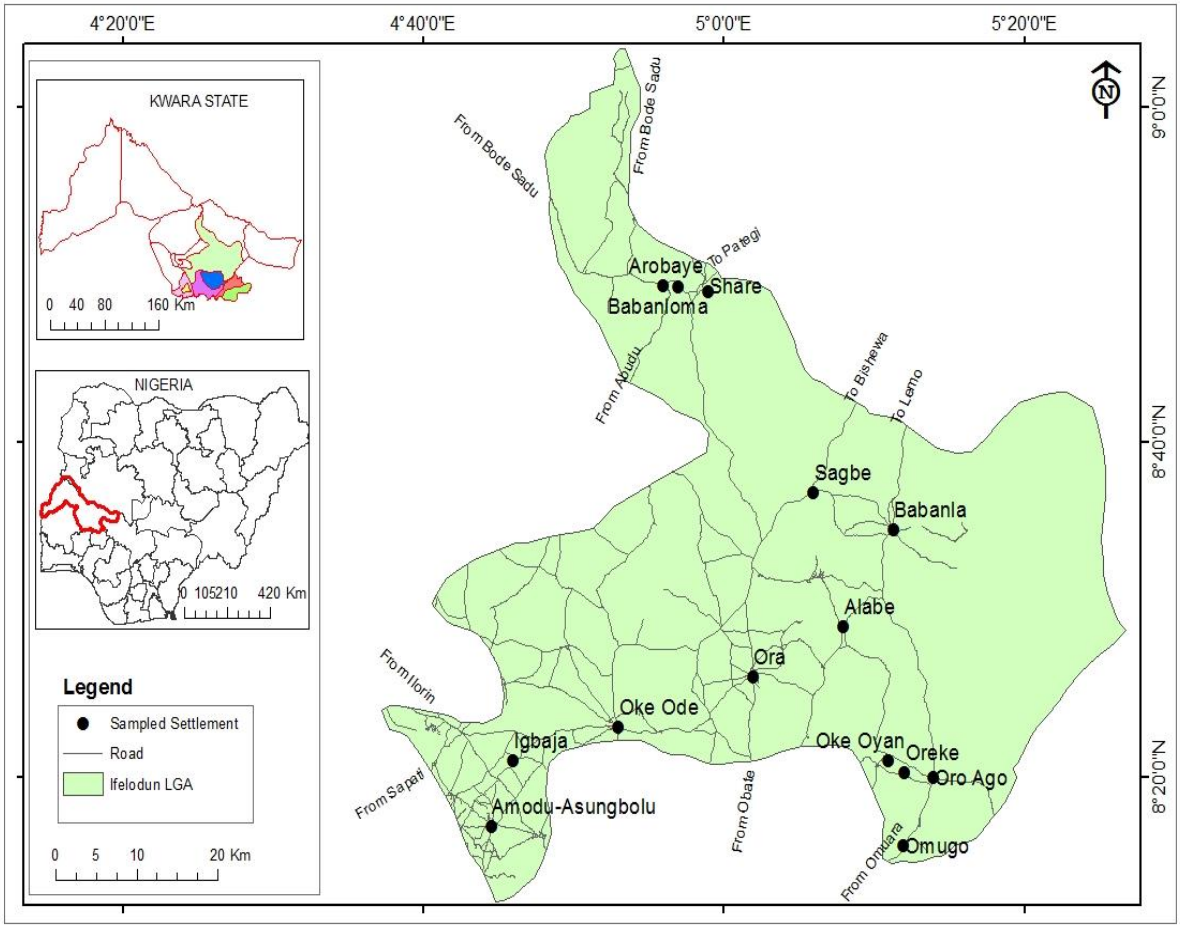

Figure 1: The study area, Ifelodun Local Government Area, Kwara State, Nigeria
Source: *Digitized from the Office of the Surveyor General of the Federation (OSGOF).*

MATERIALS AND METHODS

Major vertebrate pests responsible for on-farm losses to Maize in the study area

An analysis of major vertebrate pests responsible for on-farm losses of Maize in the study area shows that 38.6% of the respondents constituting the majority affirmed that grass cutter is the most destructive vertebrate pest causing on-farm losses to Maize in the study area. This was followed by 32% of the respondents who recognized monkeys as the most destructive vertebrate pests responsible for on-farm losses of Maize. Furthermore, 15.4% and 10.8% of the respondents identified quail and guinea fowl, respectively as the most destructive vertebrate pests associated with on-farm losses of Maize in the study area. Finally, 3.2% of the respondents subscribed that ground squirrel accounted for the greatest on-farm losses of Maize. Grass cutter therefore poses the greatest threat to Maize cultivation in the area. Furthermore, the uneven distribution of grass cutter as the most destructive pest responsible for on-farm losses of maize crops in the study area ($F(3,483) = 6.09$, $P < 0.05$) is also depicted in Figure 1. For instance, Alabe settlement had the highest (70.0%) followed by Oke-ode (50.0%), and the settlement with the lowest proportion of respondents who identified grass

cutter as the most destructive vertebrate pest of maize was Igbaja. An earlier study conducted in a Forest Ecological zone in South Western Nigeria on its part identified *Ploceus eucullatus* (weaver birds), *Streptopella semitotquato* (dove) and *Francolinus bicacaratus* (bush fowl as the bird vertebrates, while *Xerus erythropus* (red legged ground squirrel) *Rattus rattus* (black grey rat), *Mastomys natalensis* (multimammate rat) and Thrynonomys (Grass cutters/cane rat as the rodents associated with on-farm maize loss (Amusa *et al.,* 2005). The higher types and species of vertebrates identified in the Forest ecological zones could be associated with the its possession of higher density, species and size of vegetal cover; which incidentally increases its potentiality as habitat for vertebrate pests than obtainable in a guinea savanna ecological zone under study.

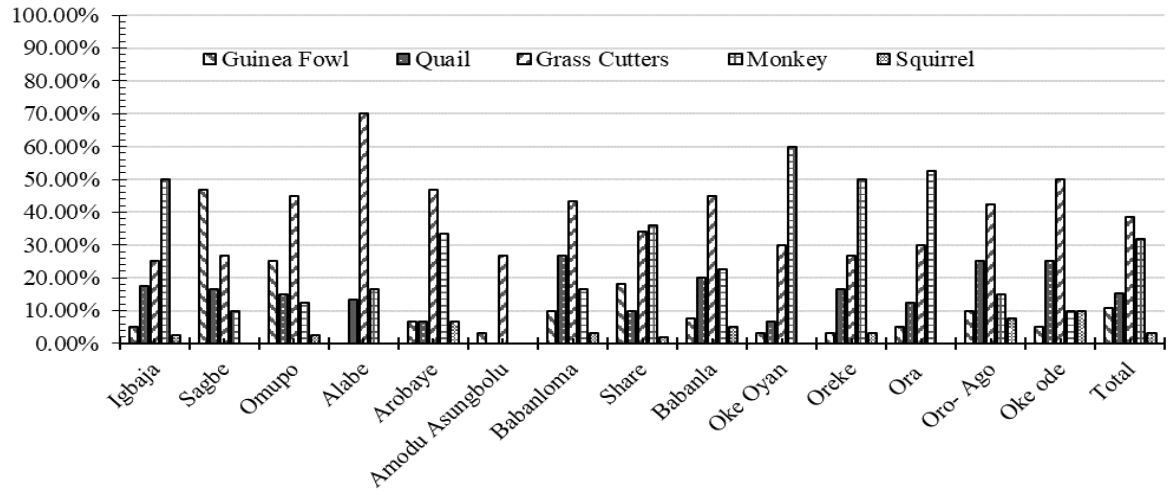

Figure 2: Major Vertebrate pests responsible for on-farm losses of Maize in the study area
Source: Author's Research, 2020

Stages at which farmers experienced vertebrate pest-induced farm losses of Maize

Analysis of the perception of farmers on the stages at which maize crop suffers on-farm losses from vertebrate pests in the study area revealed that 60.0% of the respondents across the sampled settlements perceived they experience on-farm losses due to vertebrate pests were at the maturing/fruiting stage (Figure 3); this was akin to the observation of Qamar *et al,* (2019) perhaps because of the pest gets more fed at that time. The havoc may have been caused by Monkeys known to characteristically destroy maize at the fruiting stage. Also, 33.2% of the respondents indicated that their on-farm losses to maize crops used to be in the growing stage (Figure 3). Lastly, a minority (6.8%) of the respondents stated that they usually experience on-farm losses of maize due to vertebrate pests at the germination stage (Figure 3). Spatial variability also existed across the sampled settlements. For instance, Amodu Asungbolu has the highest (80%), followed by Oke Oyan (70.0%); Oro-Ago had the lowest percentage (45.0%) of farmers who subscribed to the idea of an experience of on-farm losses of Maize due to vertebrate pest during fruiting stage. This may not be unconnected with the rurality of the location and coupled with the fact that it's surrounded by relatively large trees and shrubs. The location with the highest proportion of respondents who experienced on-farm losses of Maize at its growing stage was observed in Oro-Ago (47.5%), followed by Share Junction (46.7%) and the lowest proportion (16.7%) of respondents who experienced on-farm losses of Maize at its growing stage was observed in Oke-Oyan. Also, the distribution of respondents who experienced on-farm losses of maize due to vertebrate pests at the

germinating stage varied across the sampled settlements. For instance, Arobaye and Oke-Oyan settlements had the highest (13.3%) followed by Oke-ode (10.0%). The relatively smaller population of these settlements coupled with a lower farming population might have possibly warranted smaller scattered and poorly maintained farms which could be a catalyst for the proliferation of vertebrate pests. On the other hand, the location which experienced the lowest proportions (2.0%) of on-farm losses at germinating stage was at Babalonma; one can safely infer that the relatively larger population Babalonma allowed maize farmers in the area to maximize the use of available farmland for maize cultivation as extended maize farm was possibly owned by various farmers; which has the attendant effect limiting the hideout of vertebrate pests.

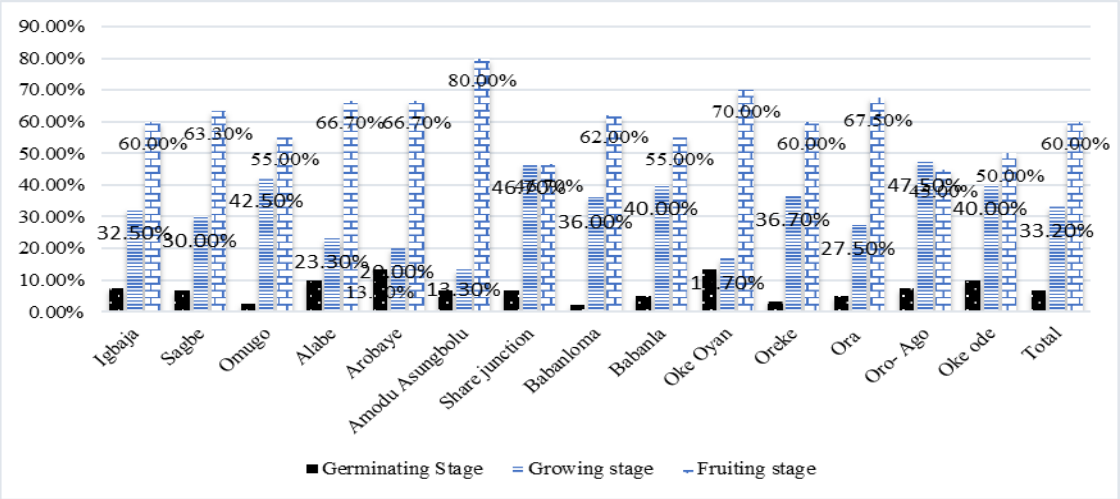

Figure 3: Stages at which farmers experienced on-farm losses of Maize due to pest in the study area.
Source: Author's Research, 2020

Effects of On-farm losses of Maize from vertebrate pests on Maize's Output and Income

The perception of respondents on whether vertebrate pests have negative impacts on maize's yields and income shows that the majority (70.8%) perceived that on-farm losses from vertebrate pests' impact negatively on maize's yields and income in the study area. ($\chi^2(500) = 86.52$, $p < 0.05$), while the minority (29.2%) disagreed. The distribution of samples based on an assessment of the negative effects of vertebrate pests-induced on-farm losses of maize on its yields and income in the study area presented in Figure 4 shows significant variation among selected settlements ($F(3,483) = 1.81$, $P < 0.05$). For instance, Sagbe had the highest (86.7%), followed by Igbaja (85.0%) and Arobaye roundabout had the lowest (53.3%) of respondents (Figure 4) affirming that on-farm losses due to vertebrate pests' impact negatively on maize's yields and income in the study area.

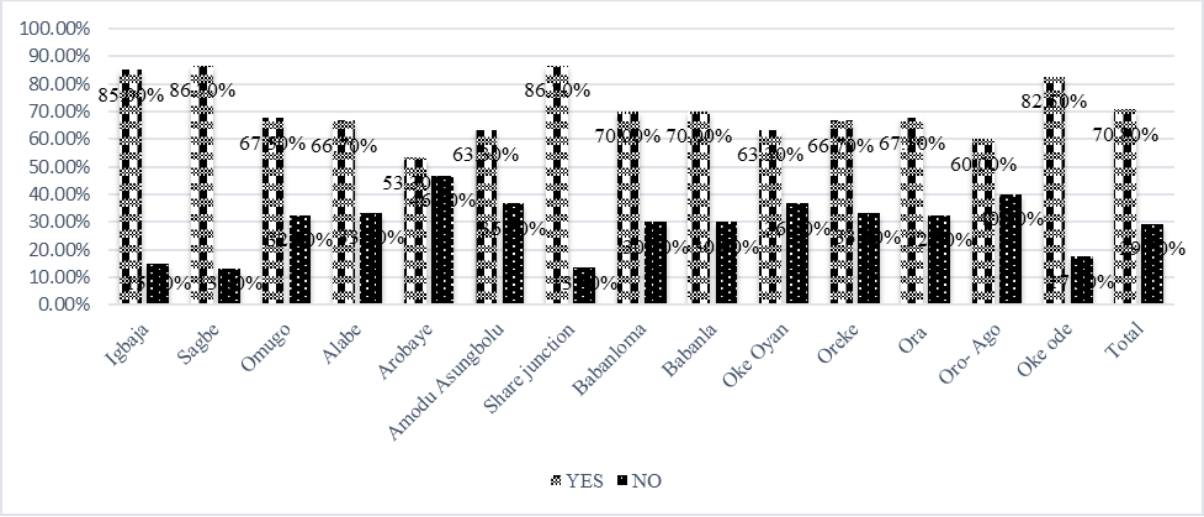

Figure 4: Perception on effects of on-farm losses of Maize due to vertebrate pest on output and income.
Source: Author's Research, 2020

Intensity of on-farm losses of maize due to vertebrate pest

The analysis of the intensity of on-farm losses of maize from vertebrate pests revealed that 58.4%, 36.2%, and 5.4% of the entire study population affirmed very high, high, and low intensity of on-farm losses due to vertebrate pests. This result further confirms the vulnerability of maize crops to tremendous losses from various categories of pests. For instance, vertebrate pests have been identified as key contributors to on-farm losses of maize and other crops including sugar cane (Quamar *et al,* 2019). Even though 58.4% of the respondents constituting the majority perceived that the intensity of on-farm losses in the study area was very high; spatial variability still exists in the distribution of respondents who made the perception across the sampled settlements (Figure 5). For instance, Figure 5 also revealed that Oke Oyan has the highest (76.7%) while Ora had the lowest (30.0%) proportion of respondents who perceived that the intensity of on-farm losses of maize due to vertebrate pests was very high. Also, while the settlements with the highest proportion (63.3%) of respondents who rated the intensity of on-farm losses of maize due to vertebrate pests as high was observed in Sagbe, the lowest proportion (16.7%) of respondents was observed in Oke Oyan. Additionally, the distribution of respondents who gave a low rating of the intensity of on-farm losses of maize due to vertebrate pests in all the selected settlements in the study area was generally uneven, Arobaiye settlement had the highest (13.3%); possibly because of its lower population and underutilization of potentials farmland which now harbours the vertebrate pests. On the other hand, Babanloma had the lowest (2.0%). This could be because of the possible concentration of farmers on pieces of land available for maize cultivation due to population pressure; with the attendant effects of reducing the habitat of vertebrate pests around the area. This study also affirmed that birds and rodents' vertebrates accounted for massive damage of maize on the field which ranged from 20 to 59% (Amusa *et al* (2005). Earlier, a study conducted in India affirmed that farmers lost about 11% of their anticipated gains to wildlife attacks on crops and domesticated animals (Madhusudam, 2003).

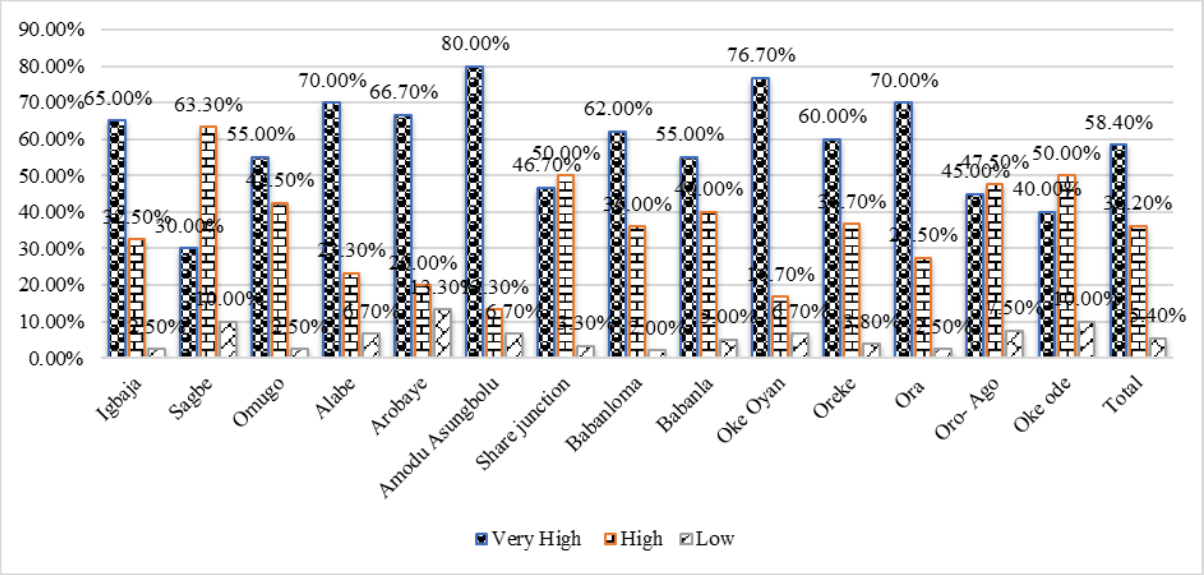

Figure 5: Intensity of on-farm-losses of maize due to vertebrate pest
Source: Author's Research, 2020

On-farm losses of Maize from vertebrate pests negatively on food security and farmer's livelihood

The study shows that 75.4% of the respondents constituting the majority agreed that on-farm losses of Maize from vertebrate pests negatively impact food security and farmers' livelihood while the minority (24.6%) disagreed. The high level of agreement may be a result of the high level of exposure of Maize farmers to on-farm losses orchestrated by vertebrate pests (rodents, birds, and monkeys). Those who affirmed the negative impacts of vertebrate pest-induced on-farm losses of Maize on food security and farmers' livelihood ranged from 93.3% at Alabe settlement to 67.5% at Oro ago town (F (3,483) =0.755, P> 0.05). More so, the highest proportion of respondents who affirmed on-farm losses of maize due to vertebrate pest were impressive (Figure 6). Earlier study in Australia on vertebrate pest affirmed a loss of at least 1 billion dollars in terms of agricultural loss and environmental damage (Saunders et al, 2010). Also, the present study corroborates the finding of Safi *et al,* (2019) where both rodent pests and bird pests were observed to be equally predatory towards valuable crops. This scenario individually and collectively impacted negatively on food security and farmers' livelihood. The massiveness of the on-farm losses has been contributory to the inability of maize yields/supply to meet the maize's demands in Africa. For instance, maize yields in Africa are very low only 1.3 tons per hectare (t/ha) compared to 4.9 t/ha worldwide, 8.4 that in industrialized countries, and 3.3 t/ha in other parts of the world (Epule *et al.*, 2021).

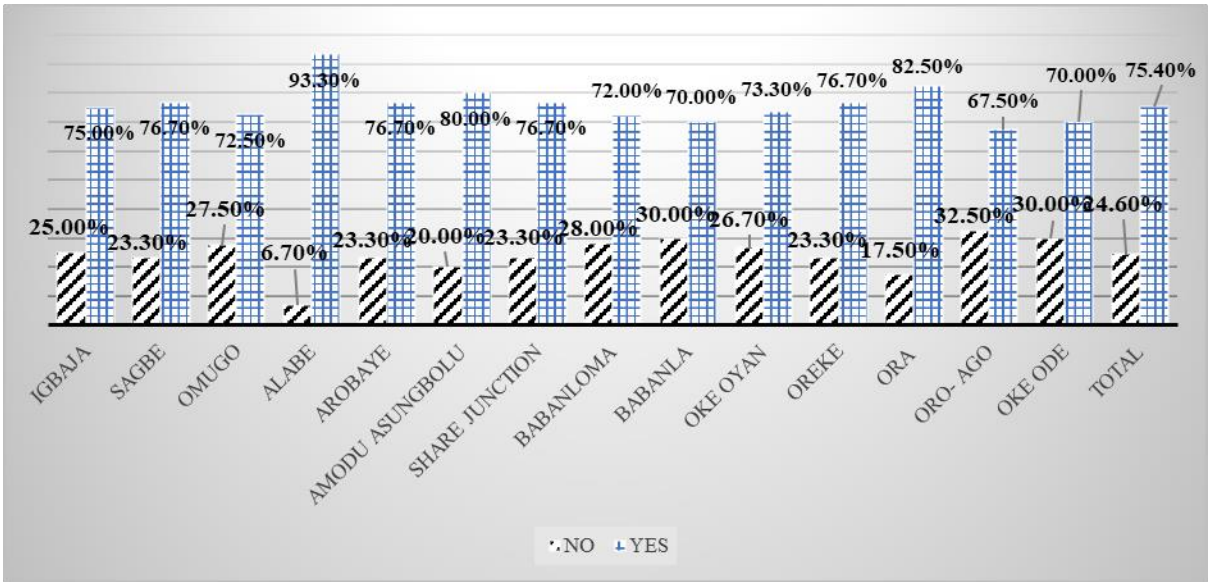

Figure 6: On-farm losses of Maize from Vertebrate pests impact negatively on food security and farmers' livelihood

Source: Author's Research, 2020

The validity of the hypothesis that assumed equality of means on the negative impact of on-farm losses of Maize due to vertebrate pests in the sampled settlements was tested using the ANOVA (Analysis of Variance) as earlier stated. The result of the analysis shows that the test statistics (F-Values) is 0.788, with the level of significance for the variable considered being 0.05 (Table 2); this implies that the H_0 hypothesis which states that there are no significant variations on the perception of respondent on the negative impact of vertebrate pests induced on-farm losses of Maize on food security and farmers' livelihood across the sampled settlements is valid. This means that a similar perception was observed among respondents in all the sampled settlements. This implied that on-farm losses of maize due to vertebrate pests' harms food security and farmers' livelihood

Table 2: Perception of the negative impact of Vertebrate pests-induced on-farm losses of Maize on food security and farmers' livelihood as Tested by ANOVA

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1.837	13	0.141	0.755	0.708
Within Groups	90.905	486	0.187		
Total	92.742	499			

Source: Author's Computation, 2020

Control measures of vertebrate pest-induced on-farm losses of Maize

Investigations on the control measure show that an overwhelming majority (60.2%) of respondents in the entire study area agreed that effective clearing of the surroundings of their farm sites was usually embarked upon to ward off vertebrate pests. Other control measures and the respective proportion of the entire study population that practiced them are the use of signals on the farm a disguise (14.0%), dogs and sounds (12.8%), hunting by guns and traps (10.6%), and use of poisons (2.4%) primarily to reduce or eliminate on-farm losses of Maize

and its attendant negative impact on farmer's livelihood and food security (Figure 7). Spatial variability also exists in the number of respondents who agreed. For instance, Figure 7 also revealed that the highest proportion of the population who subscribed to the adoption of regular clearing of the surroundings of their maize farm as a strategy to ward off vertebrate pests was found in Alabe settlement at 66.7%, the next was at Oke ode (65.0%) and the lowest was found at Babanloma (46.7%). This might have resulted because of the availability of an array of regularly maintained farms in the area. It might have also have been the position because of relatively smaller farm sizes and the generally little or no access to other scientifically and technologically inclined control measures. The results on control measure contrast sharply with the finding of Saunders *et al,* (2010) centered largely on biological control of pests observed in Australia, and the findings of Safi *et al,* (2019), which identified the use of pesticides as a major control measure to vertebrate pest. Additionally, integrated pest management (Zilberman *et al.*, 1991) could considerably reduce vertebrate pest-induced on-farm losses of maize.

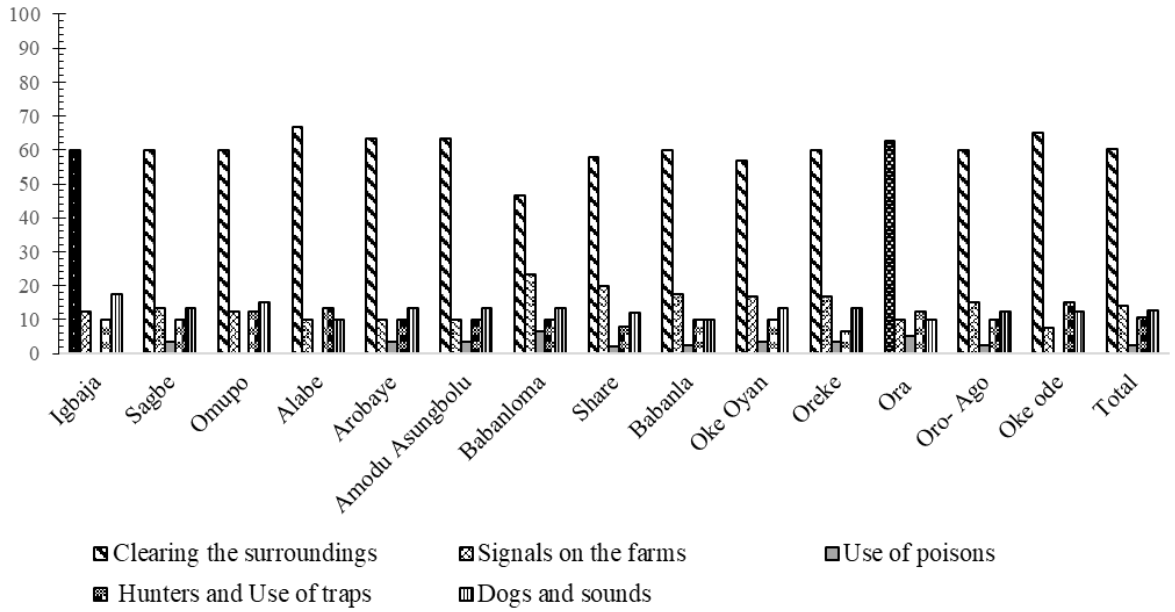

Figure 7: Control measures of vertebrate pest-induced on-farm losses of Maize
Source: Author's Research, 2020

CONCLUSION AND RECOMMENDATIONS

This study examined the perception of respondents on the vertebrate pests induced on-farm losses of maize in Ifelodun Local Government Areas, Kwara state, Nigeria. The study observed that the majority of the farmers admitted that grasscutters (38.6%) and monkeys (32.0%) were the major vertebrate pests responsible for on-farm losses of maize. 6.8%, 33.2%, and 60.0% of maize farmers sustained on-farm losses at the planting, growing, and fruiting stages, respectively from vertebrate pests under consideration, the majority (58.4%) described the intensity of on-farm losses as very high and the 70.8% subscribed that on-farm losses due to vertebrate pest has negative impacts on maize yields and income as well as food security and farmers' livelihood in the study area. However, spatial variations existed on the types, stages, and intensity control measures of on-farm losses of vertebrate pests in the study area. The study shows that there are no significant variations in the perception of respondents on the negative impact of on-farm losses of maize due to vertebrate pests on food security and farmers' livelihood in all the settlements ($F_{(3,483)} = 0.755$, $P > 0.05$). The study therefore recommends that farmers should improve their various farming operations, especially on weed control; especially on maize fields and their surroundings to ward off vertebrate pests. Farmers are

also encouraged to ensure that their farms are constantly free of weeds and ensure that their farms share no border with another with bushy thickly forested areas that could be a hideout for vertebrate pests. The government and other relevant stakeholders should empower the farmers financially to procure traps or nets for catching and killing these pests; this could be in the form of giving loans to farmers. The government and other relevant stakeholders should assist farmers by giving them a loan to procure herbicides for effective weed control to encourage farmers to operate larger farm sizes; the farmers could also use the loan to employ the services of farm labourers where and when necessary to ensure that their farms are properly maintained, maize farmers are also encouraged to have a common location of their maize farms that will look like an estate or plantation of maize instead of the small sized or fragmented farms this enhance effective weed control and ward off pests, This will reduce the frequencies and intensity of on-farm losses from vertebrate pests, improves maize's farmers' output and income, step-up food security and livelihood and creates an enabling environment for the achievement of sustainable development goal numbers 1 (end poverty) and 2 (end hunger and achieve food security) in the study and Nigeria at large.

Implication, Limitation and Future Research

This study implies that on-farm losses of maize due to vertebrate pests generally lead to poor returns from maize production investments, with negative impacts on farmers' livelihood and food security; which makes it difficult to achieve sustainable development in most rural farming populations in sub-Saharan Africa. Therefore, the study empowers farmers and sensitizes them on the need to maintain a clean farming environment to be able to effectively reduce the havoc of vertebrate pests, increase output and income from maize production, and financial well-being of maize farmers. The study's limitation lies in its failure to capture all the vertebrate pests that are involved in on-farm losses of maize. The study suggests additional findings on the cumulative impact of vertebrate and insect pests in typical maize farming settlements.

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