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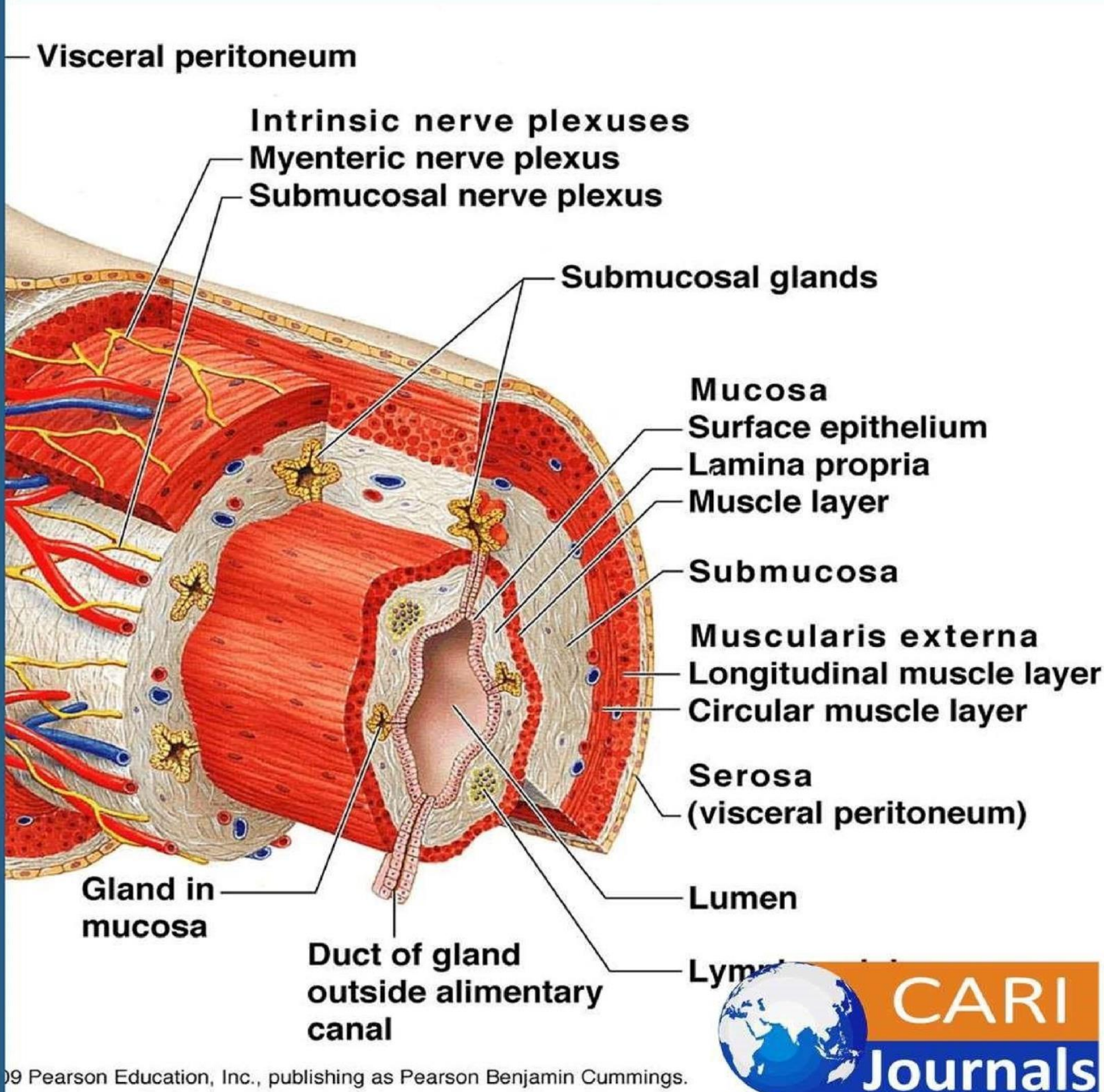

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Avian Dynamics and Behavior during Different Phenological Phases of Cereal Crops in the City of Kisangani and its Surroundings (Tshopo province, DRC)

Bird Dynamics and Behavior on Cereal Fields

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Abstract

Purpose: This study was conducted in the city of Kisangani and its surrounding areas over a six-month period, from February to July 2025. Its objective was to understand avian dynamics and behaviour during the different phenological stages of cereal crops.

Methodology: A simple point sampling method based on direct and indirect bird observation from a fixed point (listening or observation point) was used. Birds were observed during the different phenological stages of crops (sowing, vegetative growth, reproduction or flowering, and maturation).

Findings: The results showed that 18 bird species out of the 54 recorded were more involved in crop damage in the city of Kisangani and its surroundings during two main phases (sowing and maturation). At each phase, a more or less specific diversity of species was observed. Shannon diversity indices showed an average value of 2.415 for the three types of crops, while equitability was equal to 1. Regarding behaviour, it was noted that most birds frequenting crop fields were more beneficial than harmful, as only 33.33% of cases, corresponding to18 species, were involved in crop damage, where as 66.66% (36 species) acted as crop auxiliaries.

Unique Contribution to Theory, Policy and Practice: This study provides a list of bird species that attack cereal crops in the city of Kisangani and its surroundings, while identifying the most sensitive periods of attack, with a view to developing strategies to reconcile avifauna conservation with agricultural production. It also provides information on bird behaviour during different phenological phases, there by contributing to a better understanding of the role of avifauna in cereal crop fields.

Keywords: *Dynamic, Behaviour, Avian, Phenological Phases, Cereals, Kisangani*

JEL Codes: *Q57*

Introduction

Problem statement

In the Democratic Republic of Congo (DRC), and particularly in the Kisangani region, cereals such as maize and upland rice constitute fundamental food and economic resources (1) Kizungu, 2000, (2) Amundala *et al.*, 2008a, b. Sorghum is also currently cultivated in the region. However, these crops suffer from pressure exerted by granivorous birds, which are responsible for significant production losses worldwide. A study conducted in South Ubangi (3) Bosanga *et al.,* 2018, found that unmonitored fields lose an average of 28.3% of their rice yield, compared to only 4.67% when monitoring is implemented, representing a loss of 16.1% per hectare (≈ USD 97.8).

It is worth noting that species such as *Quelea quelea* , the "red-billed worker", are known to cause major damage to maize, rice and sorghum in sub-Saharan Africa, consuming up to 10 g of grain per bird/day and forming swarms of several million individuals (4) Nasasagare, 2017, (5) Bouet *et al.,* 2014.

In these swarms, other weavers (Euplectes, Ploceus), Estrildidae and Passeridae are also involved (6) Odoukpé *et al.,* 2014; (7) Nasasagare *et al.,* 2014. Although these studies have proven their relevance, unfortunately no local study precisely identifies the species present around Kisangani nor their spatio-temporal dynamics (different phenological phases), which is essential for adapting control measures.

The agroforestry environment of the Kisangani region, notably covered by forest, could promote a complex interaction between granivorous and beneficial birds (8) Lamoureux & Dion, 2016) during different phenological stages of crop growth: some insectivores, nectarivores and raptors are beneficial, while other granivorous species cause agricultural damage (9) Clergeau, 2000; (6) Odoukpe *et al.*, 2014; (10) Chemin, 2017; (11) Agossou *et al.,* 2019; (12) Yattara *et al.,* 2019; (13) CPVQ, 2000) .

This research project was initiated to determine the diversity of granivorous birds affecting maize, rice, and sorghum in Kisangani. How does this diversity vary depending on the crop? And finally, what is the frequency and behavior of the birds during different phenological stages?

Materials and methods

Study environment

The present study is conducted in the agricultural landscapes of the city of Kisangani and its surroundings, in the Tshopo Province of the Democratic Republic of Congo. In the following locations: 1) Behind the central mosque of Kisangani (N00°30'325"E025°12'087"Alt. 373m), 2) Behind the Simi-simi Airport (N00°31'239"E025°08'865"Alt. 376m), 3) Ngene-ngene at

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Kilometer Point 19 (N00°35'642"E025°17'575"Alt. 407m) and 4) Alibuku at the village of Agbokanga (N00°44'708"E025°25'495"Alt. 453m) located between pk 47- 49.

Methods

The Simple Spot Sampling Method

The avifauna data collection method used is simple point stratified sampling (SPS). Simple point sampling is based on 20-minute listening points within a wider radius (12) Yattara *et al.,* 2019; (14) Issiaka *et al.,* 2022). This method has the advantage of being at the confluence of two other classic methods: Point Abundance Indices (7) Nasasagare *et al.*, 2014 and Progressive Frequency Sampling (PFS) (7) Nasasagare *et al.*, 2014. This method, not being based on sampling but on recording contacts *in the wild*, gives excellent results in the study of bird population structure (11) Agossou *et al.,* 2019). It allows for a better evaluation of a biodiversity or bird community study (15) Odoukpé and Yaokokoré-Béibro, 2014)

This method involves counting birds from a fixed position or listening point within a radius of approximately 30 to 100m for 20 minutes. Birds are detected by sight or hearing (song, call) during the breeding season. The records mention both the species and their abundance (16) Drapeau et *al* ., 1999 .

All birds seen, whether perched or in flight, within the designated area were recorded between 6:30 a.m. and 9:30 a.m. and between 3:30 p.m. and 6:30 p.m. Counts were made by individual bird or by group size estimation (10 or 100 birds when present in large numbers). These observations will only provide qualitative data. (12) Yattara *et al.,* 2019; (14) Issiaka *et al.,* 2022.

Nine listening points were placed in locations representative of the study sites, 50 m apart. At each point, the observer was given 3 to 4 minutes to set up in order to avoid disturbing the observer. Once set up, each point was given 20 minutes, during which time all birds seen or heard were recorded, along with their approximate distance from the observer.

Over a period from February to July 2025, i.e., 6 months. With 20 days of data collection per month.

The birds observed were identified using the mobile applications: Merlinbird, Birdnet and Inaturalist and we also used the guides: "Birds of Africa South of the Sahara (17) Nik Borrow & Ron Demey, 2014.

The data were stored on Excel and we used Past software for data processing (constancy, t-test, anova test, Jaccard similarity index and Shannon index with fairness).

Results

The results of this study are presented in the tables and graphs below:

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Birds that are harmful to crops in the fields of Kisangani and its surroundings

Depredation is presented according to each type of crop and during two major phenological phases at which the birds were observed (see table 01).

Table 01: Birds that are pests of cereal crops in Kisangani and its surroundings

Species	**But**		**Rice**		**Sorghum**		**C%**
	S	**M**	**S**	**M**	**S**	**M**	
Brachycope anomala (Reichenow, 1887)	+	-	+	+	+	+	100.0
Corvus albus (Müller, PLS, 1776)	+	-	+	-	+	-	100.0
Estrilda melpoda (Vieillet, 1817)	+	-	-	+	-	+	100.0
Estrilda nonnula (Hartlaub, 1883)	+	-	-	+	-	+	100.0
Gymnobucco bonapartei (Hartlaub, 1854)	-	+	-	-	-	-	33.3
House Sparrow (Linnaeus, 1758)	+	+	+	+	+	+	100.0
Passer griseus (Vieillot, 1817)	+	+	+	+	+	+	100.0
Ploceus cucullatus (Müller, PLS, 1776)	+	+	+	+	+	+	100.0
Ploceus pelzelni (Hartlaub, 1887)	+	-	+	+	-	-	66.7
Psittacus erythacus (Linnaeus, 1758)	+	-	+	-	+	-	100.0
Pycnonotus tricolor (Hartlaub, 1862)	+	+	+	+	-	-	66.7
Pycnonous barbatus (Desfontaines, 1789)	+	+	+	+	-	-	66.7
Spermestes bicolor (Fraser, 1843)	-	-	-	+	-	+	33.3
Spermestes cucullatus (Swainson, 1837)	+	-	+	+	+	+	100.0
Spermestes fringilloides (Lafresnaye, 1835)	-	-	+	+	+	+	66.7
Streptopelia semitorquata (Ruppell, 1837)	-	-	+	-	+	+	66.7
Tortur afer (Linnaeus, 1766)	+	-	+	-	+	+	100.0
Widow macroura (Pallas, 1764)	-	-	-	+	-	-	33.3
Total: 18	**14**	**6**	**15**	**13**	**10**	**11**	

With S: Sowing and M: Maturation; +: presence and -: absence; C: constancy in %.

From Table 1, we identified a total of 18 species (33.33%) of birds that attack cereal crops during two phenological stages (see Fig. 1).

But by breaking down the damage for each type of crop:

- We observed that maize was more heavily attacked during the sowing phase, with 13 out of the 14 observed species (92.85%) being affected; whereas during maturation, only 6 species

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(42.85%) were observed, and these species most often consumed the milky kernels of maize. The difference between the two phases of predation was significant (T-test, ***p-value: 0.0067)*** on maize.

- On rice, 17 species were observed; of these, 15 were observed during the sowing phase (88.23%) and 13 during the maturation phase (76.47%). The difference between the two phases of rice depredation was not significant (t-test, ***p-value: 0.271)***.
- Finally, on sorghum, 13 species were observed; of these, 10 were observed during the sowing phase (76.92%) and 11 during the maturation phase (84.61%). The difference between the two phases of depredation on sorghum was not significant (T-test, ***p-value: 0.218)***.

Regarding consistency, it should be noted that 15 species (i.e. 83.3%) are constant predators on all three types of crops and the other 3 are incidental predator species.

Shannon diversity indices give an average of 2.415 for the three crop types and evenness gives 1. These data show us that the species are evenly distributed across the three crop types and the diversity is not homogeneous.

Regarding crop preference, we noted that 39% of the birds observed preferred rice and 28% preferred sorghum.

Fig. 1. Some crop pest species **maize, rice and sorghum fields**

The data relating to the dynamics and behaviour of the birds are summarized in Table 02 below.

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Table 02: Dynamics and behavior of birds during different phenological phases

Species	S	V	F	M	C%	Observed behaviors
Accipiter ovampensis (Gurney, JH Sr, 1875)	+	-	+	-	50	Catching insects and other prey (micro-mammals, macro-invertebrates)
Acrocephalus gracillirostris (Hartlaub, 1864)	+	-	+	-	50	Catching insects and other invertebrates
Acrocephalus schoenobaenus (Linnaeus, 1758)	+	-	+	-	50	Catching insects and other invertebrates
Actitis hypoleucos (Linnaeus, 1758)	+	-	-	-	25	Catching invertebrates
Alcedo quadribrachus (Bonaparte, 1850)	-	+	+	-	50	Catching macro invertebrates and insects
Ardea alba (Linnaeus, 1758)	+	+	-	-	50	Catching terrestrial vertebrates and invertebrates
Ardea cinerea (Linnaeus, 1758)	+	+	-	-	50	Catching terrestrial vertebrates and invertebrates
Bias musicus (Vieillot, 1818)	+	-	+	-	50	Catching insects and other invertebrates
Brachycope anomala (Reichenow, 1887)	+	+	+	+	100	Nibble the grains
Camaroptera brachyura (Vieillot, 1821)	+	-	+	-	50	Catching insects and other invertebrates
Campethera maculosa (Valenciennes, 1826)	+	-	-	-	25	Catching arboreal vertebrates and invertebrates
Caprimulgus vexillarius (Gould, 1838)	+	-	+	-	25	Catching insects and other invertebrates
Cecropis semirufa (Sundevall, 1850)	+	+	+	+	100	Catching insects and other invertebrates
Centropus senegalensis (Linnaeus, 1766)	+	-	+	+	75	Catching macroinvertebrates and micromammals
Chlorocichla simplex (Hartlaub, 1855)	+	-	+	+	75	Pecking at the grains and catching the insects
Chrysococcyx caprius (Boddaert, 1783)	+	-	+	-	50	Catching insects and other invertebrates
Chrysococcyx cupreus (Shaw, 1792)	+	-	+	-	50	Catching insects and other invertebrates
Cinnyris chloropygius (Jardine, 1842)	-	-	+	-	25	To sip nectar from flowers
Cisticola anonymus (Müller, JW.	+	-	+	-	50	To sip nectar from flowers

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1855)						
Corvus albus (Müller, PLS, 1776)	+	+	+	+	100	They peck at the grains and catch invertebrates, but also destroy young shoots and leaves.
Corythaeola cristata (Vieillelot, 1816)	+	-	+	+	75	Consume the young shoots and leaves
Criniger calurus (Cassin, 1856)	+	-	+	+	75	Catching insects and other invertebrates
Cyanomitra olivacea (Smith, A. 1840)	-	-	+	-	25	To flit from flower to flower
Elanus caeruleus (Desfontaines, 1789)	+	+	+	-	75	Catching insects and other prey (micro-mammals, macro-invertebrates)
Estrilda melpoda (Vieillet, 1817)	+	+	+	+	100	Nibble the grains
Estrilda nonnula (Hartlaub, 1883)	+	+	+	+	100	Nibble the grains
Eurillas virens (Cassin, 1858)	+	-	+	-	50	Catching insects and other invertebrates
Gymnobucco bonapartei (Hartlaub, 1854)	+	-	+	+	75	Nibble the grains
Halcyon senegalensis (Shaw, 1812)	+	+	+	-	75	Catching insects and other invertebrates
Hirundo rustica (Linnaeus, 1758)	+	+	+	+	100	Catching insects and other invertebrates
Ispidina picta (Boddaert, 1783)	+	-	+	+	75	Catching insects and other invertebrates
Limnocorax flavirostris (Swainson, 1837)	+	-	-	-	25	Catching invertebrates
Lophaetus occipitalis (Daudin 1800)	+	-	+	+	75	Catching insects and other prey (micro-mammals, macro-invertebrates)
Lophoceros fasciatus (Shaw, 1812)	+	-	+	-	50	Catching insects, other invertebrates and vertebrates, and fruit
Merops variegatus (Vieillot, 1817)	+	+	+	+	100	Catching insects and other invertebrates
Milvus migrans (Boddaert, 1783)	+	+	+	+	100	Catching macroinvertebrates and micromammals
Motacilla aguimp (Temminck, 1820)	+	-	+	-	50	Catching insects and other invertebrates
Motacilla cinerea (Tunstall, 1771)	+	-	+	-	50	It catches insects and other

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						invertebrates, but it also consumes young shoots and leaves.
Passer domesticus (Linnaeus, 1758)	+	+	+	+	100	Nibble the grains
Passer griseus (Vieillet, 1817)	+	+	+	+	100	Nibble the grains
Ploceus cucullatus (Müller, PLS, 1776)	+	+	+	+	100	Nibble the grains
Ploceus pelzelni (Hartlaub, 1887)	+	+	+	+	100	Pecking at the grains and insects
Psalidoprocne pristotera (Rüppell, 1840)	+	+	+	+	100	Catching insects and other invertebrates
Psittacus erythacus (Linnaeus, 1758)	+	+	+	+	100	Nibble the grains
Pycnonotus tricolor (Hartlaub, 1862)	+	+	+	+	100	Nibble the grains
Pycnonotus barbatus (Desfontaines, 1789)	+	+	+	+	100	Nibble the grains
Spermestes bicolor (Fraser, 1843)	+	-	+	+	75	Nibble the grains
Spermestes cucullatus (Swainson, 1837)	+	-	+	+	75	Nibble the grains
Spermestes fringilloides (Lafresnaye, 1835)	+	-	+	+	75	Nibble the grains
Streptopelia semitorquata (Ruppell, 1837)	+	-	-	+	50	Nibble the grains
Terpsiphone viridis (Müller, PLS, 1776)	+	+	+	+	50	Catching insects and other invertebrates
Turdus pelios (Bonaparte, 1850)	+	-	+	-	50	Catching insects and other invertebrates
Turtur afer (Linnaeus, 1766)	+	-	-	+	50	Nibble the grains
Vidua macroura (Pallas, 1764)	+	-	+	+	75	Nibble the grains
Total: 54	**51**	**22**	**47**	**30**		

With S: Sowing; V: Vegetative; F: Flowering; M: Maturation and C: Consistency in %.

This table on the dynamics and behavior of birds during different phenological phases of cereals indicates that 5 of the 54 observed species are accidental species ($C \leq 25$) and 48 (i.e. 90.74%) are constant species ($C \geq 50$).

By comparing bird diversity in the different phenological phases of crops using ANOVA, we found that the difference was highly significant between the sowing and vegetative phases (***p-value: 7.72E-06***); between the sowing and maturation phases (***p-value: 1.12E-05***); between the flowering and vegetative phases (***p-value: 7.78E-06***); between the vegetative and maturation

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phases (***p-value: 0.0005***); and the difference was significant between the flowering and maturation phases (***p-value: 0.0003***). However, the difference was not significant between the sowing and flowering phases (***p-value: 0.778***).

Regarding behavior, we have noticed that most of the birds that frequent the fields are more beneficial than harmful because only 33.33% of cases, or 18 species, were observed causing damage to crops, and 66.66%, or 36 species, are beneficial to crops.

The importance of each phenological phase in the composition of the avifauna of cereal fields shows that birds visit the fields more during flowering and sowing (31% and 34%) and only 15% during the vegetative phase.

Shannon diversity indices give an average of 3.549, as diversity is high in the different phenological phases of the crops and evenness gives 1. These results show us that the species are evenly distributed in the different phenological phases and there is no dominance.

The Jaccard similarity index, calculated by cluster analysis, shows that the vegetative phase has a low similarity to the other phases, at 45%; while the sowing and flowering phases are very similar, with a similarity of 82%, which tends towards 1 or 100%.

Discussion

By observing the species that attack crops, a total of 18 bird species out of the 54 identified in the agricultural landscapes of Kisangani and its surroundings were identified. Two phenological phases (sowing and maturation) were selected to identify the pest species.

The results showed that corn was most heavily attacked during the sowing phase, with 13 out of the 14 observed species (92.85%) being attacked; whereas during maturation, only 6 species were observed (42.85% of the 14 identified). The difference between the two phases of predation is significant (T-test, ***p-value: 0.0067)*** on corn. This could be explained by the fact that during maturation, the corn is well protected in its ear, and only a few species are able to attack the well-protected seeds; whereas during sowing, birds easily peck at the seeds, which are only slightly buried in the soil.

In 2000, Kizungu studied the impact of birds on maize crop yields in the Lwiro marshes of South Kivu in eastern DRC. He observed seven maize pest species: *Ploceux baglafecht* , *P. nigricolis* , *P. cucullatus* , *P. xanthops* , *Streptopelia semitorquata* , *Lonchura bicolor* , and *Passer domesticus.* Of these, *P. cucullatus* had already been reported as a cereal pest in Kisangani in the work of Mulotwa *et al.,* 1993; and the other species have been repeatedly reported as crop pests in Africa. Among these species, *P. cucullatus* , *Streptopelia semitorquata* , *Lonchura bicolor* (*Spermestes bicolor*), and *Passer griseus* were observed in our study. and other species were added to the list (*Spermestes fringilloides, S. cucullatus, Passer domesticus, Vidua macroura,* *Ploceus pelzelni, Gymnobucco bonapartei, Pycnonotus bicolor, P. barbatus, Turtur afer, Turdus pelios, Estrilada melpoda, E. nonnula, etc.*)

On rice, 17 species were observed, of which 15 were observed during the sowing phase (88.23%) and 13 during the maturation phase (76.47%). The difference was not significant in either phase of rice predation (T-test, ***p-value: 0.2669)***. This can be explained by the fact that rice is a cereal easily accessible to the various species that consume it; it is small in size, the grains are not as well protected as those of maize, and various species readily come to feed on it from sowing and especially during grain maturation. Treca, in 1987, added that rice crops allow bird species to feed in large quantities because they are generally assured of finding an inexhaustible supply of food.

In a study carried out in 1983 in the Central Niger Delta by F. Billet on the impact of granivorous birds on cereal crops, the Ploceidae family proved to be a family whose species often attack cereal crops; particularly the species *Quelea quelea* and *Passer luteus* were the most observed.

The results of this new study also reveal a strong depredation of crops by species of this family with three species (*Ploceus cucullatus, P. pelzelni* and *Brachycope anomala*) and the genus Passer which today belongs to the family Passeridae (*Passer griseus* and *P. domesticus*).

Finally, regarding sorghum, 13 species were observed. Of these, 10 were observed during the sowing phase (76.92%) and 11 during the maturation phase (84.61%). The difference was not significant in either phase of predation on sorghum (T-test, ***p-value: 0.5764)***. Like rice, sorghum is a cereal that is easily accessible to the various species that consume it. It is small in size, the seeds are not as well protected as those of maize, and various bird species readily come to feed on it from sowing and especially during seed maturation.

Mununu *et al.* (2025) assessed bird damage to seedlings of three food crops (maize, peanuts, and rice) under the ecological conditions of Kinshasa and Mount Amba. The results of this study showed significant differences in seedling damage, with a remarkable average of 40% more damage to maize compared to rice and peanuts. On developing seedlings, a remarkable average of 44% damage was observed in maize. These findings were also confirmed in our study; maize was more heavily attacked during the sowing phase than during maturation and other phases.

Rice, on the other hand, was more heavily attacked during the sowing phase and during seed maturation. Although the difference between the two phases was not significant, we observed heavy depredation during maturation.

Among the predatory species, the following species have been identified: *Quelea quelea* (red-billed worker), *Ploceus cucullatus* (police weaver), *Passer luteus* (golden sparrow), *Quelea erythrops* (red-headed worker), *Ploceus spp* , *Lonchura cucullatus* and *Corbus albus* .

In this new study, the species *Ploceus cucullatus* , *Lonchura cucullaus* and *Corbus albus* were also observed as crop pests and these species are permanent during the different phases of crop development.

Nasagare *et al.* (2017) studied the non-random predation of granivorous birds in the Kagogo-Gisumo marshes of Burundi. Their findings indicate that the Ploceidae and Estrildida families are among the most destructive to cereal crops. The species *Ploceus cucullatus* , *Euplectes ardens* , *E. axillaris* , *E. macrourus* , *Estrilda paludicola* , and *Lonchura cucullatus* were the most abundant and frequently observed in rice fields.

In the Ruzizi plain, Nasagare et *al.* (2014) found that *Passer griseus* , *Euplectes orix* , and *Lagonostica senegala* appear to cause the most damage to cereal crops; however , in the Ngoyi marshes, it is *Euplectes orix* and *Lonchura cucullatus (Spermestes cucullatus)* which are responsible for the damage to rice.

The dynamics and behavior of birdlife during different phenological stages of crops

Analyzing the dynamics and behavior of birds during different phenological phases of cereal crops, it was found that 5 of the 54 observed species were accidental ($C \leq 25$) and 49 (90.74%) were constant species. These results demonstrate that birds constitute a permanent zoological group in agricultural landscapes, as they are always present during the different phenological phases or stages of cereal crops (maize, rice, and sorghum), and confirm the fact that birds are the soul and lifeblood of agricultural landscapes (Lamoureux, S. and C. Dion, 2016).

The differences observed during these various phenological phases can be explained by the fact that during the sowing phase, there is a large quantity of food resources (arthropods, small mammals, and other invertebrates consumed by birds), whereas during the vegetative and maturation phases, resources are less abundant. During the flowering phase, there is a high presence of insects and other arthropods that play an important role in pollination.

These results show us that birds visit fields for specific reasons and that visitation is influenced by different phenological phases.

Conclusion

This study, carried out in the agricultural landscapes (cereal fields) of the city of Kisangani and its surroundings, made it possible to determine for the first time the specific diversity of birds in these landscapes.

The six-month inventory conducted in cereal fields identified a significant diversity of birds. It provided a list of birds that particularly prey on cereal crops in and around Kisangani, while also indicating the most vulnerable period for these attacks. This information will inform the development of strategies to reconcile bird conservation with agricultural production. Furthermore, the inventory details bird behavior during different phenological phases, providing insights into the role of birds in cereal fields. Resource availability is the key factor influencing the composition of the bird population during these various phases.

It is desirable to extend this study of the impact of the depredation on agricultural production and yield, but also on the economy of the city of Kisangani and its surroundings.

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