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The Role of Ciconiiformes in Controlling Pests in Rice Paddies of Kibimba, Eastern Uganda

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Authors' contributions

This work was carried out in collaboration between all authors. All authors designed the study, collected data. Author SN performed the statistical analysis and wrote the first draft of the manuscript. Authors PMM and IE gave comments. All authors read and approved the final manuscript before submission.

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ABSTRACT

Aim: The study examined the diversity and abundance of Ciconiiforme birds and their potential role in provision of environmental services to control potential pests in rice paddies.
Study Design: A cross sectional study design was used
Place and Duration of the Study: The study was conducted at Kibimba rice scheme, eastern Uganda, from October 2013 to April 2014.
Methodology: A combination of total counts, focal bird observations and a social economic survey was used. Waterbird counts were made in a total of 71 field plots, of which 18 were harvested fields, 20 ploughed fields, 23 with rice in the early stages of growth (Phase 1) and 10 with mature rice (Phase 2). Focal bird observations were conducted in harvested and ploughed flooded rice fields for ease of visibility and included watching individual birds of the Grey Heron (*Ardea cinerea)* (9), Black-headed Heron *(Ardea melanocephala)* (59) and the Open-billed Stork (*Anastomus lamelligerus)* (86) for a maximum of 15 minutes each and documenting the prey they took.
Results: There was a significant difference in the abundance of species recorded on the

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different rice stages (χ_3 = 19.104, *P* =.0001). Ploughed fields supported the highest number of waterbird species (41) and individuals (28.79±3.238) while harvested fields supported the least (7.15±0.974). Focal observations showed that the Open-billed Stork fed mostly on snails, the Black-headed Heron fed on snakes, rats and frogs while the Grey Heron fed on rats. Farmers indicated that rats, snails and birds were the primary pests of their rice crop and suggested that birds such as herons and Open-billed storks can be used to control rats and snails respectively, while the bird pests are mainly controlled through poisoning.

Conclusion: These results indicate that waterbirds can play an invaluable environmental service of feeding on potential rice pests therefore should be protected.

Keywords: Ciconiiformes; pests; paddies; Kibimba; rice phase.

1. INTRODUCTION

Agro ecosystems have increasingly become important habitats for biodiversity in light of the current human population trends that is heavily impacting on the environment. For example, rice paddies provide foraging and dispersal space for waterbirds. Birds can also boost agricultural yields through pollination, seed dispersal, and even aid in improving plant genetic diversity [1,2]. Many waterbirds such as storks, ibises, egrets and gulls forage extensively in both aquatic and terrestrial habitats. These birds also produce guano that enhances nutrient cycling and are likely to be important as control agents of agricultural pests reducing crop loss [3-5].

Rice in Uganda was introduced by Indian traders as early as 1904 [6], although it did not gain popularity until the late 1940s. Rice cultivation was gradually taken up at subsistence level by a few farmers who grew varieties such as Cakala, Matama, Kawemba, Kigaire and Seena that were introduced into Uganda through Mwanza, Tanzania. During the 1950s, Uganda developed more interest in rice, apparently to feed its growing population that included returnees from the Second World War, as well as institutions such as schools, prisons and hospitals. Surveys were consequently commissioned to establish actual potentials for growing low-land rice at a large scale in Uganda [7]. These surveys focused on several large wetlands including Doho, Olweny, Omunyal, and Kibimba, some of which were finally recommended as sites for large scale rice production. By 1966 large scale production of irrigated swamp rice was initiated at Kibimba through a partnership between the Uganda government and the Peoples Republic of China. This was aimed at reducing expenses on food imports and diversifying export earnings with emphasis on nontraditional agricultural export crops and import substitution crops, the class under which rice fell. Later commercial rice growing was also initiated at Doho (1976) and lately at Olweny Irrigated Rice Scheme. These are now nuclear farms that bring together smallholder farmers (in Doho and Olweny) and private investors (Tilda in Kibimba) with strong support from government. Today rice is considered among the food security crops in the country, and in particular, for alleviating poverty among the rural poor.

Habitat use patterns of birds on rice fields in Uganda have been reported in a number of studies [8-10], in which rice growing has been shown to create favorable feeding grounds for waterbirds, particularly Ciconiiformes. However, none of these studies have examined the role of Ciconiiformes birds in controlling potential pests in these rice paddies. This study focused on documenting bird species diversity on the rice fields at Kibimba rice scheme, with a special focus on how the Black-headed Heron, the Grey Heron and the Open-billed Stork

can contribute towards control of rice pests on these paddies. Documenting these ecosystem services is essential not only to guide agro-ecological strategies aimed at maximizing such services but also for exploring opportunities on how farmers can minimize dependence on pesticides and continuous persecution of birds. In addition, considering that agricultural production still forms the main bedrock for food security in Uganda, our findings will guide the rural human population on how to maximize output in terms of rice harvest with minimal input.

2. MATERIALS AND METHODS

2.1 Sampling Design

Rice fields were divided into blocks for water management purposes; these are further subdivided into plots that are separated by earth levees. The sampling units were 4ha plots established in each block and these plots were monitored monthly (from October 2013 to March 2014). We selected plots so that the various phases of rice cultivation were spatially interspersed (more than 300 m apart) in order to reduce the likelihood that unknown spatial factors could confound the results. In order to strengthen results, a cross sectional field survey was conducted in the month of April in which 80 randomly selected farmers were interviewed. A structured questionnaire was used as a method of collecting data. Information on what the farmers considered as pests in the rice scheme, how they manage these pests and the bird species they considered helpful in controlling some of the pests to their crop was sought from each farmer.

2.2 Waterbird Counts

Plots were censused on foot, counting all waterbirds from locations along levee perimeters which maximized observations and minimized disturbance. This was done using 22x spotting scopes and 8×40 binoculars. Given the open nature of the habitats, these counts were likely to assess absolute abundance accurately for most species except for the small waders. Birds disturbed from a field or standing on the bands at the edges of the plot and on internal earthen levees, as well as those flying just above and around the plot were included in the samples; birds seen flying overhead were not. Waterbird counts were made in a total of 71 field plots of which 20 were on ploughed fields, 23 on fields with rice at the early vegetative stage/ before flowering hereafter called Phase 1, 10 on fields with rice at the late vegetative stage/after flowering hereafter called Phase 2, and 18 on harvested fields. One-sample Kolmgrov test showed that the abundance of species did not conform to the normal distribution even after data were log transformed (P<0.05). Therefore, a Kruskal Wallis test was conducted to compare the abundance of species recorded on the different rice stages

2.3 Focal Bird Observation

Focal observations were made on three bird species namely: the Black-headed Heron (*Ardea melanocephala)*, Grey Heron (*Ardea cinerea)* and Open-billed Stork (*Anastomus lamelligerus)*. These species were chosen because they are relatively abundant and feed on large prey such as rats, snakes, frogs and snails that is easy to identify, and are considered pests of the rice crop. Each focal observation included watching an individual bird for a maximum of 15 minutes and documenting the prey they took (where possible). These observations were largely restricted to rice fields that had been ploughed and flooded, and the harvested ones for ease of visibility. Nine Grey Herons, 59 Black-headed Herons and 86

Open-billed Storks were independently observed as focal birds resulting into a total sampling effort of 2310 minutes (38.5 hours) of feeding observation time.

2.4 Collecting Data on Prey Items

Although the Black-headed Heron, Grey Heron and Open-billed Stork feed on a range of animals from small mammals to reptiles, amphibians, fish and invertebrates, our survey was confined to those that are considered as potential pests to the rice crop, namely snails and rats. Snail abundance was estimated by tossing a $1m^2$ wooden frame in the rice fields after every ten meters while walking along the levees as transects. All the snails found in this wooden frame were enumerated. Thirty of such throws were made in six plots giving a total of 180 throws over the sampling period. The presence of rats was qualitatively documented by noting the presence of holes as attempts to use the traps were futile due to the continuous presence of humans who were slashing levees to control rodents, scaring away birds from mature rice, ploughing, planting among other activities.

3. RESULTS AND DISCUSSION

3.1 Waterbird and Rice Pest Abundance

A total of 42 waterbird species of 9989 individuals were recorded and of these the Yellow-billed Egret (*Egretta intermedia)*, Black-headed Heron and Open-billed Stork were the most dominant (Table 1). A Kruskal Wallis test showed that there was a significant difference in waterbird abundance on the different rice stages (χ = 19.104, df = 3, *P* =.0001). Ploughed and flooded fields supported more species and a higher abundance of birds than the rest of the other rice stages (Fig. 1). These findings seem to agree with earlier studies [10], however, the bird abundance was notably very low. The low abundance of birds could be attributed to factors such as time of the year, hunting by locals, the level of activity at the scheme and the continuous massive aerial spraying of the roosting sites with an avicide called Fenthion, also known as Queletox by the management of the rice scheme mainly targeting the Red-billed Quelea (*Quelea quelea)* (personal observations).

3.2 Focal Bird Observations

A total of 154 focal observations were made of which 59 were Black-headed Herons, 9 Grey Herons and 86 Open-billed Storks (Table 2). Unlike the Open-billed Storks individuals that were actively foraging, more than half of the Grey Heron and Black-headed focal individuals abandoned their feeding activity half way through the observation (Table 2). The Grey Heron were observed feeding on mainly rats while the Open-billed Storks fed on snails. Sometimes Open-billed Storks swallowed items that we failed to identify and these we excluded from our data. Considering that the prey items for these bird species are also considered as pests to the rice crop (Table 3), then they could be of great benefit in controlling their population. Waterbirds do not only feed on animal pests but can also control grass weeds such as *echinochloa* spp. as well [11].

3.3 Rice Pests and Control Methods Used by Farmers

Table 3 reveals that rats, snails and birds (particularly Quelea spp) are the main rice pests at Kibimba scheme in this order of magnitude. A total of 85 individual snails were recorded from 180 throws and 80% of these snails were of *Bulinus* species. Much as the level of

prevalence of rats in the scheme could not easily be ascertained, the predominance of rat holes and trails on levees clearly indicated their presence. These findings seem to agree with findings in several Southeast Asian nations, where farmers consider rats and birds as the major biotic stresses for lowland rice [12]. In addition, rodents are considered number one pre-harvest pests of lowland irrigated rice crops, especially in the Mekong and Red River Deltas of Vietnam [13,14], and cause annual pre-harvest losses of around 17% in Indonesia [15-18]. Control efforts by land managers and governments often do not reduce damage, either because control is conducted after damage has already occurred [19], or because the rodent populations recover rapidly after control and continue to cause damage [20].

Waterbird groups such as herons particularly the Black-headed Heron (local name: Omunaha), egrets, storks, particularly the Open-billed Storks (local name: Ekupi), cranes, eagles were mentioned by farmers as key in controlling pests on their fields (Table 4). Other methods used to control pests by these farmers included poisoning, scaring and hunting for birds and rats, clearing the levees for rats and hand picking snails (Table 5). The low abundance of snails on this rice scheme could be a clue that either the Open-billed Storks are cleaning up this habitat, which has an indirect effect of reducing incidences of schistosomiasis infection among the humans interacting with this habitat or it may be due to the continuous hand picking and use of poisons in the scheme. An increased abundance of snails in rice fields poses a huge threat of schistosomiasis outbreak to the work force with negative impacts on production [21]. These findings seem to suggest that waterbirds can act as biological controllers of these pests as also evidenced by studies elsewhere [22]. Despite these ecosystem services provided by birds, the management of Kibimba Rice scheme has continued to spray these birds while they are at the roosting sites. This practice will eventually lead to the decline in bird numbers thereby destabilizing the ecological dynamics of this habitat.

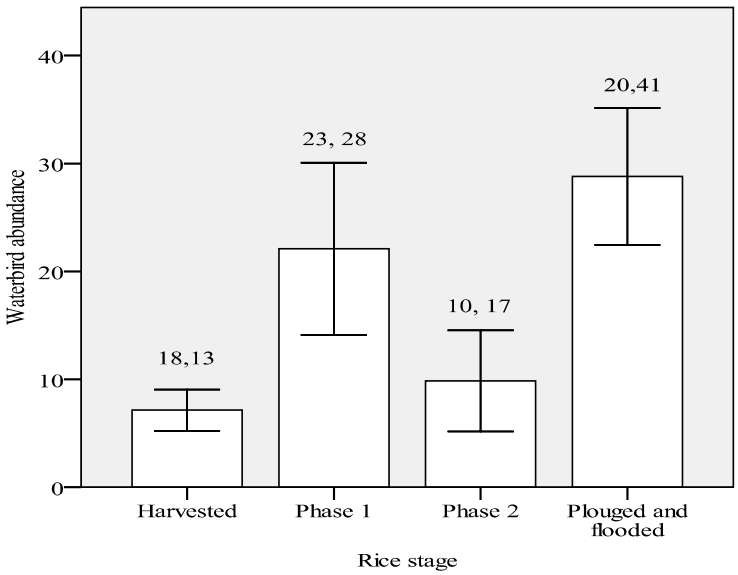

Fig. 1. Waterbird abundance (mean ± SE) in each rice phase. The number above each bar represents the number of counts made and number of species recorded in each rice phase respectively

Table 1. List of all Waterbird species recorded at Kibimba rice scheme

Common name	Scientific name	Order	Abundance	% Proportion
Abdmin's Stork	*Ciconia ciconia*	Ciconiiformes	11	0.11
African Crake	*Crex egregia*	Gruiformes	1	0.01
African Jacana	*Actophilornis africanus*	Charadriiformes	10	0.1
African Open-billed Stork	*Anastomus almelligerus*	Ciconiiformes	1151	11.63
African Spoonbill	*Plattalea alba*	Ciconiiformes	407	4.11
Black Crake	*Limnocorax flavirostra*	Gruiformes	12	0.12
Black-headed Heron	*Ardea melanocephala*	Ciconiiformes	1320	13.33
Black-winged Stilt	*Himantopus himanntopus*	Charadriiformes	304	3.07
Cattle Egret	*Bubulcus ibis*	Ciconiiformes	639	6.46
Common Pranticole	*Glareola pranticola*	Charadriiformes	1	0.01
Common Sand piper	*Actitis hypoleucos*	Charadriiformes	173	1.75
Common Snipe	*Gallinago gallinago*	Charadriiformes	5	0.05
Eurasian Marsh Harrier	*Circus aeruginosus*	Falconiiformes	11	0.11
Fulvous-whistlng Duck	*Dendrocygna bicolor*	Anseriformes	15	0.15
Gargany	*Anas querquedula*	Anseriformes	8	0.08
Glossy Ibis	*Plegadis falcinellus*	Ciconiiformes	5	0.05
Great Snipe	*Gallinago media*	Charadriiformes	1	0.01
Great-white Egret	*Egretta alba*	Ciconiiformes	142	1.43
Greenshank	*Tringa erythropus*	Charadriiformes	38	0.38
Grey Heron	*Ardea cinerea*	Ciconiiformes	179	1.81
Grey-crowned Crane	*Balearica pavonina*	Gruiformes	142	1.43
Hadada Ibis	*Bostrychia olivacea*	Ciconiiformes	791	7.99
Hammerkop	*Scopus umbreta*	Ciconiiformes	42	0.42
Knob-billed Duck	*Sarkidornis melanotos*	Anseriformes	25	0.25
Little Egret	*Egretta garzetta*	Ciconiiformes	604	6.1
Long-tailed Cormorant	*Phalacrocorax carbo*	*Pelicaniformes*	138	1.39
Long-toed Plover	*Vanellus crassirostris*	Charadriiformes	28	0.28
Marsh Sand Piper	*Tringa stagnatilis*	Charadriiformes	46	0.46
Purple Heron	*Ardea purpurea*	Ciconiiformes	52	0.53
Sacred Ibis	*Threskiornis aethiopica*	Ciconiiformes	596	6.02
Saddle-billed Stork	*Ephippiorhnchus senegalesis*	Ciconiiformes	10	0.1
Spur-winged Geese	*Plectropterus gambensis*	Anseriformes	13	0.13

Table 1 Continued….

Spur-winged Plover	*Vanellus spinosus*	Charadriiformes	4	0.04
Squacco Heron	*Ardeola ralloides*	Ciconiiformes	101	1.02
White Stork	*Ciconia ciconia*	Ciconiiformes	116	1.17
White-faced whistling Duck	*Dendrocygna viduata*	Anseriformes	56	0.57
White-winged Black Tern	*Chlidonias leucopterus*	Charadriiformes	36	0.36
Woolly-necked Stork	*Ciconia episcopus*	Ciconiiformes	4	0.04
Wood Sandpiper	*Tringa glareola*	Charadriiformes	671	6.78
Yellow-billed Duck	*Anas undulata*	Anseriformes	44	0.44
Yellow-billed Egret	*Egretta intermedia*	Ciconiiformes	1742	17.6
Yellow-billed Stork	*Mysteria ibis*	Ciconiiformes	205	2.07

This list includes all birds recorded of which majority are Ciconiiformes

Table 2. Number of individuals observed for each focal bird species

Focal bird species	Number observed	Individuals that caught prey	Individuals that did not catch prey	Most common prey item
Black-headed Heron	59	22	37	Mix of rats, snakes and frogs
Grey Heron	9	3	6	Rats
Open-billed Stork	86	43	43	Snails

Table 3. Organisms considered by farmers as rice pests

Proportion of respondents	Rats	Snails	Birds
Proportion of respondents who mentioned the pest	77.8	54.4	25.6
Proportion of respondents who didn't mention the pest	22.2	45.6	74.4

Table 4. Birds species mentioned by farmers as potential in controlling rice pests

Proportion of respondents	Heron (Rats)	Egrets (Insects)	Open-billed storks (Snails)	Ducks (Worms)	Cranes (Worms)	Eagles (Rats)
Proportion of respondents who mentioned the bird species	61.1	3.3	15.6	10	4.4	35.6
Proportion of respondents who didn't mention the bird species	38.9	96.7	84.4	90	95.6	64.4

In brackets are the rice pests controlled by the mentioned bird species

Table 5. Ways in which farmers control the rice pests mentioned in Table 4

Proportion of respondents	Clearing levees	Poisoning	Scaring	Hand picking	Hunting
Proportion of respondents who mentioned the control method	5.6	83.3	3.3	53.3	51.1
Proportion of respondents who didn't mention the control method	94.4	16.7	96.7	46.7	48.9

4. CONCLUSION

The distribution of waterbirds on rice paddies is affected by the different stages of the rice crop. In addition, rice paddies support mainly birds of the Ciconiiforme order. The high abundance of species such as Black-headed Heron and Open-billed Stork and the evidence gathered from the farmers clearly indicates that these waterbirds can play an invaluable environmental service of feeding on potential rice pests. We therefore suggest that in order to maintain the value of these birds on rice fields, manager/farmers in eastern Uganda should consider them as biological controllers of pests and not as pests

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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