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ARTICLE

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Status of Nahan’s Partridge *Ptilopachus nahani* (Dubois, 1905) (Aves: Galliformes: Odontophoridae) in Uganda

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Abstract: We carried out a survey of Nahan’s Partridge *Ptilopachus nahani* in the Ugandan forests of Mabira, Bugoma, and Budongo from December 2016 to December 2017, using a point count method employing a call playback technique. The aim was to establish the population status of this globally threatened species, which was last surveyed in 2003. Separate analyses of the number of groups per point and those involving use of the Distance Program yielded the same density estimates, indicating that either method reliably estimates the density of the species. The density estimates for the three reserves were 31.6, 25.2, and 13.3 groups per km² for Bugoma, Budongo, and Mabira forest reserves, respectively. In the last 14 years, it appears that the density of the species for Uganda has increased from 16.3 to 23.4 groups per km², which when extrapolated translates to 16,000 and 23,000 groups, respectively. This represents a 44% increase in density, or a group growth rate of 450 per year. The lowest density and population increment was registered in Mabira and we attribute this to the apparently high incidence of disturbance and degradation of this forest compared to the other two. Since Mabira, Bugoma, and Budongo are the only remaining large tropical rainforest reserves in Uganda, strengthening their conservation or upgrading their conservation status to national parks is required to save the species.

Keywords: Conservation, degradation, density, endangered species, ecotourism sites, hunting, nature reserve, playback, vulnerable.

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Competing interests: We declare that we have no significant competing financial, professional, or personal interests that might have influenced the performance or presentation of the work described in this manuscript.

Author details: Eric Sande holds a PhD (wildlife ecology) and has published over 20 articles in conservation but largely focusing on threatened birds. He is a member of IUCN-SSC/WPA Galliformes Specialist Group for Africa and currently a Senior Lecturer and Head of Zoology, Entomology and Fisheries Department, Makerere University, Uganda. SISIRIA AKOTH is wildlife ecologist with over 10 years’ experience. She has worked with wildlife/academic organizations and consultancy firms. Akoth is a graduate with Bachelor’s degree in Conservation biology and Master’s degree in Zoology, Makerere University, Uganda. She is currently a research fellow at Sokoine University of Agriculture, Tanzania. UBALDO RUTAZAA is young natural scientist with 5 years’ experience in field data collection. He holds an honours bachelor’s of science (zoology and botany) and is currently undertaking a masters degree of zoology from the Department of Zoology, Entomology and Fisheries Sciences, Makerere University, Uganda. William Olupot has a doctorate in ecology. He has published more than 30 articles on collection. He holds an honours bachelor’s of science (zoology and botany) and is currently undertaking a masters degree of zoology from the Department of Zoology, Entomology and Fisheries Sciences, Makerere University, Uganda.

Authors contribution: WO as director Nature and Livelihoods and ES (Galliform specialist) conceived the project; ES, SA, and UR collected the data; ES led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

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INTRODUCTION

Nahan’s Partridge *Ptilopachus nahani* is categorized as a globally Vulnerable species (BirdLife International 2019a), although between 2000 and 2018 it was categorized as Endangered. It is an enigmatic galliform known from a few localities in the eastern Democratic Republic of the Congo (DRC) from Yangambi eastwards, and in central and western Uganda (Dranzoa et al. 1999; McGowan 1994). Although Budongo, Bugoma, and Mabira forests are recognized as Important Bird Areas in Uganda (Byaruhanga et al. 2001) and are legally protected forest reserves, Mabira is under severe pressure from disturbance including logging and hunting. Nahan’s Partridge is a strict forest specialist species (Bennun et al. 1996), inhabiting closed forest up to 1,400m (Dranzoa et al. 1999), but its tolerance of degraded and secondary habitats is not well known. In fact, until a study by Sande (2001), the species was listed as Data Deficient by IUCN (Collar et al. 1994; McGowan et al. 1995). Being one of the main sought-after species in Uganda for avi-tourism, its conservation through tourism would benefit the three forest reserves and their biodiversity. Nahan’s Partridge was previously wrongly classified as a francolin. Now it is classified as a partridge, a sister species to another African endemic, the Stone Partridge *Ptilopachus petrosus*. It is most closely related to the New World quails (Odontophoridae) (Crowe et al. 2006; Cohen et al. 2012; BirdLife International 2016). Although the species was downgraded from Endangered to Vulnerable in 2019, its population in some parts of its range remains unknown and its global population size is believed to be decreasing (BirdLife International 2019a).

The population status of Nahan’s Partridge is of particular concern because it is a forest specialist species occurring in only three forest reserves in Uganda (Mabira, Bugoma, and Budongo). Fuller et al. (2004) carried out a survey of the species in the three forest reserves in 2003 and estimated the Ugandan population to be 40,000 individuals. They recommended, among other actions, the survey to be repeated every 10 years. This is the first study to follow up those recommendations. Conservationists used the occurrence of this species as one of the arguments to reverse the 2007 government proposal to degazette 7,000ha of Mabira forest reserve for growing sugarcane. Fuller et al. (2004) estimated the density of the species in the naturally forested part of Mabira (204km²), Bugoma (300km²), and Budongo (428km²) forest reserves (hereafter Mabira, Bugoma, and Budongo) as 8.3, 19, and 21 groups km⁻², respectively (Fuller et al. 2012). They attributed the relatively low density in Mabira to a high rate of logging and human disturbance compared to the other two forests. In their assessment of recreational values to promote sustainable use of Mabira, Olupot (2015) and Olupot & Isabirye-Basuta (2016) recommended the need for assessment of the status of the species in the entire Mabira to promote tourism and discourage the illegal human activities that threaten it. This study was conducted in part as a response to those recommendations.

The general aim of this study was to assess the population status of Nahan’s Partridge in Uganda. Specific objectives were to:

1. Determine the population status of the species in Uganda after 14 years
2. Compare the population status of the species in the existing and proposed ecotourism sites (Olupot & Isabirye-Basuta 2016) in Mabira Forest Reserve.

METHODS

Study area

The study was conducted in the Ugandan forest reserves of Mabira, Budongo, and Bugoma (Figure 1).

Mabira Forest Reserve (Figure 2a) is the largest block of moist semi-deciduous forest remaining in central Uganda. It is estimated to be 303km² in total area (Howard 1991) but Westman et al. (1989) estimated the least degraded, high forest area to have fallen from 285.4km² in 1973 to 204.2km² in 1988. As Fuller et al. (2004) used the area estimate of 204.2km² for their study, we use the same for this study. The reserve lies in a gently undulating landscape, characterized by numerous flat-topped hills and wide, shallow valleys. The reserve is isolated from other protected areas by settled and agricultural land. The relative closeness of Mabira to Kampala (59km), and the presence of various ecotourism facilities, makes it a potentially popular site for visitors (BirdLife International 2019b).

Mabira Forest Reserve is divided into three management zones. The strict nature reserve covers 23% of the forest and no activities are legally permitted there except scientific research and law enforcement. Tourism activities are permitted only in the recreational and buffer zones which covers 22% of the reserve. The production zone which covers 54% of the reserve is allocated to sustainable supply of round wood for Uganda’s plywood and veneer industry (Ministry of Water and Environment 2010). Despite having the designated zones, it is difficult to regulate the use of forest resources in the reserve because Mabira has 22
legal enclaves (Howard 1991). The human population living in the forest enclaves was approximately 825,000 with a density of 200–230 people per km² in 2001 (Mrema et al. 2001). Mabira is considered an Important Bird and Biodiversity Area (IBA) because of the presence of the Nahan’s Partridge (VU) and the Papyrus Gonolek Laniarius mufumbiri (NT) (BirdLife International 2019b).

The reserve is home to 315 species of birds (Byaruhanga et al. 2001) and 30 species of mammals including the endemic Uganda Mangabey Lophocebus albigena ugandae. The survey was conducted in the following compartments: Wantuluntu, Namaganda (Nature Reserve), Namusa Hill, Kiwala, Lugala, Najjembe, Griffin, Bugoma, and Buwola (Mulberry forest) (Figure 2a). Some of these sites (Namaganda, Namusa Hill, Najjembe, and Buwola) were visited during previous studies and are relevant to both objectives of this study. Although not sampled during the early 2000s, we also sampled in Kiwala, Lugala, and Griffin sites with the primary purpose of fulfilling objective 2.

Bugoma Forest Reserve (Figure 2b) is situated on top of an escarpment east of and overlooking Lake Albert. It sits on a gently sloping area, which drains towards lake Albert in the west. It comprises irregular blocks of high forest intersected by large patches of Hyparrhenia, Pennisetum, and Cymbopogon grasslands, which occupy approximately 18% of the reserve. About half of the forested portion is dominated by Iron Wood Crynometa alexandri and a further 38% is mixed Forest (BirdLife International (2019c). Bugoma is an IBA because of Nahan’s Partridge (VU) and the Grey Parrot Psittacus erithacus (EN) (BirdLife International 2019c), and the forested area is 300km² (Howard 1991). The reserve is home to 225 species of birds (Byaruhanga et al. 2001) and 23 species of mammals including the globally endangered Chimpanzee Pan troglodytes (Humle et al. 2016). The survey was done in the nature reserve (Figure 2b) which is dominated by Crynometa alexandri.

Budongo Forest Reserve (Figure 2c), is one of the most important forest reserves in Uganda for biodiversity conservation. It lies on the escarpment north-east of lake Albert and covers 793km² of which 428 is forested. It consists of a medium-altitude moist semi-deciduous forest, with areas of savanna and woodland.
Figure 2a. Mabira Forest Reserve showing where the survey was done.

Figure 2b. Budongo Forest Reserve showing where the survey was done.

Figure 2c. Bugoma Forest Reserve showing where the survey was done.
The reserve occupies gently undulating terrain, with a general slope north-north-west towards the Rift Valley. Budongo has five main forest-types: colonizing, mixed, Cynometra, Cynometra-mixed and swamp-forest. The vegetation has also changed considerably following 60 years of selective logging and silvicultural treatment which favored the growth of valuable timber species, especially mahoganies. Today, the forest is the richest in Uganda for native timber production. The Budongo Conservation Field Station (BCFS) based at Sonso carries out research throughout the forest, mainly on primates and birds (BirdLife International 2019d). Budongo is an IBA because of the presence of the Nahan’s Partridge (VU) and the Brown-cheeked Hornbill Bycanistes clyndricus (VU) (BirdLife International 2019d) with a forested area of 428km² (Howard 1991). The reserve is home to 360 species of birds (Byaruhanga et al. 2001) and 24 species of mammals including the globally endangered Chimpanzee Pan troglodytes (Humle et al. 2016). The survey was carried out in three compartments namely: N15 (66.7km²; Nature Reserve), N3, (384.4km²; logged in logged 1947–52) and W21 (24.5km²; logged in logged 1947–52) and W21 (24.5km²; logged in logged 1963-64 and 1996-97) (Figure 2c).

Survey techniques
The field survey was conducted on the following dates: 14–23 December 2016, 7–8 January 2017 and 2–3 December 2017 in Mabira; 11–19 November 2017 in Bugoma, and 15–24 December 2017 in Budongo. The point count method was used to survey the birds. At each point, locations of the birds were determined using a call playback technique at the points spaced evenly along line transects of varying lengths at distances of approximately 200m. Playback is the only method currently available for surveying the presence, absence, density and relative abundance of the species. Playback surveys have been used in the past to survey the species (Sande 2001; Sande et al. 2001; Fuller et al. 2004, 2012). In their verification of the methods used by Sande (2001), Fuller et al. (2012) noted that the playback method is now well developed, and recommended the use of the method for future surveys of the species. Elsewhere, playback surveys have been widely used to determine the presence of elusive birds (Glahn 1974; Marion et al. 1981; Gibbs & Melvin 1993).

The survey effort was 162, 231 and 397 points (covering 32.6, 46.4 and 79.6km) in Bugoma, Budongo, and Mabira forest reserves, respectively. The 200m interval between survey points was used because the investigator can hear the call within a radius of 100m (Sande et al. 2001; Fuller et al. 2004, 2012). At every point, we played the call for 20 seconds, three times at an interval of one minute. Fuller et al. (2004) on the other hand played for 10 seconds, waited for any ensuing response in 60 seconds and did this for two more playbacks. They, thus, estimated density from responses after three and a half minutes (70 seconds x3). Fuller et al. (2004) recommended that future surveys use a playback period of 20 seconds, play a total of three times, with a one-minute gap between each playback.

Fuller et al. (2012) demonstrate that movement of birds toward the sound stimulus during playback surveys can lead to significant overestimation of bird densities. They further showed that a higher number of groups responded to the third playback than the first two. This exacerbates the problem of overestimation, because some birds delayed several minutes before responding and were therefore likely to move a substantial distance toward the observer before being detected.

Sande (2001) found that 77% (n=525) of Nahan’s Partridge responded to the playback within one minute and used only these records to estimate density in Budongo Forest in 1997–1999. Also for this study, only responses within one minute were used in the estimation of density. This minimized the risk of overestimating density arising from birds moving towards the observer before being detected as the response within the one minute meant that the birds would not have moved a substantial distance before they responded. This is confirmed by the fact that the population estimate by Sande (2001) for Budongo Forest reserve (6000–7000 groups) (using the responses within one minute) was comparable with the estimate by Fuller et al. (2012) (8000 groups) in 2003 using the adjusted response distance (based on the responses from three call backs taking into account the distance they could have moved before responding). Thus, either the population estimate based on only the responses within one minute of the playback (Sande 2001) or that based on adjusted response distance (Fuller et al. 2012) can be used to avoid overestimation of density.

For every survey point we recorded the GPS coordinates, and wherever we got a positive response we estimated the distance from the researcher to the responding birds (sighting distance) and the number of individuals in case they were seen. Playback surveys were conducted from around 07.30h to around 15.00h.

Data analysis
Two methods were used: the number of groups per point, and distance analysis. A requirement of the latter is at least 60–80 sightings for fitting the detection
function (Buckland et al. 1993). Since this may not always be possible for rare or globally threatened species, there is need to test and recommend other methods that can be used to analyse data sets with fewer observations. This is important in conservation terms since threatened bird species require regular assessment to feed data into the Global Bird Species Program that is updated every four years.

Using the number of groups per point method, we obtained the mean response distance \( r \) from which the birds responded to the observer (which ranged from 10–200 m), the area of each point surveyed \( (\pi r^2 \text{ m}^2) \), the number of points surveyed in each forest reserve \( (n) \) and the total area surveyed in the reserve \( (n \pi r^2 \text{ m}^2) \). Thus, using the total number of groups \( g \) recorded in each forest reserve, the density of groups per \( \text{m}^2 \) was \( g / n \pi r^2 \) and the number of groups per \( \text{km}^2 \) was calculated.

The Program DISTANCE as described by Buckland et al. (1993) and Laake et al. (1993) was used. For point counts, this program calculates the density of animals using the sighting/radial distances. According to Bibby et al. (1998), each point surveyed is regarded as a sample and the effort is the number of times the point was surveyed. Buckland et al. (1993) stated that often when distances are estimated, the observer tends to round to convenient values (heaping) and recommended that the analysis of such data can be improved by grouping the distance data taking the midpoints as the distance measurements for each observation. Following Buckland et al. (1993), we used midpoint distances as these also remove the zero distance in the unlikely event that a bird was observed on the point. The six bands (groupings) used were: 0–5, 6–15, 16–30, 31–50, 51–100, 101–200 m. Distance analysis using point count data requires sighting distance and the number of individuals for every group recorded. For groups whose individuals were not seen during our surveys, the mean group size for the forest in question was used. This technique (and the groupings) was used by Sande (2001).

**RESULTS**

**Use of the number of groups per point and distance sampling analyses methods**

The mean distance from the observer at which the birds responded was 73.14, 73.43 and 62.90 m in Bugoma, Mabira, and Budongo, respectively. The density estimates using the number of groups per point and that using Distance sampling in each of the three forest reserves didn’t differ \( (Z<1.96, P>0.05, \text{ Table } 1) \). This shows that either method can be used to estimate density for the species and thus the number of groups per point method can be reliably be used to estimate density when the number of observation or sightings is less than 60. Therefore, the results presented in Tables 2, 3 and 4 were based on distance analysis method since the number of observations were more than 60. Results presented in Tables 5 and 6 however (comparisons among Mabira forest reserve’s compartments) were based on the number of groups per point analysis method since the number of observations in study compartments were less than 60.

**Density and relative abundance of Nahan’s Partridge**

The density estimates using Distance analysis for the three reserves were 31.6, 25.2 and 13.3 groups per \( \text{km}^2 \) for Bugoma, Budongo, and Mabira, respectively (Table 2). Results show an increase of density in Uganda from 16.3 in 2003 to 23.4 groups per \( \text{km}^2 \) in 2017. The mean group size in the three reserves was not significantly different \( (F=1.52, \text{ df}=2, 124, P=0.21, \text{ One-way ANOVA}) \). From 2002 to 2017, a period of 14 years, the total number of individuals of Nahan’s Partridge in Uganda increased by 50% from about 40,000 to 60,000 (Table 3). Sande (2001) found that although the Nahan’s Partridge breed throughout the year, the peaks of breeding were January to March, and then August to November. The survey by Fuller et al. (2004) was done from July to September while that for this study was done from November to January during the peak of the breeding season. Since our study was done in the breeding months, it is a good time to survey these birds. Call playback surveys are recommended as the most efficient survey method during the breeding season, especially for those species that are known to respond to call playback, occupy relatively large home ranges and/or are otherwise difficult to detect (Ministry of Environment, Lands & Parks 1999). The time when our study was done is therefore the best to get a good population estimate, and hence our results are reliable and not an over or under estimate.

Intra-reserve status analyses are required for monitoring of population changes within each reserve. Comparisons were done only for Budongo and Mabira where there was data from compartments with different management histories. In Budongo, the three compartments with different management histories (N15-Nature Reserve, N3-logged in logged 1947–52 and W21-logged in logged 1963–64 and 1996–97) were surveyed in 1997 and 2017. In 2017, the mean group size from the three compartments was not
The density was, however, significantly higher between N15 and N3 (Z=2.74, P=0.006) and also significantly higher between W21 and N3 (Z=3.25, P=0.001). The density in N15 and W21 was similar (Z=0.53, P=0.593) (Table 4).

Olupot & Isabirye-Basuta (2016) recommended among other things the assessment of the status of the Nahan’s Partridge in the entire Mabira Forest Reserve and setting up of new tourism camps. We conducted our surveys in nine sites (Table 6). Using the number of groups per point method, the highest densities of Nahan’s Partridge were recorded in Wantuluntu (39.3 groups/km$^2$) and lowest in the forest adjacent to the Buwoola enclave (2.0 groups/km$^2$), which is predominantly a Mulberry forest (Table 5). The density was significantly higher in Wantuluntu compared to other sites (Z>2.58, P<0.01). There were no significant differences in the densities between the existing and proposed ecotourism sites and between proposed ecotourism sites and the nature reserve (Z<1.96, P>0.05) (Table 6).

**DISCUSSION**

**Status of Nahan’s Partridge population in Uganda**

The study has established that the density of the globally Vulnerable Nahan’s Partridge in Uganda increased from 16.3 to 23.4 groups per km$^2$ in 14 years. Over the years, the total number of groups of Nahan’s Partridge in Uganda grew from 16,000 to 23,000 (44%).
The population growth is attributed to the fact that the species inhabits only three remaining largest forest reserves (Mabira, Budongo, and Bugoma) which are protected by law. There is sustainable utilization of forest resources in the three forest reserves and the other 503 central forest reserves in Uganda. Human activities in the species habitat are allowed but fairly regulated by the Uganda National Forestry Authority (NFA). Mabira, Budongo, and Bugoma, the three major forest reserves in Uganda, happen to be the only reserves in the country that harbor Nahan’s Partridge. They have been zoned into nature reserves (20% of the forest is strictly protected), protection/buffer zone where low-impact uses are permitted (30%) and the production zone for controlled production of timber and other forest products (50%). Although these zones occur in theory, the situation on the ground is very different because the communities utilize the zones the way they want in some reserves due to ineffective enforcement by NFA. Current forest destruction within and outside protected areas in Uganda is alarming. According to NFA (2018), forest cover across the country declined sharply from 24% (4,933,271ha) of land area in 1990 to less than 9% (1,956,664ha) in 2018 (https://www.nfa.org.ug/index.php/12-nfa-news).

The lowest density in Mabira can be explained by less favourable management forest practices compared to the other reserves. Our study observed that at the time of the survey, logging was very severe in Mabira Forest Reserve in particular, although the intensity was not quantified. It often involves use of tools such as power saws to cut or damage large mature trees and trees with prominent buttresses such as *Ficus exasperata* and *Alstonia boonei* (Image 1a,b), which are vital for nesting and roosting of Nahan’s Partridge. Loss of such trees reduces the breeding and roosting micro-habitats of the species. Sande (2001) found that 91% (n=58) of breeding females nested in buttresses. Another tree species that is intensively being harvested in Mabira forest reserve is the wild rubber tree *Funtumia elastic* (Image 2a,b). We were reliably informed by locals that this tree is highly desired for making face-boards in house construction and sofa set chairs. Other than the timber harvesting, we encountered many charcoal burning spots in Mabira Forest Reserve; some with stumps being collected for burning, some covered with soil ready for burning, and others after burning and charcoal taken (Image 3a–c). The fact that Mabira Forest Reserve has up to 22 enclaves (villages) legally settled within the reserve makes it a fertile ground for forest encroachers compared to Budongo and Bugoma, which do not

<table>
<thead>
<tr>
<th>Points surveyed</th>
<th>No. of groups</th>
<th>Groups/km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wantuluntu</td>
<td>6</td>
<td>39.3</td>
</tr>
<tr>
<td>Nature Reserve (Namaganda)</td>
<td>113</td>
<td>18.4</td>
</tr>
<tr>
<td>Namusa Hill**</td>
<td>15</td>
<td>15.7</td>
</tr>
<tr>
<td>Kiwala Hill**</td>
<td>17</td>
<td>13.9</td>
</tr>
<tr>
<td>Lugala**</td>
<td>9</td>
<td>10.5</td>
</tr>
<tr>
<td>Najjembe*</td>
<td>85</td>
<td>10.5</td>
</tr>
<tr>
<td>Griffin*</td>
<td>46</td>
<td>9.2</td>
</tr>
<tr>
<td>Bugoma</td>
<td>38</td>
<td>8.7</td>
</tr>
<tr>
<td>Buwola (Mulberry)</td>
<td>23</td>
<td>2.0</td>
</tr>
</tbody>
</table>

*—existing eco-tourism site | **—proposed eco-tourism site

### Table 4. Density (95%CI) and number of groups (abundance) (95%CI) of Nahan’s Partridge in Budongo in 2017 compared to 1997.

<table>
<thead>
<tr>
<th></th>
<th>N15</th>
<th>N3</th>
<th>W21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean response Distance</td>
<td>59.1±5.9</td>
<td>67.5±10.4</td>
<td>62.3±5.6</td>
</tr>
<tr>
<td>No. of responses</td>
<td>32.0</td>
<td>16.0</td>
<td>34.0</td>
</tr>
<tr>
<td>Sampling Effort</td>
<td>84.0</td>
<td>73.0</td>
<td>71.0</td>
</tr>
<tr>
<td>Density (Gps/km²) (2017)</td>
<td>34.7 (28.7–42.9)</td>
<td>15.3 (21.4–11.5)</td>
<td>39.3 (33.1–47.4)</td>
</tr>
<tr>
<td>Density (Gps/km²) (1997)</td>
<td>15.7</td>
<td>16.4</td>
<td>22.1</td>
</tr>
<tr>
<td>Z Value (2017 Vs 1997 density)</td>
<td>2.676 (P=0.007)</td>
<td>0.195 (P=0.845)</td>
<td>2.284 (P=0.022)</td>
</tr>
<tr>
<td>Total No. of groups (2017)</td>
<td>2,316 (1,915–2,859)</td>
<td>5,337 (4,007–7,458)</td>
<td>962 (810–1,162)</td>
</tr>
<tr>
<td>Total No. of groups (1997)*</td>
<td>751</td>
<td>6,051</td>
<td>450</td>
</tr>
<tr>
<td>Population change based on No. of groups</td>
<td>Tripled</td>
<td>No change</td>
<td>Doubled</td>
</tr>
</tbody>
</table>

*Sande (2001)

### Table 5. Status of Nahan’s Partridge in the existing and proposed ecotourism sites of Mabira.

<table>
<thead>
<tr>
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<td>15.7</td>
</tr>
<tr>
<td>Kiwala Hill**</td>
<td>17</td>
<td>13.9</td>
</tr>
<tr>
<td>Lugala**</td>
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<td>10.5</td>
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<tr>
<td>Najjembe*</td>
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<td>10.5</td>
</tr>
<tr>
<td>Griffin*</td>
<td>46</td>
<td>9.2</td>
</tr>
<tr>
<td>Bugoma</td>
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<td>8.7</td>
</tr>
<tr>
<td>Buwola (Mulberry)</td>
<td>23</td>
<td>2.0</td>
</tr>
</tbody>
</table>

*—existing eco-tourism site | **—proposed eco-tourism site
Table 6. Pair-wise comparison of density between the different compartments.

<table>
<thead>
<tr>
<th>Pairs</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Z-Value</th>
<th>P-Value</th>
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</thead>
<tbody>
<tr>
<td>Wantuluntu vs Nature Reserve</td>
<td>39.3</td>
<td>18.4</td>
<td>2.751</td>
<td>0.006</td>
</tr>
<tr>
<td>Wantuluntu vs Namusa</td>
<td>39.3</td>
<td>15.7</td>
<td>3.182</td>
<td>0.001</td>
</tr>
<tr>
<td>Wantuluntu vs Kiwala</td>
<td>39.3</td>
<td>13.9</td>
<td>3.482</td>
<td>0.000</td>
</tr>
<tr>
<td>Wantuluntu vs Lugala</td>
<td>39.3</td>
<td>10.5</td>
<td>4.081</td>
<td>0.000</td>
</tr>
<tr>
<td>Wantuluntu vs Bugoma</td>
<td>39.3</td>
<td>8.7</td>
<td>4.416</td>
<td>0.000</td>
</tr>
<tr>
<td>Wantuluntu vs Najjembe*</td>
<td>39.3</td>
<td>10.5</td>
<td>4.081</td>
<td>0.000</td>
</tr>
<tr>
<td>Wantuluntu vs Griffin</td>
<td>39.3</td>
<td>9.2</td>
<td>4.322</td>
<td>0.000</td>
</tr>
<tr>
<td>Nature Reserve vs Namusa</td>
<td>18.4</td>
<td>15.7</td>
<td>0.462</td>
<td>0.644</td>
</tr>
<tr>
<td>Nature Reserve vs Kiwala**</td>
<td>18.4</td>
<td>13.9</td>
<td>0.791</td>
<td>0.429</td>
</tr>
<tr>
<td>Nature Reserve vs Lugala**</td>
<td>18.4</td>
<td>10.5</td>
<td>1.469</td>
<td>0.142</td>
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<td>Nature Reserve vs Bugoma</td>
<td>18.4</td>
<td>8.7</td>
<td>1.863</td>
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<tr>
<td>Nature Reserve vs Najjembe*</td>
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<td>10.5</td>
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<td>0.142</td>
</tr>
<tr>
<td>Nature Reserve vs Griffin</td>
<td>18.4</td>
<td>9.2</td>
<td>1.751</td>
<td>0.080</td>
</tr>
<tr>
<td>Nature Reserve vs Namusa**</td>
<td>15.7</td>
<td>18.4</td>
<td>-0.462</td>
<td>0.644</td>
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<tr>
<td>Namusa** vs Kiwala**</td>
<td>15.7</td>
<td>13.9</td>
<td>0.330</td>
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<td>Namusa** vs Lugala**</td>
<td>15.7</td>
<td>10.5</td>
<td>1.015</td>
<td>0.310</td>
</tr>
<tr>
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<td>15.7</td>
<td>8.7</td>
<td>1.417</td>
<td>0.156</td>
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<tr>
<td>Namusa** vs Najjembe*</td>
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<td>10.5</td>
<td>1.015</td>
<td>0.310</td>
</tr>
<tr>
<td>Namusa** vs Griffin*</td>
<td>15.7</td>
<td>9.2</td>
<td>1.302</td>
<td>0.193</td>
</tr>
<tr>
<td>Kiwala** vs Bugoma</td>
<td>13.9</td>
<td>8.7</td>
<td>1.093</td>
<td>0.274</td>
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<tr>
<td>Lugala** vs Bugoma</td>
<td>10.5</td>
<td>8.7</td>
<td>0.410</td>
<td>0.681</td>
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<tr>
<td>Lugala** vs Najjembe*</td>
<td>10.5</td>
<td>10.5</td>
<td>0</td>
<td>1.000</td>
</tr>
<tr>
<td>Lugala* vs Griffin*</td>
<td>10.5</td>
<td>9.2</td>
<td>0.292</td>
<td>0.770</td>
</tr>
<tr>
<td>Kiwala** vs Lugala**</td>
<td>13.9</td>
<td>10.5</td>
<td>0.688</td>
<td>0.491</td>
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<tr>
<td>Kiwala** vs Najjembe*</td>
<td>13.9</td>
<td>10.5</td>
<td>0.688</td>
<td>0.491</td>
</tr>
<tr>
<td>Kiwala** vs Griffin*</td>
<td>13.9</td>
<td>9.2</td>
<td>0.977</td>
<td>0.328</td>
</tr>
<tr>
<td>Bugoma vs Najjembe*</td>
<td>8.7</td>
<td>10.5</td>
<td>-0.410</td>
<td>0.682</td>
</tr>
<tr>
<td>Bugoma vs Griffin*</td>
<td>8.7</td>
<td>9.2</td>
<td>-0.118</td>
<td>0.906</td>
</tr>
<tr>
<td>Najjembe vs Griffin*</td>
<td>10.5</td>
<td>9.2</td>
<td>0.292</td>
<td>0.770</td>
</tr>
</tbody>
</table>
have such settlements within the reserves. According to BirdLife International (2019a), Nahan’s partridge is currently categorized as globally Vulnerable because it’s very small, severely fragmented global range is declining in the area of occupancy and in the extent and quality owing to deforestation and forest degradation. The high forest destruction of Mabira forest reserve is a significant contribution to this global decline of the species area of occupancy.

Fuller et al. (2004) indicated that around Mabira, Bugoma, and Budongo forest reserves, 54% and 30% of the respondents said that they hunt galliformes by hand and using nets, respectively. Netting is probably by far the more destructive of these two hunting techniques. Hunters string out nets and then drive ground animals towards them using dogs and by shouting and beating objects. During our survey on Bugoma Hill (Compartment 192 of Mabira), the informant (our local guide who himself also occasionally participates in hunting) informed us that forest management authorizes hunting in that compartment three days a week (Tuesdays, Thursdays and Saturdays), however, this is contradicted by NFA managers who insist that hunting is not authorized. Hunters can kill up to 30 duikers and six Nahan’s Partridges in a single expedition. If this is true, extrapolating from the figures provided by the informant it would appear that one team of hunters can kill up to 18 Nahan’s Partridge in a week. Such a level of off-take likely explains why the abundance of Nahan’s Patridge in Mabira lower than in other reserves. Further detailed studies on the impact of hunting on the species need to be carried out in the three reserves.

Density and relative abundance of Nahan’s Partridge in Budongo from 1997 to 2017

Sande (2001) and this study provide a good baseline assessment of the population status of the species after two decades and a prediction of the population of the species in the next 50 years if the conservation efforts currently undertaken are maintained or improved.

The tripling of the groups in 20 years in the Nature Reserve (N15) can be explained by two factors. Firstly, the relatively rapid population growth in the nature reserve is explained by the healthy breeding environment there. Our study has observed that Budongo’s Nature Reserve (N15) still remains relatively intact. It is an Ironwood Cynometra forest which Eggeling (1947) suggested that this represents the climatic climax and a species poor forest type with Cynometra alexandrii dominating and forming 75% of the cover. C. alexandrii usually has extensive thin buttresses near the base that can be up to 8m long and several metres high. Sande (2001) found that 91% of the Nahan’s Partridge nested in buttresses and nest survival and nest success were higher in the unlogged Nature reserve than in the logged habitat with C. alexandrii being the most commonly used tree species for nesting. So a microhabitat with many large buttresses provides a good breeding environment for the species.

The second factor could be that fewer researchers and research assistants spend less time in the nature reserve compared N3. There is therefore a high human-Nahan’s Partridge encounter rate in N3 compared to N15 and W21. This is because most of the research in Budongo is done on primates, especially Chimpanzees. The habituated groups of Chimpanzees spend most of the time in N3 (where Sonso, the Budongo Conservation Field Station is located) because fruiting trees, especially figs, are abundant there. The number of researchers and field assistants, and the amount of time they generally spend, are much less in N15 and W21 than in N3. Nahan’s Partridges being very shy birds, their daily activity patterns particularly nesting are affected by human disturbance. According to Sande (2001), the survey from March 1998 to January 2000 reported that 43% of the nests (n=58) were located 2m or less from the trail and 76% of these did not succeed probably due to disturbance. It is therefore probable that the relatively low research activity in N15 and W21 provides better nesting conditions for the birds. Thus the tripling of the number of groups in N15 can be explained by the buttress-rich environment provided by C. alexandrii and the less human-Nahan’s encounter while only the latter explains the doubling of the population in W21. The high human-Nahan’s encounter in N3 probably explains the no change over the years. The impact of researcher’s activities on Nahan’s Partridge’s nest success and nest survival needs to however be further investigated.

Density of Nahan’s Partridge in the proposed ecotourism sites

The highest density in Wantuluntu (39.3 groups per km²) should be interpreted with caution because of the small sample size (five sightings). When this site is excluded, the density of Nahan’s Partridge was generally the same in all the sites (11 groups per km²). This was probably because of the high and increased incidence of human activities generally in all the sampling sites including what we noted in the strict nature reserve. Although sustainable utilization of natural resources is allowed in forest management in Uganda, areas gazetted as strict nature reserves should be managed for
the purpose they are set aside for particularly in Mabira. This will allow better assessments and predictions of the impact of forest disturbance and utilization on biodiversity.

Compared to Watuluntu and Namaganda areas, Kiwala and Lugala (sites that Olupot & Isabirye-Basuta 2016 recommended for ecotourism development) did not do well in terms of Nahan’s Partridge abundance. This was probably because of the high and increased incidence of human activities noted there, particularly
tree cutting for charcoal and fire wood. The two recommended sites are nonetheless good potential ecotourism sites that could be developed. Kiwala Hill Area was recommended because of a good landscape and camp site. In addition, it has an excellent hiking route (Image 4a) from the valley near Nagojje Ranger post to the sugarcane plantation that looks like the famous Royal mile of Budongo (Image 4b) which is believed to be one of the best places for forest bird watching in Uganda according Rossouw & Sacchi (1998). Lugala on the other hand has a good forest and high potential for hiking route and camp site. Our survey in Lugala found that in addition, an excellent 2–3 km long birding trail along the forest boundary where the visitors would enjoy watching the forest edge birds, e.g., turacos and hornbills.

Namusa Hill is the third potential ecotourism site which could be developed. Our study found that because it has a good landscape appeal, good birding trail of up to 5km, the hill top has a grassland meadow with a transitional grassland-forest interface (Image 5a) and a swamp at the top of the hill (Image 5b). The hill is therefore an excellent bird watching site where forest specialists, forest generalists, grassland birds and water birds can be seen.

Possible causes for the low abundance of Nahan’s Partridge in *Broussonetia papyrifera* forest

*Paper mulberry Broussonetia papyrifera* is an exotic tree that has colonised a large degraded area in the eastern part of the forest. This is where the population of Nahan’s Partridge was minimum. Fuller et al. (2004) also did not report occurrence of Nahan’s Partridge in this habitat. As this is a monodominant *B. papyrifera*-dominated forest (Image 6a), the diversity of arthropods that are known to be one of the major food items for the species is low. The trees also do not have large buttresses that can provide nesting and roosting sites,
probably reducing breeding success. We suspect these are the likely reasons why the population in that particular forest type is low because we know that the species prefers forest types that have trees with large buttresses and a lot of undergrowth (Image 6b) that presumably has lots of arthropods and insect larvae.

CONCLUSIONS

Results from this study show that the density of Nahan’s Partridge (Image 7) increased by seven groups per km² in Uganda, while the total number of groups and total number of individuals increased by 44 and 50% respectively in the period of 14 years. The lowest density was noted in Mabira, where the level of forest disturbance and degradation was notably higher as the forest lies in the vicinity of highly-industrialized and populous Kampala City, Jinja, Lugazi, and Mukono municipalities, which are in dire need of forest products including bushmeat. The rampant exploitation is exacerbated by the apparent weak and limited law enforcement by NFA. There is, therefore, an urgent need to hasten conservation action in these only remaining forest reserves in Uganda that will save the 315, 225, 360 bird species and 30, 23, 24 mammal species in Mabira, Bugoma, and Budongo forests, respectively, many of which will undoubtedly disappear if the forests themselves disappear.

RECOMMENDATIONS

1. Carry out a detailed study on impacts and mechanisms through which forest, use including hunting, affect Nahan’s Partridge populations in Uganda.  
2. Stop or at least discourage hunting, particularly with nets as they over exploit and do not discriminate forest floor fauna according to target and non-target species and age groups.  
3. Assess the impact of research intensity on the nesting success of Nahan’s Partridge in Budongo Forest Reserve.  
4. NFA should ensure that the strict nature reserves within these forests are better managed to ensure that they are visited strictly for research and law enforcement.  
5. As threatened primates and other biodiversity occur in the three forest reserves, including globally endangered chimpanzee in Budongo and Bugoma and the endemic Uganda Mangabey Lophocebus albigena ugandae, every effort should be made to strengthen conservation of the three reserves, including the possibility of having them gazetted as national parks.

REFERENCES


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