# AVIAN FLIGHT HEIGHTS ACROSS POWER LINES IN DAR ES SALAAM

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## ABSTRACT

*In recent years, Africa has experienced an increase in power generation projects. However, such development projects come with negative side effects on the environment. For example, electrocution and collision with power lines have become among the causes of mortality to populations of large terrestrial birds. Many species of birds are especially vulnerable to collision with high voltage transmission lines because of the height of these structures with respect to birds' flight altitudes. Despite the increased power lines networks, there have been very little studies on the flight heights of birds in relation to power lines. From December to February 2015, we studied flight heights of local birds as they commuted across low (LVP, 33KV) and high (HVP, 132KV) voltage power lines in Dar es Salaam. In additional to avian flight heights, we also studied their behaviours as they approached the power lines. The two power lines had different heights from the ground (13 m versus 24 m) but we targeted birds that passed between 13 ± 5 m and 24 ± 5 m recording whether a bird passed below, between or above electric cables. Using the abundance of birds that crossed the power lines, we found no preferred flight heights at LVP and HVP although all egrets passed above the cables. Changing of flight heights as birds approached power lines was recorded only for egrets whereas collision was observed for Indian House Crow and House Sparrow. We recommend that before any installation or erection of power lines, investigation on birds' routes to and from roosts and foraging sites must be conducted first. Use of underground connections and wire-marking or bird flight diverters at sensitive locations can help to reduce the risk of collision for both local and migratory flying animals especially birds.*

**Keywords:** Collision, electrocution, flight heights, power lines, urban

## INTRODUCTION

Bird flight altitudes are measured as an average height from the ground to a flying bird. Migrating and non-migrating birds show different flight heights. Migrating birds take advantage of thermals and stronger tail winds when

conditions permit, allowing them to conserve energy (Newton, 2008) while staying well above power lines. In general, flight altitudes of migrating birds range from a couple hundred meters to more than 6,000 m (van Rooyen & Ledger, 1999). The height at which birds fly is an important factor in collision incidents. Most collisions occur during short distance, low altitude flights, with a high frequency of power line crossings. For non-migrating birds, and movements between stopping overs for migrating birds, flight altitude is likely to fall within the range of power line heights.

Birds' flight is a function of their feeding, mating, and roosting behaviours. These behaviours usually occur within approximately 200 m of the ground, which can expose birds to collision risk when in the proximity of power lines. Many species of birds are especially vulnerable to collision with high voltage transmission lines because of the height of these structures with respect to flight altitude, and because of their low visibility, whereas many species are potentially less vulnerable to collisions with distribution lines (Morkill & Anderson, 1991). Collectively, divers, grebes, herons, ducks, geese, swans, rails, gallinules and coots and gulls are prone to collisions where power lines occur in close proximity to water bodies or wetlands.

Electrocution and collision with power lines are considered to be a major cause of death for some avian species (Crivelli *et al.*, 1988, Smallie, 2008) such as bustards, vultures, cranes, storks and flamingos (Fiedler & Wissner, 1980). These kinds of birds have limited maneuverability in the air and have difficulty making swift, evasive actions to avoid colliding with power lines (Smallie, 2008). Electrocution can occur when a bird perches on a cross-arm and completes an electrical circuit with two or more body parts. Electrocution can also happen when the bird comes between two energized components or an energized and an earthed (also called 'grounded') component of the pole structure. Collisions, on the other hand, happen when birds fly directly into electrical lines, poles and pylons and the bird is typically killed when it collides with such obstructions and the subsequent impact with the ground, or it dies from the resulting injuries (Lehman *et al.*, 2007).

There has been increased power lines network in most cities in Africa where they are yet to use underground wiring systems, and even recently (in 2011) in Dar es Salaam a 132 KV power line was installed in a populated urban area from Ubungo to Oysterbay, while already other large power line at high heights take power to upcountry and Zanzibar (upon reaching the seashore at

Kunduchi in Dar es Salaam). Despite all these, there have been very little or no studies on the flight heights of urban birds in relation to power line network in Tanzania. Moreover, while some of the bird species may have already moved from Urban to outskirts of the cities following habitat loss to urbanization, resident birds that use mudflats, islands, river creeks for roosting and nesting have less option than to stay, and they continue moving or commuting between roosting and foraging sites. The daily movements are threatened by the infrastructure such as; tall buildings, communication towers and power lines. It is hypothesized that birds change the flight height when arriving to the power lines to avoid collision and electrocution. Thus, this study aimed at assessing the avian flight heights in relation to power lines and to investigate the responses (behaviours) of birds while crossing the power lines.

## METHODS

The study was conducted in Dar es Salaam, a region covering a total area of 1, 800 sq.km, of which landmass is 1, 350 sq.km. It is Tanzania's leading industrial region and a financial capital, located on the western shores of the Indian Ocean. According to 2012 national population census, it is home to about 4.3 million people. There are many small islands and estuaries that provide good roosting sites for many medium to large birds, and is listed as an Important Bird Area (Baker & Baker 2002). In recent years, infrastructure networks such as raising buildings, communication towers, and electric networks have increased dramatically. Dar es Salaam has a complex power line network in Tanzania.

The study was conducted in three different sites along the Ubungo-Mwenge power lines network (Ubungo, Mlimani city and Mwenge), with high voltage power line (HVP) of 132KV, with a height of 24 m, and low voltage power lines (LVP) of 33 KV with a height of 13 m. Where on each power line type, three observation stations were selected after preliminary visits, priority were given to areas where many birds cross to and from roosting and or foraging sites. Each selected observation points was surveyed three times in the evening hours from 17h30 to 18h30. The study was conducted from December 2014 to February 2015. Different bird species crossing power lines were recorded, the number of individuals, and a note was taken to whether birds cross the power line at below (to -5 m), between or above (to +5 m) the electric cables. We also recorded avian behaviours mainly changing flight altitude, perching on the

poles or on the wires, isolation from flock, and change of direction when approaching or while crossing power lines.

**Data analyses**

Data were tested for normality by using Shapiro Wilk Test before being subjected to statistical analysis to test for significance differences for the means. Non-parametric, Kruskal-Wallis, statistical test was used to compare the flight heights within each voltage power line (below, between and above) while avian flight heights between HVP and LVP was tested by using Mann-Whitney, *U*-test. Behaviours (isolation from the flock, collision, changing the flight height, change of direction, perching, etc.) were recorded and their frequency was determined and depending on the frequency; because of limited samples, descriptive analysis was used. All data were analysed by using PAST and SYSTAT software.

## RESULTS

**Species composition**

Overall, we recorded 11 bird species; IHC (*Corvus splendens*), House sparrow (*Passer domesticus*), Little egret (*Egretta garzetta*), Cattle egret *(Bubulcus ibis*), Goliath heron (*Ardea goriath*), Hamerkop (*Scopus umbretta*), Black kite (*Milvus migrans*), Little swift (*Apus affinis*), Sacred ibis (*Threskiornis aethiopicus*), Black-headed heron (*Ardea melanocephala*), and Wire-tailed swallow (*Hirundo rustica*). With exception of sacred ibis, the rest were also recorded at Ubungo. Only two bird species, IHC and House sparrow, were recorded at Mlimani City while five bird species namely IHC, House sparrow, Little egret, Cattle egret and Sacred ibis were recorded at Mwenge. IHC was abundant at all sites and they crossed both LVP and HVP. The other common species were House sparrow, Little egret, Wire- tailed swallow and Cattle egret. The rest of the species were observed crossing only HVP (Table 1). Two species (IHC and House sparrow) among all, crossed the power line at all altitudes (i.e. below, between and above the cables), the rest of the species were passing above the cables.

**Table 1: Mean and Standard deviation (Mean±SD) of the number of individuals of each species at different study locations along LVP and HVP**

| Species | Ubungo | | Mlimani City | | Mwenge | |
|---|---|---|---|---|---|---|
| | LVP | HVP | LVP | HVP | LVP | HVP |
| IHC | 608.7±15.0 | 399.3±114.0 | 104.7±20.5 | 144.3±95.2 | 335.7±28.8 | 362.3±134.5 |
| Little egret | 31±11.53 | 47.7±32.1 | - | - | 28.7±6.03 | 20.3±10.6 |
| House sparrow | 32±3.0 | 35.3±52.6 | 46.3±12.22 | 14.7±13.2 | 46.7±9.3 | 39±21.1 |
| Cattle egret | - | 2±1.73 | - | - | - | - |
| Goliath heron | - | 1 | - | - | - | - |
| Hamerkop | - | 1 | - | - | - | - |
| Black kite | - | 1 | - | - | - | - |
| Little swift | - | 1 | - | - | - | - |
| Black -headed heron | - | 1 | - | 1 | - | - |
| Sacred ibis | - | - | - | 1 | - | - |
| Wire -tailed swallow | - | 8 | - | - | - | - |

## The flight heights within HVP

There were variations between the flight heights within HVP (Kruskal Wallis Test, H=18.07, P<0.001). Many birds were passing below and above the power lines than between the electric wires (Figure 1). Pairwise Mann-Whitney comparisons test showed a significant difference in flight height preference for above and between cables (P<0.001), below and between (P=0.003) but there was no significant difference for below and above (P= 0.199).

## Flight heights within LVP

Preference for flight heights within LVP varied significantly (H=30.53, P<0.001). Many birds were passing above than between or below the power lines (Figure 2). Pairwise Mann-Whitney comparison test show a significant difference for above and between cables (P=0.004), below and above (P<0.001) but there was no significant difference for below and between cables (P=0.08543).

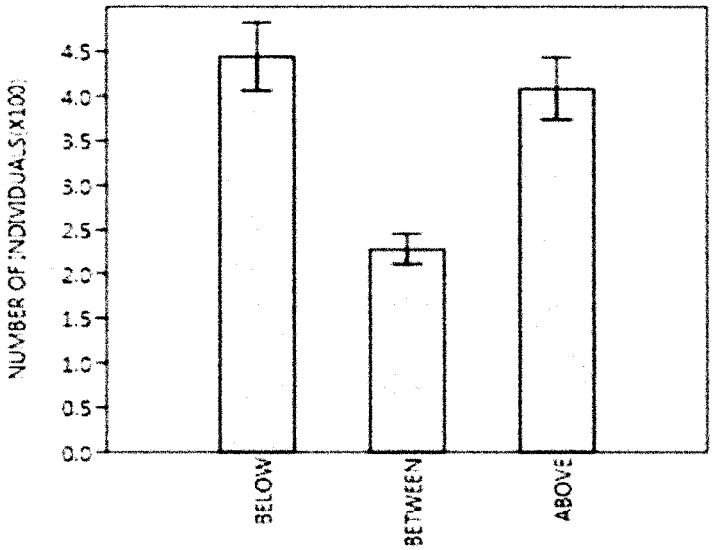



***Figure 1:.*** *Avian flight height preferences at HVP (132 KV)*

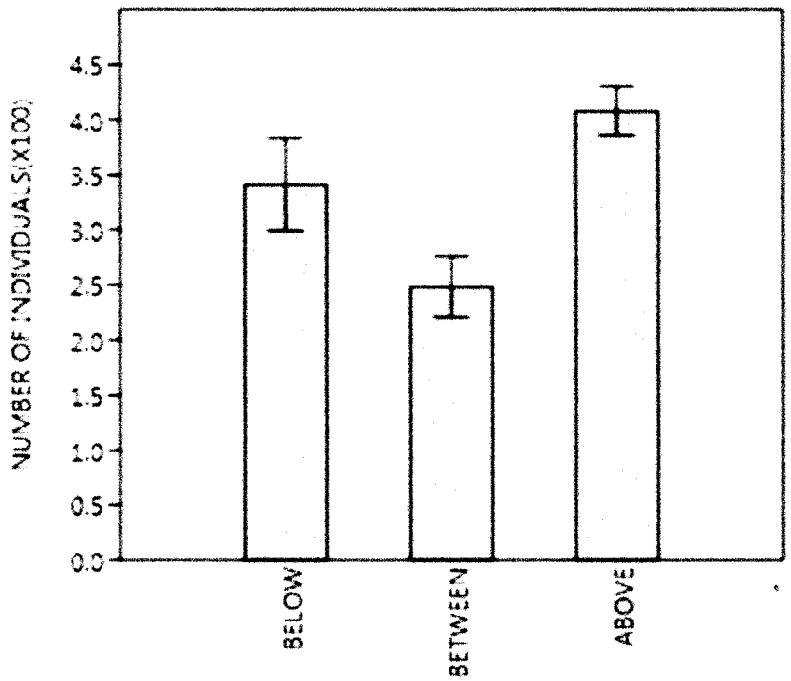



***Figure 2:*** *Avian Flight height preferences at LVP (33KV)*

## The flight heights between HVP and LVP power lines

There were no variations between the avian flight heights preferences within HVP and LVP (Mann-Whitney U-test, $U$=2.9221x10$^{-5}$, P=0.647) (Figure 3). This indicates that LVP and HVP are within the observed flight heights of the local birds.

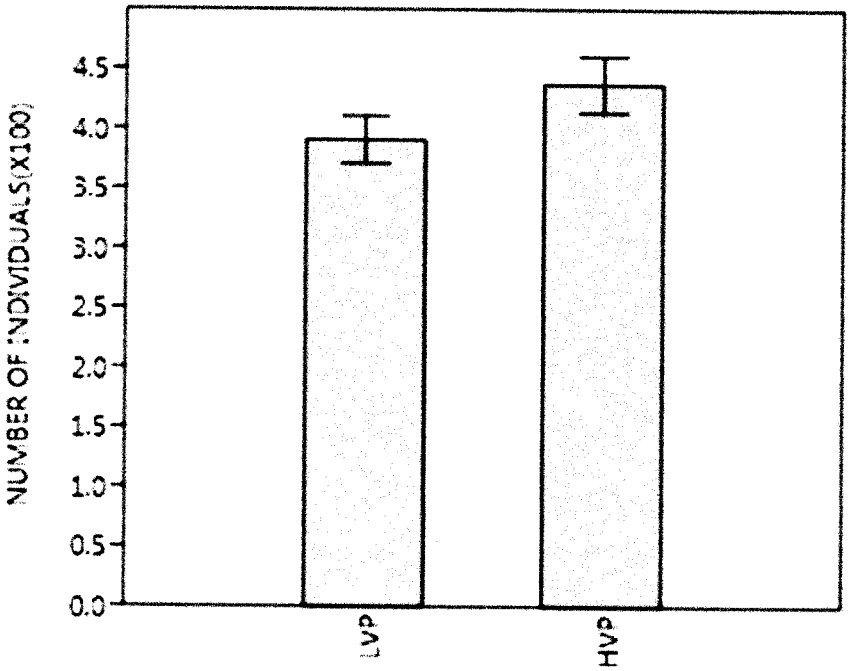



***Figure 3**: Flight heights of local birds at HVP (132KV) and LVP (33KV)*

### Power lines and bird behaviours

All species passed above the power lines with exception of IHC and House sparrow which passed in all levels (below, between and above) of the power lines. Collision was observed for IHC and House sparrows while crossing LVP. The change of flight heights were observed for Little and Cattle egrets while crossing HVP. Also perching on the wires of LVP was observed on IHC and House sparrow (Table 2). Birds did not perch on wires on HVP.

## DISCUSSION

Few species were observed crossing power lines during the study. This is because in urban areas of Dar es Salaam few species roost communally. Egrets, house crows, house sparrow commute daily from roosting sites to foraging areas which are mostly located outside the Central Business District (CBD). Solitary and small family living species usually disperse in areas near their roosting sites for feeding.

Because resident urban species move shorter distances between roosting and foraging sites, they move at lower altitude compared to long-distance migrants, and thus are vulnerable to collision with power lines and other tall infrastructures within urban areas. The power lines height of both LVP and HVP in Dar es Salaam fall within the local avian flight heights suggesting high

risk of collision. These power lines heights are standard throughout the region, thus most resident birds are affected in the same ways, and if such infrastructures are constructed or erected within the migratory routes of long distance migrants may pose serious threats especially at stopping over sites. However, as a strategy to avoid collision and electrocution, it seems that some species avoid collision by changing altitude or flight heights when approaching power lines especially medium and large birds such as little egrets.

**Table 2. The frequencies (%) of the impacts of power lines on different birds while crossing HVP and LVP**

| Impacts of power lines on avian behaviors | Species | Frequency (%) | |
|---|---|---|---|
| | | HVP | LVP |
| Isolation from the flock | Indian house crow | 0.5 | 5.3 |
| Perching on the pole | Indian house crow | 1.7 | 13.3 |
| Perching on the pole | Black kite | 0.24 | 0 |
| Perching on the wires | House sparrow | 0 | 4 |
| Perching on the wires | Indian house crow | 0 | 40 |
| Raising the flight heights | Little egret | 94.4 | 0 |
| Raising the flight heights | Cattle egret | 1.5 | 0 |
| Collision | Indian house crow | 0 | 16 |
| Collision | House sparrow | 0 | 6.7 |
| Change of direction | Indian house crow | 1.7 | 9.3 |
| Change of direction | House sparrow | 0 | 4 |

This avoidance behavior is not known if it happens when birds meet objects while in flight or is by learning? If it is by learning, how long does it take to learn when a new power line is installed and what impact a new power line causes before birds can learn? This can be established by monitoring collision

and electrocution when a new power line is installed, but bird carcasses may not stay longer (Pallett, 2014), they are removed by human during cleanliness and by dogs, cats and crows.

Large birds have poor maneuverability which could lead to collision if they attempt to pass through or between electric wires at HVP unlike IHC and House sparrow which cross between power lines. Conversely, in other studies using behaviours categories similar to the one used in this study, birds reacted most commonly by raising the flight heights (James & Haak, 1979, Morkill & Anderson, 1991). However, it is mostly likely that our study birds have learn the presence of power lines through experiences and may be moving at small speed unlike long-distance migrating birds which are constraints with time and stopping over sites. Birds that approach power lines at the middle or between electric wires, change behaviours more often than those approaching either well above or well below the lines (Morkill & Anderson, 1991).

IHC and House sparrow were seen perching on cables at LVP this is because a bird has the same charge as the power lines, and when it sits on it, it has more resistance than the lines themselves, but this cannot help for HVP.

## CONCLUSION AND RECOMMENDATION

Birds changed flight height when arriving near the power lines to avoid collision, moreover, IHC and House sparrow passed through the power lines. This study confirms that power line networks in urban areas interfere with movements of local birds, a subject which has been ignored by both wildlife experts and electric engineers or project developers. Thus the study recommends that, research must be conducted before the installation of power lines, in order to identify sensitive areas such as daily commuting and migratory routes of local and migratory birds, respectively. Resident birds that roost communally use specific routes to and from the foraging sites, such routes shouldn't be interrupted by infrastructures such as power lines. Migratory birds also when moving within or from foraging stopping-overs are likely to be affected by power lines. Such sensitive areas should be identified before such infrastructures are erected. In order to reduce the collision rate, wire-marking or flight bird diverters must be used to increase the visibility of the wires, which alerts birds to the presence of power lines and provide them with more time to avoid the collision.

## ACKNOWLEDGEMENTS

We thank Mr. Emmanuel Fidelis for helping in data collection. This paper has benefited from comments made by participants at a seminar presentation at the Department of Zoology and Wildlife Conservation in early June 2015 and TAWIRI Scientific Conference in Arusha in December 2015.

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