Influence of climatic variability on the distribution of Red-billed Quelea (*Quelea quelea*) In Hadejia-Nguru Wetlands, Northern Nigeria.

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Abstract

Quelea birds are one of the most abundant and destructive birds in the world, causing $US70 million damage to grain crops per annum. Their food searching behaviour results in crop damage if they cannot find sufficient seeds in natural grasslands. A flock of 2 million can consume 50 tonnes of grain in a day. It is estimated that an individual quelea can eat three to five grams of grain per day and waste a lot more on the ground by its feeding activity. The Red-billed quelea, (*Quelea quelea,)* is widely distributed throughout Africa and occurs only on the African continent. These birds are long distance migrants the red-billed quelea's range and migration is determined by suitable breeding conditions which is tied to rainfall patterns. As a result, since rainfall patterns vary annually, so do quelea migration patterns. Among these *Quelea quelea* birds are known for their remarkable migration behavior, particularly during the transition from the dry season to the wet season, primarily due to changes in temperature, food availability, and breeding habits. Birds are considered as useful biological indicators because they ecologically adapt to all kinds of habitats. Wetlands are important habitats of fauna. However, the importance of wetlands depends on different factors (wetland size, diversity of vegetation, water quality, food resources and topography. This paper reviews the migration and distribution of quelea based on rainfall and temperature pattern. This clearly indicates that the migration and movement in quelea birds is determine by rainfall pattern and availability of grass seeds which forms their major food. Using the information of rainfall availability, a forecast model is developed to dertermine the timng of migration of the birds to different parts of their ecological range in Southern Africa

Introduction

Due to their ecological adaptation to a wide variety of habitats, birds are regarded as a valuable biological indicator. Wetlands are crucial wildlife habitats. However, a number of variables, including wetland size, flora diversity, water quality, food resources, and geography, affect how important wetlands are (Taye, 2017). The spatiotemporal distribution of certain important natural resources has a significant impact on bird species abundance. Therefore, a number of studies conducted in other parts of the world tried to investigate the variables influencing bird distribution and abundance at both spatial and temporal scales. Bird abundance and distribution are significantly influenced by seasonality. Seasonality influences the bird population's access to food and cover, which in turn influences the success of breeding and, eventually, the species' ability to survive. The availability of different food items for birds is known to be impacted by seasonal variations in temperature, rainfall, and microhabitat conditions in both space and time. These could change the distribution, diversity, and abundance of birds in a region based on how sensitive a species is to the type of habitat. In particular, it has been discovered that the patterns of habitat occupancy and seasonal abundance in migratory bird species are determined by processes operating in breeding and wintering grounds (Girma, Mamo, Mengesha, & Asfaw, 2017).

During the breeding season and when preparing for migration, the red-billed quelea is primarily granivorous, with the exception of feeding its nestlings insects that are good source of protein for growth or consuming insects before migration or breeding that aid in the development of wing muscles for high flying and energy reserves for breeding. Rainfall patterns have an impact on migration because they alter the supply of some annual grass seeds, which are these species' primary food source.

Literature review

Migration in Red billed quelea

It is believed that Quelea birds are a migratory pest of grain crops. The red billed quelea may migrate over great distances and typically travel in flocks of several hundred (Sabastian & Z.M., 2023). One of the most prevalent and damaging birds in the world, Quelea birds harm grain crops annually to the tune of $US70 million. If they are unable to locate enough seeds in natural grass lands, their food searching behaviour damages crops. Fifty tons of grain can be consumed in a day by a flock of two million. According to estimates, a single quelea can consume three to five grams of grain every day, but its feeding activity causes it to waste much more on the ground. An entire crop can be destroyed by Quelea flocks that descend on grain fields. Millions of birds may be in the flocks, breeding colonies may span several hectares, and 500 nests may be found on a single thorn tree. There almost 1.5 billion breeding birds in the world. Because they migrate, the birds do not always live in one location or nation. The birds travel short or large distances to find the best food sources. (Bolo, 2019).

Because quelea birds eat grass seeds, their travels are influenced by vegetation and weather cycles. When they germinate at the beginning of the wet season, they abruptly disappear. The birds are then compelled to relocate to locations that have not yet seen rain from the early rainy areas. The birds eat other, transient food sources, including termites, which are plentiful after showers, when the rain finally reaches their new locations and grass seed begins to sprout there as well. A diet like this gives the birds the chance to build up migratory fat reserves and enables mass migration "early rains migration".

These motions transport the birds back through the areas where rain had fallen earlier in the season, away from their "dry season quarters" until they arrive at a location where fresh seeds are already available. Six to eight weeks will have passed since the initial rains drove them out at the start of the cycle. The birds then undergo a "breeding migratory" so named because they stop along the way to nest , before slowly making their way back to their dry season quarters. The conditions at hand will determine how many times they can reproduce during this time, generally speaking, more breeding attempts are allowed during periods of good rainfall. The majority of damage to subsistence agriculture is caused by young birds that fledge from successful colonies during these times when millet or sorghum is ready to be harvested. One researchable limitation was the ability to foresee such occurrences (R.A. Cheke, 1999). Only found on the African continent, the Red billed quelea (Quelea quelea) is widely spread throughout the continent. Long distance travelers, the red billed quelea's range and migration are dictated by appropriate breeding circumstances, which are linked to patterns of rainfall.

Therefore, just as rainfall patterns change every year, so do the patterns of quelea migration. When the last of the dry grass seeds sprout in South Africa's interior in November, the quelea is compelled to look for nourishment elsewhere. These birds then have two options for migration: either to Angola or to eastern South Africa and Mozambique. Rainfall in these regions starts in September or October (Cheke R. A., 2007). In Africa, birds are a very specific pest of cereal crops because they can travel great distances, are abundant, and have a varied diet, whereas agricultural crops may only play a supporting role. Because there are numerous factors that affect the frequency and severity of bird damage, there is therefore a great deal of variation in the amount of damage that farmers endure. Field properties (e.g. field size), agronomic properties (e.g. timing of production) and environmental properties (e.g. climate) are examples of these factors. Bird migration is one of the most remarkable natural phenomena that has always captivated people and sparked the interest of researchers. Despite the fact that migration is being studied more and more, many factors that influence migratory flows and routes are still unknown or poorly understood. Various works have examined migration paths and bird features while considering a number of parameters, and it is particularly challenging to study the relationship between migration paths and trophic availability on the terrain. In addition to nutritional requirements, migration is influenced by weather, the place of origin and destination, visibility, and other factors, particularly in alpine environments. (Tattoni, 2016). Migration as noted by Dingle and Drake (2007), is a complicated process. The subpopulations of migratory birds and insects interact over thousands of kilometers, and they are adapted to react to environmental changes. These creatures survival and evolutionary processes are shaped by this interconnectedness and its ensuing spill over effects, which work in tandem with environmental limitations, especially wind and rainfall patterns. Climate change will cause these to change, which will have an impact on future migration patterns (Cheke, 2017)..

Because of variations in temperature, food availability, and nesting behaviors, Quelea quelea birds are renowned for their exceptional migratory behaviour, especially during the move from the dry to the wet season. During the Belg season, a number of migratory bird species visit the northern Ethiopian region of Raya Tigray. The arrival of rain causes this movement, which is essential to their survival and procreation. The terrain changes during this period due to a

profusion of vegetation growth and an increase in water availability. This shift in the habitat draws a variety of insects, amphibians, and small animals, which gives the migrating girds a plentiful supply of food (Abadi, 2024).

Quelea rainfall forecast model-

Throughout sub Saharan Africa, Quelea quelea are a significant pest of small -grain crops. Birds breed in large colonies when conditions allow, and these colonies are the focus of control efforts. Quelea are long distance migratory from within Africa whose intricate routes change every year in response to changes in rainfall patterns. The effectiveness of control measures will be significantly increased if it is possible to predict where and when colonies could be established. For the Southern African subspecies, we provide such a forecasting model Quelea *quelea lathamii*. The model is based on and offers a partial test of ward's (1971) conjectured rainfall migration model, which postulates that rainfall patterns and the availability of grass seed drive quelea movements (Cheke R. A., 2007).

Methodology

In order to determine how climate variability affects the distribution of red billed quelea birds in Hadejia -Nguru wetlands area. A systematic literature review was conducted by collecting articles on spread and distribution of red billed quelea in response to climate changes specifically, the distribution of rainfall and temperature found using search engines like google Scholar, PubMed and Science Direct. Since temperature and rainfall have a significant impact on species distribution in the ecosystem, they were given priority among the key climatic variables. The information gathered spans the years 1970 -2025 and focuses mostly on the region's red-billed quelea distribution and climate variability**.**

Influence of rainfall pattern on the migration of quelea birds

The granivorous bird known as the red billed quelea (*Quelea quelea* Lin) is found in sub Saharan Africa in extremely high numbers- up to 1500 million birds. In reaction to local rainfall patterns and the availability of their preferred food, the seed of annual grasses and , during the breeding season, larval insects, they are long distance migrants that can travel up to 3000 km(Oschadleus 2000).

The majority of management efforts target non-breeding bird roosts breeding bird roosts that pose a hazard to com mercial grain crops, particularly rice and wheat that are irrigated. In some regions, effective reporting procedures and quick communication channels between farmers and control teams are already established (Cheke, 2007). Although there is usually a north-to-south underlying pattern, migratory patterns can be complicated and varied since bird reproduction in arid settings is generally linked to unpredictable rainfall. Limited land area and moderate but dry weather may result in migratory patterns and an ecology that is unique to the area and its neighbouring continents. Rainfall has a greater impact on migration than in the north due to the southern hemisphere's generally milder and drier climate, particularly for certain nomadic birds. However, temperature also predicts the frequency and routes of migration for many species. Although each southern continent has unique characteristics, some patterns are similar through out them. Although only few southern species have been investigated, migrants from the southern hemisphere appear to exhibit ecophysiologies and orientation mechanisms to those of species from the northern hemisphere (Dingle, 2016). The red-billed quelea (*Quelea quelea*) a serious pest of grain crops in Africa, has been managed 'in many

nations for almost 20 years. However, its number do not seem to have changed all that much. The brief drop in population in South Africa between 1955 and 1963 and the ongoing loss in the Sahel states can be attributed to low rainfall , which negatively impacts the availability of the bird's native food source , wild grassseeds (Ward, 1979).Every area community is aware of the Redbilled Quelea's (Quelea quelea) reputation as a pest of small grains.It was believed that East African Redbilled Queleas traveled 1500–1800 kilometers from Tanzania to Somalia.

The idea of migration was created by considering the rainfall patterns in each area and understanding when breeding occurs in various range locations. It was believed that more research on the migration would enable the development of a management plan that would use control operations to stop migrations or moves from breeding grounds to crops (ELLIOTT, 1990). There are two basic theories as to why quelea numbers are so large. First, with enough rainfall, their primary food source – wild annual grass seed – is widely dispersed throughout vast semi-arid areas. With an annual rainfall of roughly 450 mm, gaston (1976) demonstrated that over 2t/ha could be generated in natural quelea habitat. Second, quelea can reproduce itinerantly two or three times a year where ever conditions are most suitable because they can track the movements of the inter tropical convergence zone and the rainfall that results from it (Elliott, 2006). The body temperature of redbilled queleas (Quelea quelea, red circles, lower panel) climbed significantly above previously recorded values at higher air temperatures during acute heat exposure, but stayed mostly within the range observed in other passerine birds at air temperatures below 45 °C.In experiments employing the same experimental methodology, the grey band represents the range of individual values in three southern African species27 and five Australian species40.The dashed line shows that body and air temperatures are equal.At air temperatures higher than 46.9 °C (upper panel), the ratio of evaporative heat loss (EHL) to metabolic heat production (MHP) rose to an average maximum value of 1.49 (Freeman M. T., 2020).Red-billed quelea (*Quelea quelea*) reached maximum body temperatures during acute heat exposure that were far higher than those previously recorded for birds. Filled circles are used to represent species averages (or breed averages for domestic fowls). Data for non-domesticated species come from 27-30,40,41,50-54, while data for poultry come from 15 and 16. Both species averages (filled circles) and individual values (crosses0 are displayed for red billed queleas (current study) and varied seed -eaters (*Sporophila aurea*, data from 23) scientific(M. T. Freeman, 2020).The critical thermal maxima of mammals and birds rarely surpass 46 °C, while vertebrates' thermal tolerances are typically limited to body temperatures below 45–47 °C. The red billed quelea (Quelea quelea), an African passerine bird that can occasionally number in the millions, was the subject of our investigation about thermoregulation at high air temperatures. According to this finding, this species can raise its body temperature to extra ordinarily high levels. Individual readings as high as 49.1oC were recorded when queleas exposed to air temperatures above 45oC increased their body temperature to 48.0 ± 0.7 °C without showing any signs of illness. With a tolerance of body temperature > 48 °C that is unusual among birds and mammals, these values surpass recognized avian fatal limits.

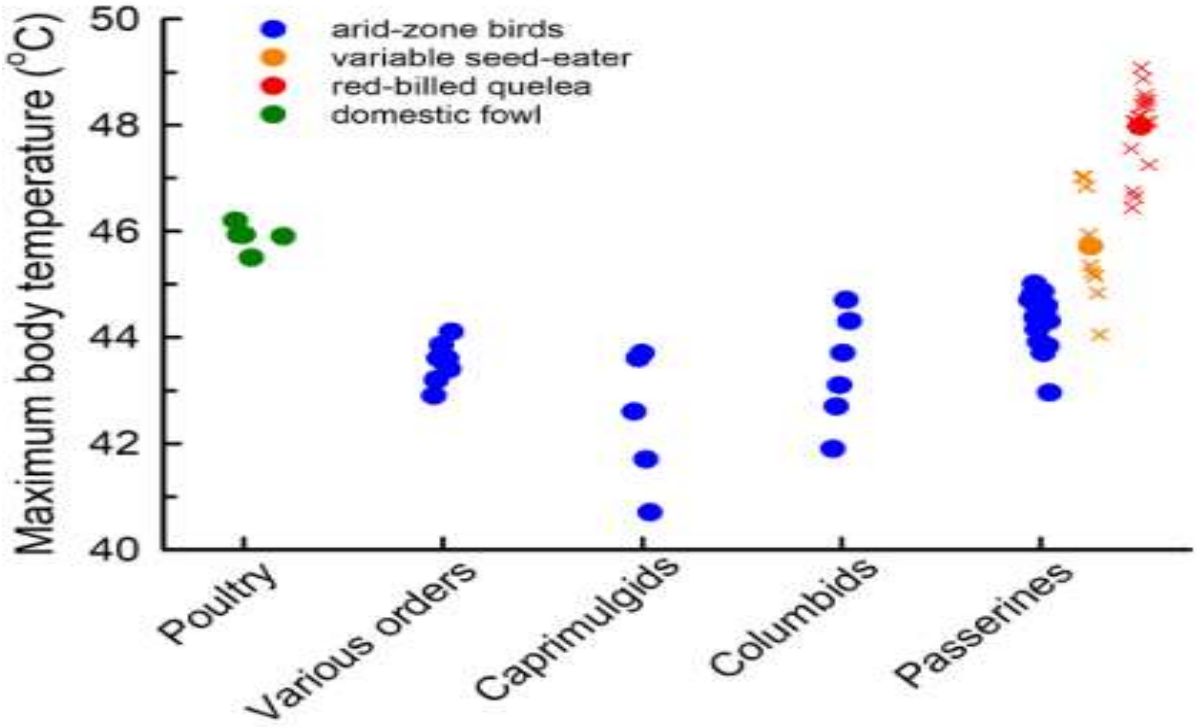

Figure 1. Temperature response of different bird species source (Freeman M. T., 2020)

Matthews and Wynes (2022) predict that if glob al greenhouse gas emissions are not drastically c ut, temperature will probably surpass 1.5 degree s Celsius within the next ten years.

In the IGAD member nations, climate patterns h ave already changed, with certain areas seeing te mperature spikes of up to 2 degrees Celsius.Acc ording to climate estimates, the IGAD region is expected to see a significantly warmer future tha n the global average.Climate variability will cau se changes in the frequency and severity of disas ters like floods, droughts, and outbreaks of pests and diseases, requiring adjustments to agricultur al techniques and human and animal migratory p atterns.Businesses, governmental actors, suprana tional organizations, and local communities mus t all develop the capacity to anticipate and adjust to these changes (Lazutkaite). Outside of the woodland zone in sub-Saharan Africa, the Red-billed quelea is one of the most common bird species in the world. Throughout the year, it is noticeable and recognizable due to the flocks' enormous size and their characteristic "rolling" motion when grazing on the ground. The large flocks of this species are so noticeable that congregation most likely did not lower reporting rates, despite the fact that flocking typically lowers reporting rates. It travels great distances every day to get to food, water, roosts, demonstrating its remarkable degree of mobility. There have been suggestions of seasonal long-distance migrations, and ringed birds have been reported to travel 2200 kilometers. However, it has been proposed that there is a regular seasonal "early rains migration" from November to January towards KwaZulu-Natal, Swaziland, and Mozambique.

The spatiotemporal distribution of certain important natural resources has a significant impact on bird species abundance.Consequently, several studies conducted in other parts of the world have attempted to investigate factors that influence bird distribution and abundance at both spatial and temporal dimensions.Bird abundance and distribution are significantly influenced by seasonality. Seasonality influences the bird population's access to food and cover, which in turn influences the success of breeding and, eventually, the species' ability to survive. (Girma, Mamo, Mengesha, & Asfaw, 2017). However, anthropogenic variables, such as agricultural activities like feedlots and crop fields, where populations may be ten times bigger than in grasslands, are having a significant impact on habitat selection. Because the red billed quelea are gregarious birds that migrate, eat, and mate together, their population size has become an issue for humans, as they prefer agricultural areas and significantly reduce a farmer's crop yield. (Bauer, 2019) Water availability in ecosystems is the primary indicator of climatic conditions influencing the demographic rates of long-distance migrants at the Afrotropical non-breeding grounds. Long-distance migrant populations may be impacted by water availability due to its impact on adult survival and subsequent breeding output. More primary and secondary productivity results from increased water availability, giving birds access to more food sources. As a result, Afro palearctic migrants should have a greater adult survival rate when the environments where they do not breed have more water. Breeding performance may also be impacted by climate variations at non-breeding sites.

Reduced water availability in Africa, for example, may cause migrants to arrive at breeding grounds later, have worse body conditions once they arrive, and have an impact on recruitment, brood size, fledgling numbers. However, the Afro -palearctic migrants' non-breeding grounds span a wide range of environments, from the wet rain forests in equatorial regions to the extremely arid Sahel zone. In areas with more severe water limitation, we might anticipate that the potential benefits of increased water availability on adult survival and subsequent breeding and production may be greater (Telenský, 2020).

Because they migrate seasonally between nations and ecosystems, migratory animals are susceptible to a variety of challenges, both climate -related and non-climate related. This may expose animals to the effects of climate change at various points throughout their migration path, where there may be interactions and differences in the cue timing. Studies of the granivorous Red billed quelea in comparable African environments provide evidence that precipitation plays a significant role in influencing grassland bird populations. Rainfall encourages the growth of new grass and causes the number of invertebrates (caterpillars and Orthoptera nymphs) to increase quickly, which in turn encourages bird breeding. The adults follow an incoming rain front to re-breed as soon as the young fledge. They nomadically monitor the availability of grass seeds and move ahead of the next rain front, which causes the remaining seeds to germinate and restarts the cycle six weeks after the species' range has finished receiving rainfall and the birds have ceased reproducing (Martay, B., & Robinson, 2023).Since arrival timing on the breeding grounds is crucial for mate and territory selection, as well as because a decline in numbers directly affects the size of the breeding population, climatic effects on migration are probably most significant for the spring (northward) migration.Since the Sahel region of Africa serves as a major feeding ground for numerous migratory species, increased desertification of this region is especially concerning (Mannert, 2006)..

Red-billed quelea birds' lifecycle, behaviour, and agricultural implications

The red billed quelea (*Quelea quelea*), sometimes known as the "feathered locust" is one of the most common bird species on the planet and a major transboundary annoyance (McWilliam & Cheke, 2004).
Native to sub-Saharan Africa, it contributes to a thriving ecology but is also a dangerous agricultural pest that seriously damages cereal crops including rice, sorghum, and millet (Crook and Ward, 1968). Climate unpredictability combined with changes in land use exacerbates the destructive behaviour of these birds. They can destroy large fields of crop s in a startlingly short amount of time, demonstrating the incredible amount of damage they are capable of causing. Originating in the IGAD region, QB has occasionally caused epidemics in nations such as Sudan, Ethiopia and Kenya (Cheke and El Hady Sidatt, 2019; McWilliam and Cheke, 2004). The seasonal cropping and rainfall cycles, as well as the agricultural environment of Africa, are closely linked to the life cycle and destructive potential of Quelea birds. Their mating seasons coincide with those of cereal crops, they frequently start during the wet seasons, which offer a plenty of food and nesting materials (Whittington-Jones, 2001). Because of this alignment, the Quelea birds can reproduce several times in a single season, which is a natural survival tactic but, regrettably, has disastrous effects on agriculture (Dallimer and Jones, 2002). These birds are also drawn to agricultural areas by human caused alterations to their natural habitats, particularly land removal. Human agricultural practices, especially the introduction of irrigated cropping systems, are also having a growing impact on Quelea's breeding and migrating habits. The typical migration timings and extents of the quelea birds may have changed as a result of the year-round availability of feedlots. Knowing these trends also helps with controlling and forecasting quelea birds movements, which enables the creation of focused mitigation techniques for agricultural damage(Cheke et al., 2007)

Discussion

Due to their high fecundity, availability of preferred food sources, and capacity to travel great distances in search of food (they can travel 48-64 km in a single day), Quelea birds have become abundant in semi-arid regions of Sub-Saharan Africa (Mmbaga et al., 2023). A field of crops can be quickly consumed or dest royed by large flocks, which then proceed to the next field (Cheke and El Hady Sidatt, 2019; Mc william and Cheke, 2004). Super flocks, sometimes numbering in the millions, have wreaked havoc on farms within hours of their arrival. For comparison, one bird eats about 10 grams of grain a day, thus a million birds can eat roughly ten metric tons of grain a day. According to FAO estimates from 2021, this feeding behaviour causes substantial economic losses, with Kenya alone experiencing yearly crop losses of USD 50 million (Muiruri, 2023). The tens of millions of flocks that frequently aris e demonstrate the enormous potential for agricul tural destruction and the urgent need for sustaina ble pest management.
Because of its exceptional feeding powers, QB i s one of Africa's most damaging bird pests. (Cheke et al., 2007)
Quelea populations are more subtly impacted by corruption. Quelea are abundant each year and are found strewn across their range in areas with rather stable habitats, like those next to lakes, marshes, and irrigated fields. However, their numbers vary greatly depending on the surroundings.

Young quelea are less likely to be generated during multi-year droughts. The conditions are

favourable enough to encourage breeding when the annual rainfall reaches 20 to 45cm. Quelea populations grow and can become disruptive when there are good rains. The birds can raise their numbers to pandemic proportions in a single breeding season by breeding twice or three times in a single year. (Keith, James O, 2024).

Because woody cover rises with rainfall, species' preferences for drier or more humid zones were partially impacted by an overall preference for open or more wooded landscapes, even if the distribution of the different bird species was mostly related to yearly rainfall (Zwarts, Authors, 2022).The Quelea, storks, egr ets, herons, and wheatears are the most frequentl y seen migratory birds in Raya Tigray.Due to va riations in temperature, food availability, and bre eding behaviors, Quelea quelea birds are renown ed for their exceptional migratory activity, espec ially during the move from the dry to the wet sea son (Abadi, Assefa, 2024).In addition to breedin g, migratory birds use transient and fluctuating e nergy sources to stay alive throughout the non-breeding season.In tropical Africa, all trans-Saharan migrating Marsh Harriers made a post-migratory movement (F1) or at least stopped ove r in a post-migratory location. Since the harriers' initial stops following migration grow drier, these movements are most likely connected to shifting food abundance. Locusts and red billed quelea, which are common prey following the rainy season, peak in occurrence when one arrives in the savannas south of the Sahara (Raymond, 2008).

We examined the red-billed quelea's (*Quelea quelea*) thermoregulation following acute heat exposure as part of a study on adaptive diversity in avian heat tolerance. With post breeding population estimates of over 1.5 billion individuals, this little (18g) African passerine is often regarded as the most abundant non-domesticated bird on earth. It is very social and can create large flocks of up to several million individuals. We hypothesized that this species thermal physiology is different form that of normal tiny song birds because of its unusual natural history. Regular drinking is a habit of red-billed queleas. The average hydration level of a large number of flock members, rather than that of a single individual is likely what determines when flocks visit water sources. Selection should favour the ability to conserve water by facultative hyperthermia in situations where individual hydration status may vary significantly among a large flock. As a result, we hypothesized that severe facultative hyperthermia protects queleas from the danger of dehydration. We measured the correlations between body temperature, evaporative heat loss, and metabolic heat production in South African re billed queleas in order to investigate this hypothesis. For a passerine, queleas' ability to disperse up to 150% metabolic heat production by evaporation is quite limited, among 30 species, the greatest EHL/MHP was 1.75 ± 0.31 27, 29, 30, 40, 45.

Regular drinking passerines have higher heat tolerance limits and can increase EWL fractionally more than non-drinking species in arid zones (Freeman, 2020).

Animal life is characterized by mobility, howeve r the pattern of movement frequently differs amo ng species, individuals, time, and location (Hans son & Åkesson 2014).Being frequently dramatic , easily observable for some species at certain lo cations, and predictable in both space and time, migration is arguably the most commonly appre ciated kind of animal movement (Alerstam 1990 , Wilcove & Wikelski 2008, Newton 2010).Long distance migration is believed to have develope d as a defense mechanism against recurring drop s in the availability of local resources (food) or o ther unfavorable environmental conditions, wher eas local movement patterns are frequently drive

n by needs like finding mates, avoiding predator s, and securing food.

Raptors are among the majority of migratory bir d species that feed while migrating and may pau se at points where food is abundant (Newton 200 8).The migratory falcons stopped over, probably to feed, and might have come upon populations of prey such as quelea colonies or swarming ter mites (Rhinotermitidae) (Aljahdhami, 2021).Bas ed on research initially conducted in Botswana (Jones 1975, 1976), studies conducted in Zimbab we have demonstrated a substantial association b etween the amount of rainfall from the previous season and the degree of depredation, which is li kely a measure of the birds' status.When there is a prolonged period of good rainfall, quelea seem to be able to reproduce multiple times with larg er numbers, endangering crops the following sea son.According to observations made in Zimbab we, this association happens regardless of contro l methods, suggesting that they have little longte rm impact on seasonal numbers.Although more aspects need to be clarified, seasonal rainfall has become a very accurate source for predicting qu elea difficulties for the upcoming season:For inst ance, the amount of grass cover, especially annu al species, that remains at the start of winter, whi ch appears to be preferred by birds (Lagrange, 1 988).

Conclusion

In conclusion, the distribution of Red-billed quelea in the Hadejia-Nguru wetlands area is mostly determined by temperature and rainfall. Rainfall affects the availability of food, including grass seeds and insects. Because increased rainfall encourages reproduction, population growth, and food availability, it affects the birds' reproductive cycle. Many species will face difficulties in surviving due to changes in rainfall and temperature patterns including red billed quelea. In Hadejia- Nguru wetlands increase in rainfall increases the population of quelea as it determines availability of grass seeds and insects and favours multiples of breeding in a single year and conversely series of drough years make the population of the birds to reduce drastically.

The growing population of resident quelea in this area is very alarming and data from ongoing monitoring will be essential for wise specie management. In addition, tracking of bird movement and the timing of life cycle events like migration and breeding, ringing offers an economical method of estimating bird survival rates. In addition, climate change has an impact on timing, migration, and survival, as such, these factors should be regularly observed (de Villiers, 2009).

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