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MOVEMENTS OF RED-FOOTED FALCONS AT WESTERN-AFRICAN STOPOVER SITES

MASTER'S THESIS (MSC)

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TABLE OF CONTENTS

1. INTRODUCTION

The Red-footed Falcon *(Falco vespertinus*, Linnaeus 1766) is a medium sized raptor of high conservation concern in the world (P. Palatitz *et al.* 2018). Their current population numbers between 287,500 and 400,000 worldwide; though this is still an issue of dispute amongst scientists (BirdLife International, 2021). Due to their annual migration habits, they are referred to as aerial nomads since they are constantly on the move. These birds spend the whole year travelling between continents making them a very good model animals for studying long distance migration and sensors of the environment in large scale.

Due to their migratory nature, they are of different relevance and use to different countries and cultures. Their decline over the past decades have made them a threatened species according to the IUCN ((The IUCN Red List of Threatened Species, 2021; IUCN RED LIST,2022). During their annual obligatory migrations these birds fly over cca. 17,000 kilometers in a loop to Africa through the Mediterranean and back to Europe. They winter in in the southern part of Africa in and around the Kalahari basin (P. Palatitz *et al.* 2018) usually from October to March and return around April–May to mate and breed in the lowlands of Eurasia. Migration has been widely studied and the need to migrate has been linked to many factors including internal genetic clock, the pursuit of literal "greener pastures" with long daylight hours and plentiful food, and ultimately survival of a species or population (P. Palatitz *et al.* 2018) which aren't very well adapted to extreme temperatures. Though migration has been widely studied in animals in general, each migratory species differs from the other in terms of time of migration, route of migration, choice of migration sites and even the use of migratory stopovers.

Stopovers are a very important factor in the annual journey of The Red-footed Falcon (Austin, & Lincoln, 1952; Bounas *et al.* 2020; Kusler, 2004). Stopovers are known to be utilized by migrating animals to refill energy resources needed to reach their next destination (Newton, 2008). In other words, migration stopovers serve as fuel sources for migrants (Mehlman *et al.* 2005). Stopovers are especially important for birds since they require a lot of energy for flight and these energy resources should be readily available in any form at the stopover sites. Thus stopover sites are not chosen at random and seem to be carefully chosen sites which have proven to be effective in providing the needed energy resources over the evolution of the species or population (Fehérvári *et al.* 2014; Kusler, 2004; Newton, 2008). The specialty of the Red-footed Falcon migration is that different routes are used to and from the wintering sites with different stopover sites on the way to the wintering sites in Southern Africa and back from the wintering sites to Europe giving it a loop shape pattern (Katzner *et al.* 2016).

Their migratory nature makes it quite difficult in studying them fully because they are always on the move and spend only 3 months in the year to breed and 2 more months to prepare for the post nuptial migration (P. Palatitz *et al.* 2018).

This study aims to describe the use of stopover sites in Ghana, West Africa, based on data from satellite-tracked falcons within an international project of MME BirdLife Hungary and its partner (P. Palatitz *et al.* 2018) and literature gathered from the stopover sites to understand the habitat choice; the resources and conditions available at the sites that make the sites suitable for use by the birds. This study is important since landscapes keep changing all the time and the least changes in the conditions of the stopover sites can significantly affect the traditional migratory patterns of these already threatened species (Affedzie-obresi *et al.* 2019; Calabrese *et al.* 2020; Kusler, 2004; P. Palatitz *et al.* 2018), thus these stopover sites should be well studied and documented so that the particular resources available at these chosen sites by the birds can be monitored, improved or protected.

I used a qualitative approach for studying the use of the stopover sites in time (2015 and 2016) and space. I processed the literature available for the study site and possible reasons for the use of these particular locations as stopover sites. Overall, this study aims to provide a picture of the use of stopover sites in Ghana and the driving forces for the selection of stopover sites which can be a basis on which Red-footed Falcons can be protected in Ghana and West Africa whiles they undertaking their annual migration.

2. LITERATURE REVIEW

2.1. Migration

Migration is a well-known phenomenon in ecology and is evident in many animal groups such as birds, reptiles, fishes, insects, and amphibians (Alestram *et al.* 2003). Bird migration, being it long distance; over 1000's of miles and even across oceans, or short distances; a few kilometers away from the animals home range, has evolved independently in most species and differs significantly in routes, method, preparation and reason (Alestram *et al.* 2003). It is widely accepted that migration in all species is at least partly controlled by genetic inheritance. The timing and duration of movement, special adaptations for energy accumulation, deposition and metabolism, behavioural adaptations to cope with variable conditions (weather, wind, currents) during the journey and control of orientation and navigation are all subject of genetic control (Austin, & Lincoln, 1952). Environmental factors are also known to control migration, especially in birds; factors such as habitat degradation, food supply in breeding grounds, change in land use types, anthropogenic factors such as pollution, and change in weather conditions are all important drivers of migration (Zoologica *et al.* 2020). Environmental factors however have been studied to have very significant effects on short distance migrants but have quite minimal effects on long distance migrants whose genetic urge to migrate is stronger (Alestram *et al.* 2003).

What makes migration different from other types of movements observed in animals is that migration is regular, recurrent and seasonal and it usually involves whole populations moving from one place to another; the predictability of this phenomenon is what makes it interesting (Austin *et al*, 1952). Migration is a very important biological phenomenon not just for the animal species involved but also for the ecosystem. Long distance migrants are very important seed dispersers (Joost Brouwer, 2012) and create a link between different continents, islands and ecosystems. This ensures gene flow, expansion of range of microbes, parasites, or many plant taxa and even colonization of new locations by plants (Jahn *et al.* 2017 & Viana *et al.* 2016).

Apart from the ecological importance of migration, humans and cultures have valued migration as a phenomenon of change, and celebrated it and looked forward to it all over the world. Birds arrival in many places is celebrated as a mark of seasonal change and source of lean meat (Zoologica *et al.* 2020). Over the years, it has become important for people to see or witness some migrant birds at specific times of the year and the slightest change in arrival or movement of birds has been an indication of something not being right (Austin, & Lincoln, 1952). Migrant birds are therefore markers of environmental health to many people and cultures. The enthusiasm for witness migrant birds is not only due to their symbolic and aesthetic values but also the ecological benefits most farmers receive from these birds are premier insect pest control agents.

2.2. Raptors

There are over 500 species of raptors worldwide which are known to science (Cruz *et al.* 2021) Raptors are also called birds of prey because they feed because they feed on other animals. In Hungary, 36 of the 300 raptor species have been recorded. The Red-footed Falcon is one of these raptors and is classified in the order *Falconiformes* (del Hoyo *et al.* 2020). Red-footed Falcons and other members of *Falconiformes* are differentiated from other raptors by the characteristics that members of *Falconiformes* do not build their own nests but rather occupy nests of other species or can even lay eggs on bare surfaces (P. Palatitz *et al.* 2018), also, members of *Falconiformes* kill birds with their beaks after grasping them with their talons rather than killing the prey with their talons as other Raptors do such as those from the order *Accipitriformes* (hawks, eagles, vultures, and kites). *Falconiformes* are also usually dusk hunters as compared to *Accipitriformes* which are diurnal hunters (Purger, 1998a).

2.3.The Red-footed Falcon

The Red-footed Falcon is a raptor species classified by the IUCN as Near-Threatened (BirdLife International, 2018) and a global threatened species of conservation concern (SPEC 1) (BirdLife International, 2017) making a significant species of interest. This is mainly because of its sharp decline in population by 30 to 40% between 1990 and 2000 (BirdLife International, 2004). Its population is currently estimated at 300,000 to 800,000 individuals, with between 30,000 to 64,000 pairs in Europe (BirdLife International, 2017). The species is predominantly known in Europe and its distribution spreads across several countries in Europe.

2.3.1. Taxonomy

The Red-footed Falcon, formerly known as the Western Red-footed Falcon is classified under the family *Falconida* (P. Palatitz *et al.* 2018). It is also described as a monotypic species which means that there are no other subspecies which makes this raptor a very unique and important one. It shares common ancestry with parrots according to various gene mapping and DNA analysis done (P. Palatitz *et al.* 2018).

2.3.2. Morphology

As a raptor, the Red-footed falcon shares the hooked bill feature that mostly identifies raptors. Hooked bill functions to tear the flesh of prey (Purger, 1998a). They also possess very strong but small feet edged with very sharp claws or talons for the purpose of efficiently grasping prey either airborne or on the ground. The body size of the Red-footed Falcon ranges from 28–31 cm and the wingspan is 65–78 cm making it a pigeon-sized bird (P. Palatitz *et al.* 2018). The females are usually heavier weighing about 130 to 210 grams whiles the males weigh between 120 to 180 grams. This species displays sexual dimorphism in weight, patterns and coloration. The adult female is easily identifiable by its ochre brown and gray with black stripes, whiles the adult male has a slate-gray color with a silver wash on the upper wing and have very bright orange-red legs and, core and orbital ring. The female also has the orange orbital ring, core and legs but its less bright in the sex than the male and a white face with black eye stripe and moustaches (P. Palatitz *et al.* 2018). Young birds are brown above and buff below with dark streaks, and a face pattern like the female.

2.3.3. Breeding

Breeding is an important aspect of the life cycle of the Red-Footed Falcon which ensures continuity and survival of its generation. Members often live and breed in colonies, in pairs, however, some individuals prefer to live in solitude but do pair up for the breeding season (P. Palatitz *et al.* 2018). Ideal breeding sites include wooded steppe, open rural environments with a predominance of extensive cultivation and pasture with stands and rows of trees (del Hoyo *et al.* 2020). Red footed falcons use the nests of other bird species as Rook (*Corvus frugilegus*), artificial nest boxes and solitary corvid nests for breeding (Chavko & Krištín, 2017; P. Palatitz *et al.* 2015).

Breeding takes place From May to July though it can last longer depending on other factors such as availability of prey or the weather. Outside this period, when the young ones are fully fledged, the birds continue their yearly migratory cycle and winter in the southern parts of Africa, mainly in Angola, Botswana and Namibia (P. Palatitz *et al.* 2009). Falcons start their pre-nuptial migration in late March – early April and arrive to the breeding ground from late April to June. Immediately after arrival to the breeding grounds these birds start preparations for breeding.

2.3.4. Feeding

Because Red-footed Falcons can be described as aerial nomads they feed mostly on insects, but a variety of foods from arthropods to small mammals such as voles, lizards and some toads are part of their diet (A. Palatitz, 2012). During the breeding season Red-footed Falcons feed on small rodents, anurans, and different insects, especially on *Orthoptera*, *Odonata* and *Coleoptera* (Keve & Szijj, 1957). Red-footed Falcons are very good pest control animals that feed on insects and small rodents in bulk. They are generalist feeders but mostly feed on insects that are caught on the wings (Purger, 1998a). On very rare occasions when food is scarce due to adverse weather conditions, Red-footed Falcons can prey on smaller birds (P. Palatitz *et al.* 2018). Evidence of diet preference of the Red-footed Falcon are based on remnants of prey collected from nests and breeding sites and these have shown that orthopteran insects form a greater portion of food for young birds (Szövényi, 2015). A study by Haraszthy *et al.* 1994 conducted in the Hortobágy region (East Hungary) found that orthopteran prey items form the largest part of the detectable prey biomass. In a study by Purger, 1998b in Yugoslavia, the diet of Red-footed Falcon was recorded to be dominated by insect diet comprising about 94% of the total diets remains collected. The study also recorded a higher preference for *orthoptera* as compared to *coleoptera* and *odonata* that comprised the insect diet.

2.4. Migration of the Red-footed Falcon

During a period between breeding seasons (often described as the non-breeding season), falcons have been observed to migrate from their breeding sites in Europe to other parts of the world (Bayly *et al.* 2018). Red-footed Falcons and other large raptors have developed special techniques and behavioural adaptations to overcome the ecological constraints such as thermal soaring on the Mediterranean sea (Bounas *et al.* 2020) and the use of stopover sites along the journey (Newton, 2008). These migrants depend on a number of sites often referred to as stopovers as they over winter outside their breeding habitats. These sites provide critical resources such as the fuel for migratory flights, safe roosting sites, and refuges during unfavourable climatic conditions (Mehlman *et al.* 2005; Newton, 2008). A successful migration also depends on birds avoiding in-flight hazards such as collisions with human infrastructure (Longcore *et al.* 2013) and persecution by humans (Newton, 2008).

Migrating land birds stop at multiple sites of different importance or use for the birds but play a key role in determining their chances of survival and the speed of migration (Weber *et al.* 1998). Diurnal migrants typically stop on a nightly basis between daytime flights, while nocturnal migrants generally stop on a daily basis when migrating overland (Newton, 2008).

Migrants can be encountered at numerous sites along the length of their migratory routes (Faaborg *et al.* 2010). Recent studies on a range of species have shown that, individual land birds often make long stopovers at just three or four key areas along the migratory route (Callo *et al.* 2013; Delmore *et al.* 2012; Fraser *et al.* 2012; McKinnon *et al.* 2013; Renfrew *et al.* 2013; Stanley *et al.* 2012), at which they accumulate large energy reserves (Bayly *et al.* 2012). These findings highlight an urgent need to identify major stopover regions and assess the needs of birds within them.

One of the major factors driving the organisation, speed and, ultimately, the success of migration is the quality of resources at stopover sites and their impact on the rate of fuel deposition (Spedding *et al.* 2008). Indeed, with time-minimisation emerging as the main currency shaping the evolution of migration strategies (Alestram, 2011), migratory birds are expected to seek out sites that maximize their fuel deposition rate and, accordingly, their speed of migration (Buler *et al.* 2007; La Sorte *et al.* 2014). Migratory birds therefore require the availability of high-quality habitats in specific regions along their migratory routes (Bayly *et al.* 2018; Weber *et al.* 1999). These habitats must not only sustain high rates of fuel deposition but also offer low to moderate predation risk, as migratory birds may avoid sites with elevated densities of predators or trade-off their foraging rate against predator surveillance (Alestram & Lindström, 1990; Delingat *et al.* 2006; Pomeroy *et al.* 2006; Warnock, 2010). Recent work on *Catharus* thrushes in northern Colombia has shown that the energy reserves acquired at key stopovers may enable birds to cover 30% or more of their total migratory distance (Bayly *et al.* 2012, 2013; Gómez *et al.* 2017) highlighting the enormous influence that individual stopover sites can have on a migratory journey.

Prior to breeding between May and July, Red-footed Falcons arrive in Europe from Africa where they winter, as part of the migratory cycle. A number of studies have indeed confirmed the migration of Red-footed Falcons to and from the African continent (Fehérvári *et al.* 2014; Katzner *et al.* 2016). Katzner *et al*. (2016) in their study to track the migratory pattern of the Red-footed Falcon observed that the birds departed from breeding grounds in September moving through the Caspian Sea towards the Middle East. The birds then entered the continent through north eastern Africa, arriving in Angola and Southern Africa in October. There is however limited literature on key stopover sites in the continents as studies have not been able to fully identify patterns of migration of the birds into Africa.

1.5. Migration in Western African stop-overs

Data of satellite-telemetry tracking of Red-footed Falcons indicate their use of stopovers in Western Africa, especially during the pre-nuptial migration (P. Palatitz *et al.* 2018). Higher concentration areas have been identified in Ghana and it is suspected that these birds utilise these sites as stopovers in their migratory cycle. It is therefore important to characterise the features of these sites for which the birds may be attracted to. In Ghana, three locations have been observed to receive higher concentration of birds during the migratory cycle especially in April when the birds are preparing to migrate back into Europe (Figure 1).

Two of these sites are located in the northern half of the country while the third location is located around the Eastern part of the country.

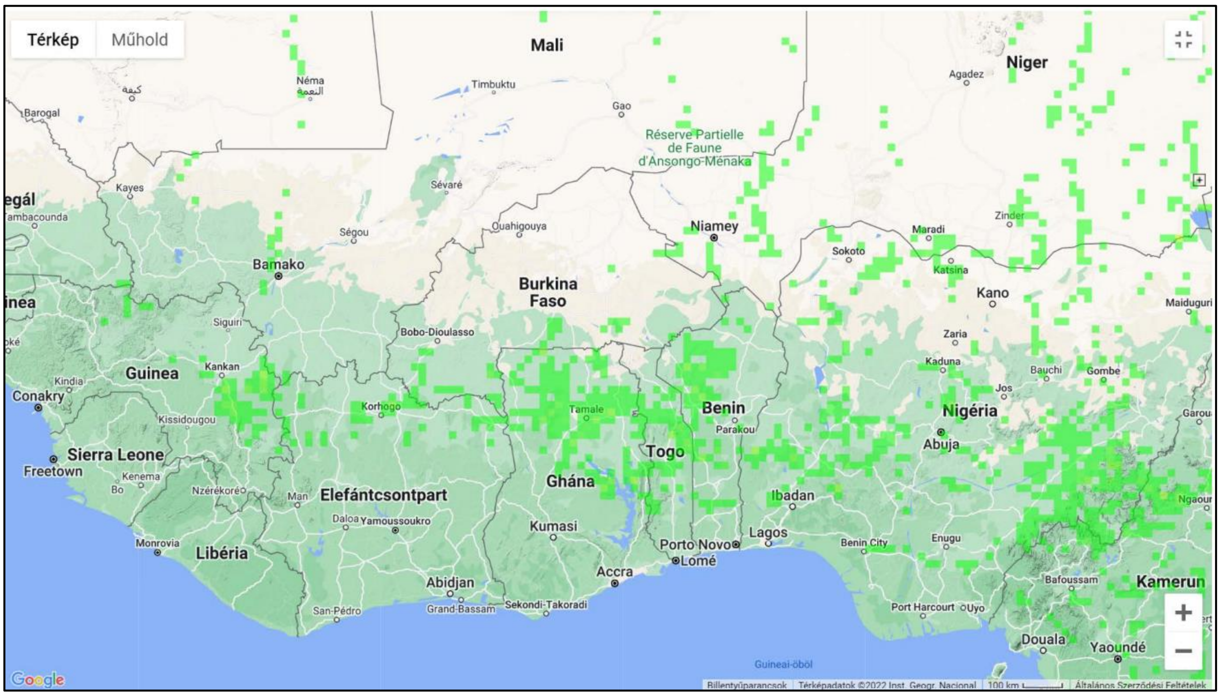

Figure 1 Distribution density map of satellite-tagged Red-footed Falcons in Western Africa during pre-nuptial migration (April). (source: Birdlife Data 2015 redrawn based on the dataset published in P. Palatitz et al 2019).

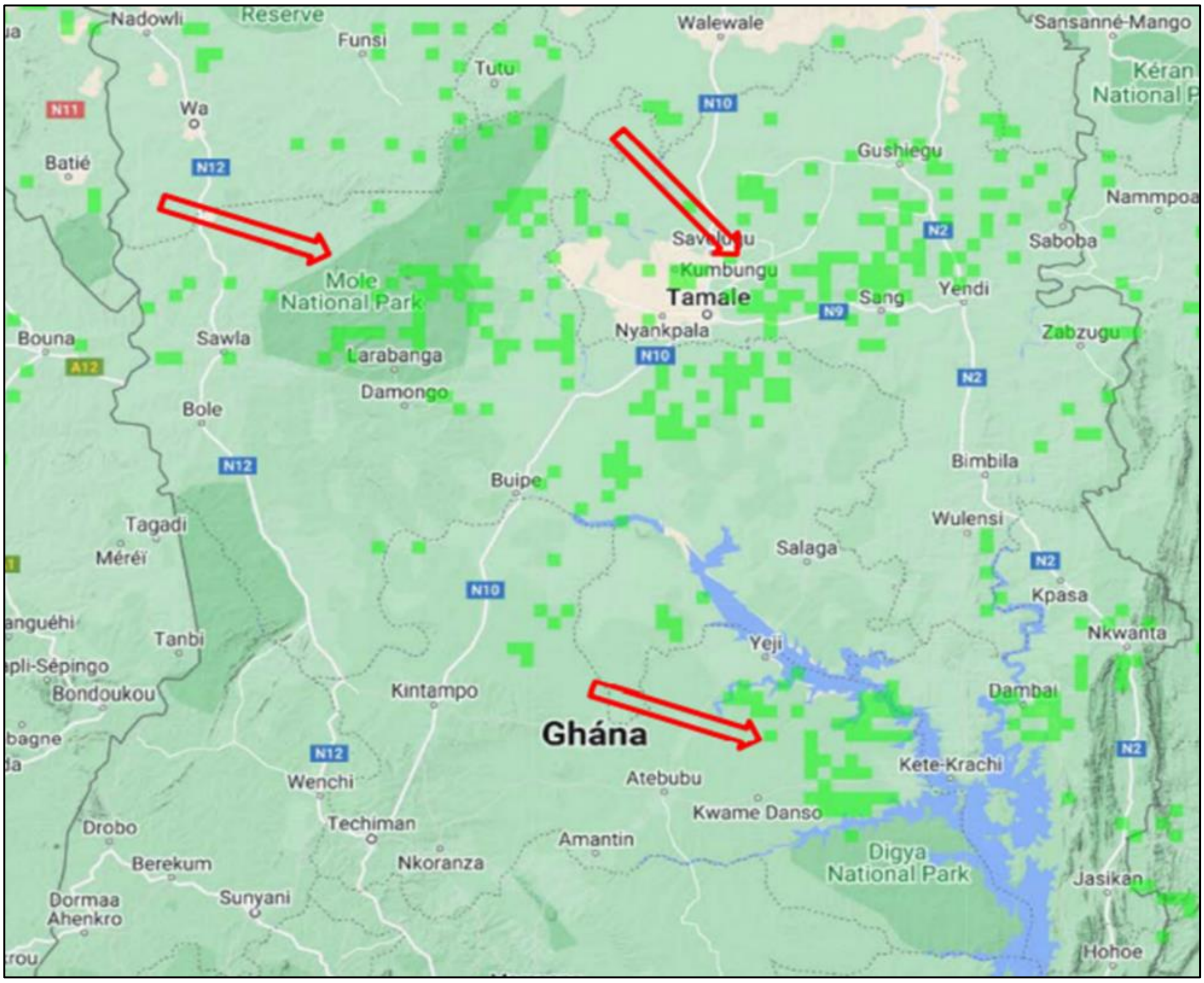

Figure 2 Stopover sites of higher concentrations (shown by red arrow) of visits of the red-footed falcon in Ghana in April (source: Birdlife Data 2015 redrawn based on the dataset published in P. Palatitz et al 2019)

3. MATERIAL AND METHODS

3.1. Data Collection

The data used in this study is telemetry dataset collected and provided by the Red-Footed falcon Conservation Workgroup of MME Birdlife Hungary. BirdLife is the official scientific source of information on birds for the IUCN Red List (Birdlife International Bio page). Altogether 28 Red-footed Falcons were deployed with 5 grams satellite PTTs from 2009 to 2016. These individuals were selected to cover the extent of the world population; thus, tagging was carried out in Italy, Hungary, eastern and western Romania and in Kazakhstan from LIFE Nature projects (Palatitz 2018).

The individual movement data of 5 tagged Red-footed Falcons was used for this study Data analysis was restricted to the movements of these birds in Ghana, West- Africa from 19/04/2015 to 25/04/2016. Night roost data of the Red-footed Falcons from 3 years (2015,2016, and 2017) were used in this study. Most of the data are from 2015, due to the large number of birds deployed with transmitters in 2014.

The study area, Ghana, is a West African Country located on the Gulf of Guinea with a land area of 238,533 km^2 (Hastings, 1977). Since West Africa gradually becomes drier as you move northwards towards the Sahel and Sahara, Ghana is Characterized by its southern part consisting of mainly tropical forests whiles the northern part is more drier and consists of savanna (Hastings, 1977). Ghana is divided into 5 major Vegetative Zones: Tropical Rainforest Moist Semi Deciduous Forest, The Interior Wooded Savanna found mostly in the Northern Ghana, the Coastal Scrub And Grassland, the Strand and Mangrove zones as shown figure 3 (Dawood & Afful, 2018). There are 16 Administrative regions in the country with the divisions based on a unique characteristic language, population, economic activities, culture or other factors (Dawood & Afful, 2018). Ghana lies between 1°E–3°W longitude and 5°N–11°N latitude (Hastings, 1977) and has a generally tropical climate with a daily temperature range between 24°C and 30°C and a humidity between 77–85 percent (Ghana Travel Weather Averages (Weatherbase)).

Ghana is divided into four climatic regions; South-Western Equatorial, Tropical Continental, Dry Equatorial and Wet Semi Equatorial. The northern parts of Ghana, which are the focus of this study are Characterised by the Tropical continental climate which is hot and dry, has a single rainfall season annually (May–September) and an average humidity of 49.97% (Child Protection Baseline Research Report, 2014).

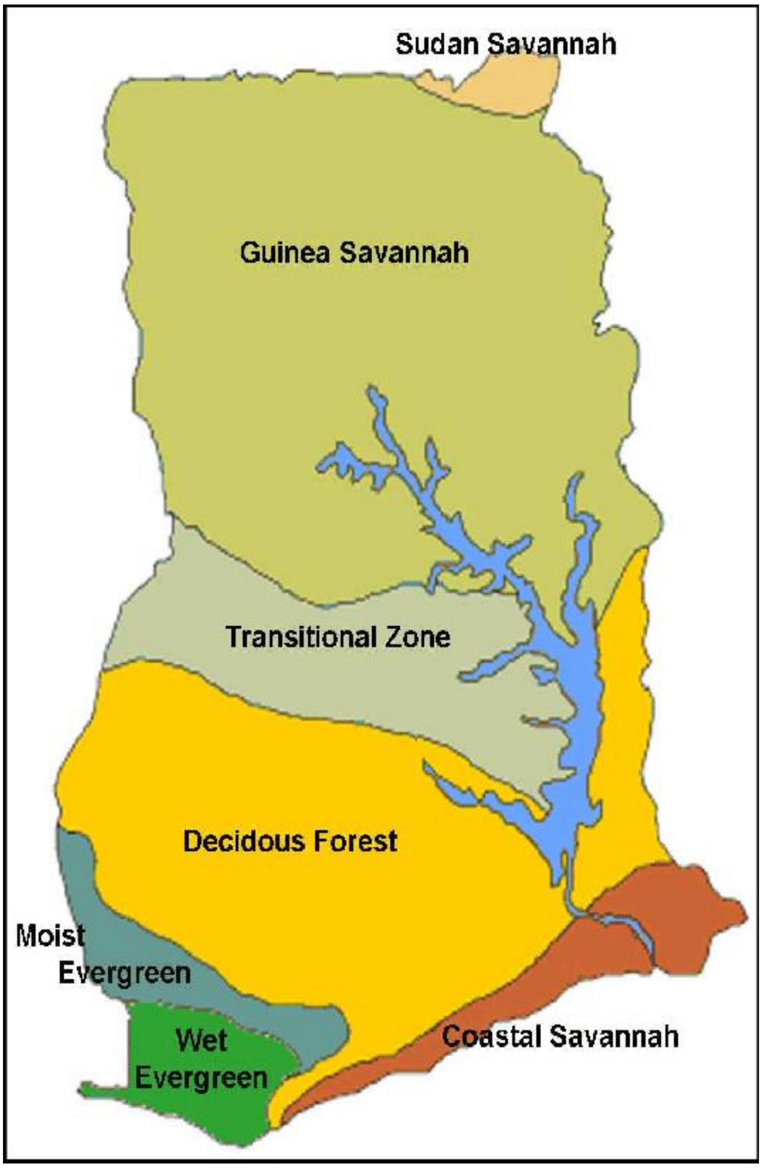

Figure 3 Map of Ghana showing the major ecological zones (Appiah et al. 2014)

3.2. Data Analysis

The data retrieved from the Birdlife database was streamlined to three focal points, where the aggregation of the Red-footed Falcons were highest, that is, there were some random locations where some Red-footed Falcons were recorded to be using but were used either a single time or by a single individual for a short period of time (only 1 or 2 days) though the falcons stayed in west Africa throughout April and May due to extreme easterly winds in 2015 (P. Palatitz *et al.* 2018). These random locations were not added to the analysis in this study. The locations made with the ARGOS satellite system were filtered as follows:

- The points within the borders of Ghana were selected
- The period between 22:00–05:00 UTC was selected (roosting sites)

- Locations of sufficient measurement quality (ARGOS classes 3,2,1) were selected.

Results were analysed from scientific papers which have been documented and published over the last 20 years with few exceptions dating back to 1990 and 1952. The main sources of these papers were: Google Scholar, Web of Science, Scopus, Research Gate and Wiley online library. The key words used in the search were; "Red footed falcon", "Red footed falcon migration", "Intra African migration", "Red footed falcon in Ghana", "Migratory birds in Ghana". These searches resulted in a total of 104 papers from the "topic" section of the sites from which 17 were fully analysed for this thesis, because they had direct links and relevant information to this study. These papers had in their contents scientific works that were either studying the climate of an area, the agricultural use of an area, the economic important of tourist sites and some other large mammals but none directly mentioning the Red-footed Falcon in Ghana.

The major factors that were considered in these scientific papers and studies included: precipitation of warmest quarter, precipitation of driest quarter, temperature seasonality, annual precipitation, and precipitation of driest month, the topology of the study sites, the avifauna populations in the study sites, the insect communities in the study sites and general vegetation structure of the study sites.

Historical weather data were gathered and analyzed for years 2015, 2016 and 2017 in the 3 focal points of this studies from 1st February to 30th May of each year. The weather data was collected and analyzed from "visualcrossing.com" and "Weather and Climate" websites. The weather data was compared to the movement of the birds within the borders of Ghana to see if there is any correlation Between the weather and movement.

Quantum GIS (v3.30) was used to display and analyse the telemetry data obtained from Birdlife International database.

4. RESULTS

Birds arrived in Ghana from the East, in the second half of April, and left Ghana to NW at the end of the month in 2016 and 2017. However in 2015 some of the birds stayed until the end of May. The weather in the year 2015 was exceptional when strong NE winds dominated the flyway over the Sahara. Red-Footed Falcons stayed longer in the region (Ghana) waiting for the right conditions as shown in figure 4. After several weeks, they chose the westerly route back to the breeding grounds as shown in figure 5.

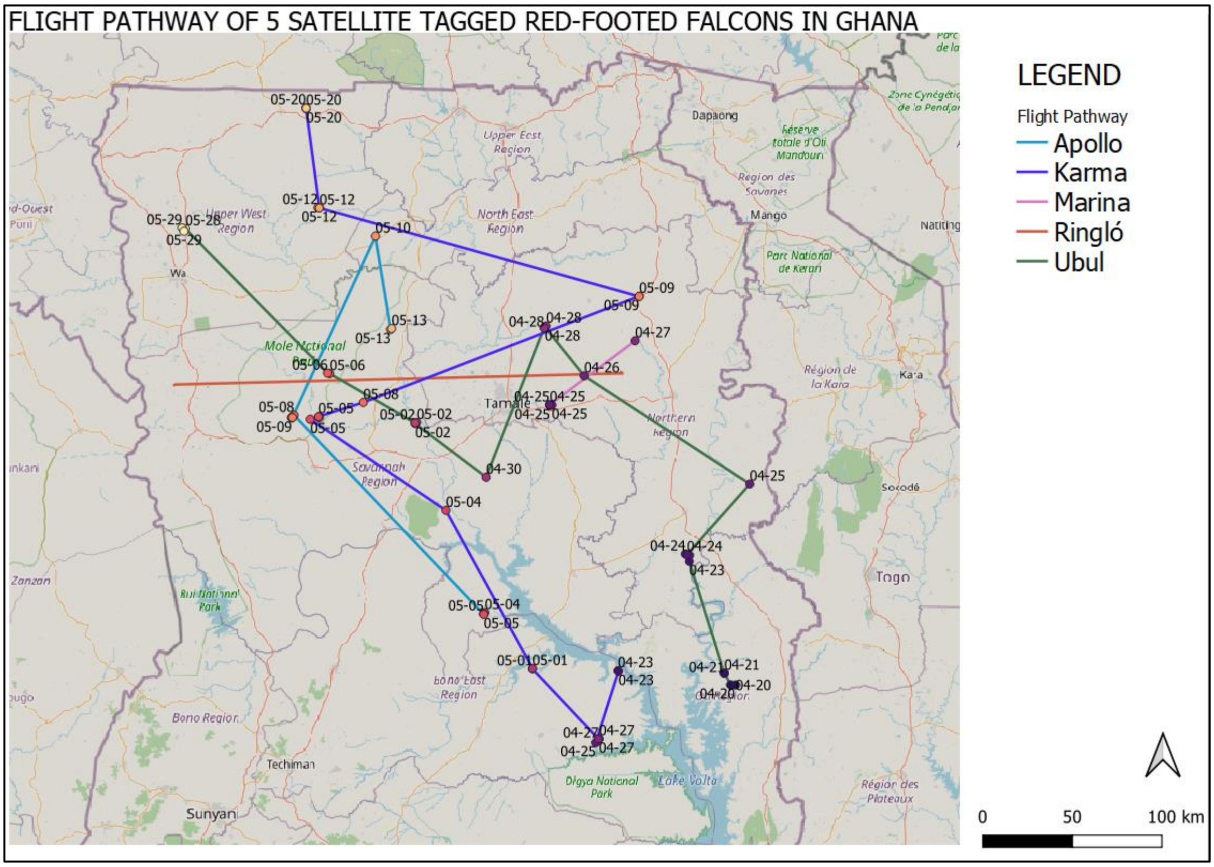

Figure 4 A QGIS generated map showing the Movement and flight pathway of 5 satellite tagged Red footed falcons in Ghana in 2015 and 2016.

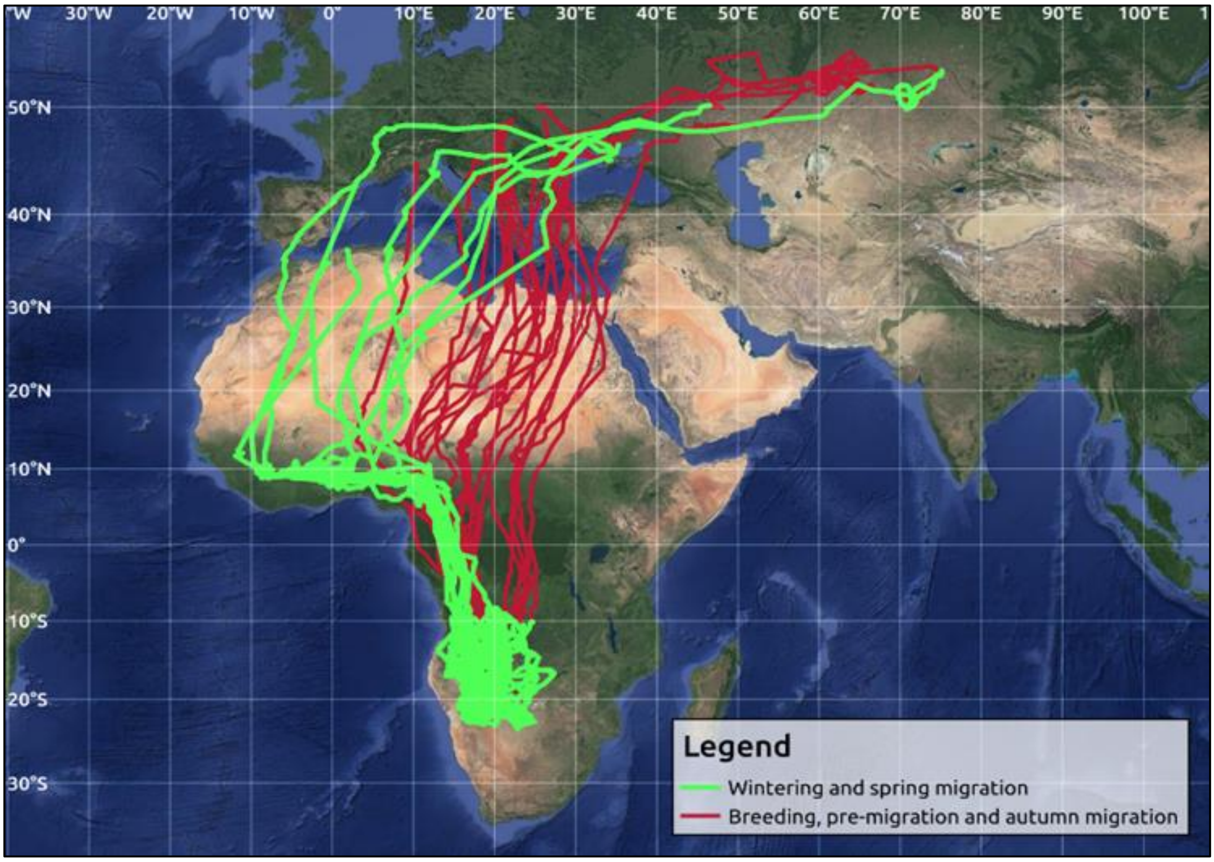

Figure 5 The map of loop migration of Red-Footed Falcons from Palatitz et al 2018

Table 1 below presents the geographic locations of the identified sites where the Red-footed Falcons had aggregated within the borders of Ghana on their return journey to Europe in 2015 and 2016.

Table 1 Geographic features of three stopover sites of red-footed falcon identified in Ghana via radio telemetry in order of the place of first arrival to the place of last place of settling before departure to Europe.

	Location 1	**Location 2**	**Location 3**
GPS coordinates			
Closest Locality	Around Digya National Park	Kumbungu/Tamale	Mole National Park
Region	Bono east region	Northern region	Savannah region
District	Sene-East district	Kumbungu district	West-Gonja district

4.1. Location 1 – Sene East District

The first stopover site of the Red-Footed Falcons in Ghana is located within the Sene East District of the Bono-East region. Where the birds arrived from the 20th of April 2015, the location however indicates the presence of the birds in an uninhabited area as shown in Figures 2 and 3. Closer to the area is the Digya National Park also located within the District. The district covers a vast land area of 4,392.4 km^2 and shares boundaries with East Gonja District to the north, Krachi West to the East, Sene West to the West and Kwahu North to the south (Ghana Statistical Service, 2014).

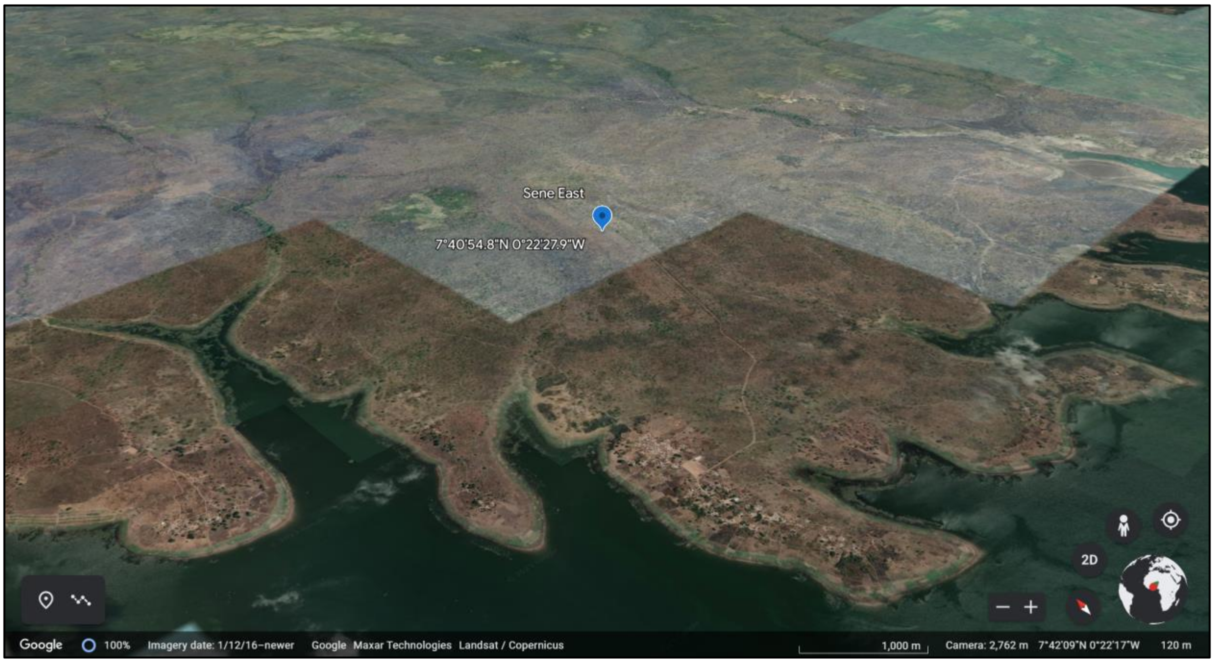

Figure 6: A real time aerial view of the Sene East location (source: Google earth)

4.1.1. Climatic conditions

The district has a tropical climate, with high temperatures averaging 27 ^{o}C and a double maxima rainfall pattern. Rainfall ranges from an average of 900–1,098 mm per year (Ghana Statistical Service, 2014). The district falls between the Wet Semi-Equatorial and Tropical Continental Climatic Regions of Ghana and experiences two seasons, rainy and a long dry season. The rainy season starts from April to October giving way to the dry season from November to March (Ghana Statistical Service, 2014). The rainfall distribution varies from year to year, sometimes with intermittent droughts and floods mostly peaking in August. Humidity is quite high in the area with an average of about 75%. The population of the District according to the 2021 population and Housing Census stands at 72,081 with 38,433 males and 33,648 females (Ghana Statistical Service, 2021). One of the key features of the area is the presence of the Volta Lake (one of the largest man-made lakes in the world) on the east and south borders of the area. Aside the presence of the lake, the area is also drained by the Pru and Sene Rivers (Ghana Statistical Service, 2014). As a result, fishing is one of the main activities of people living within the district in addition to farming.

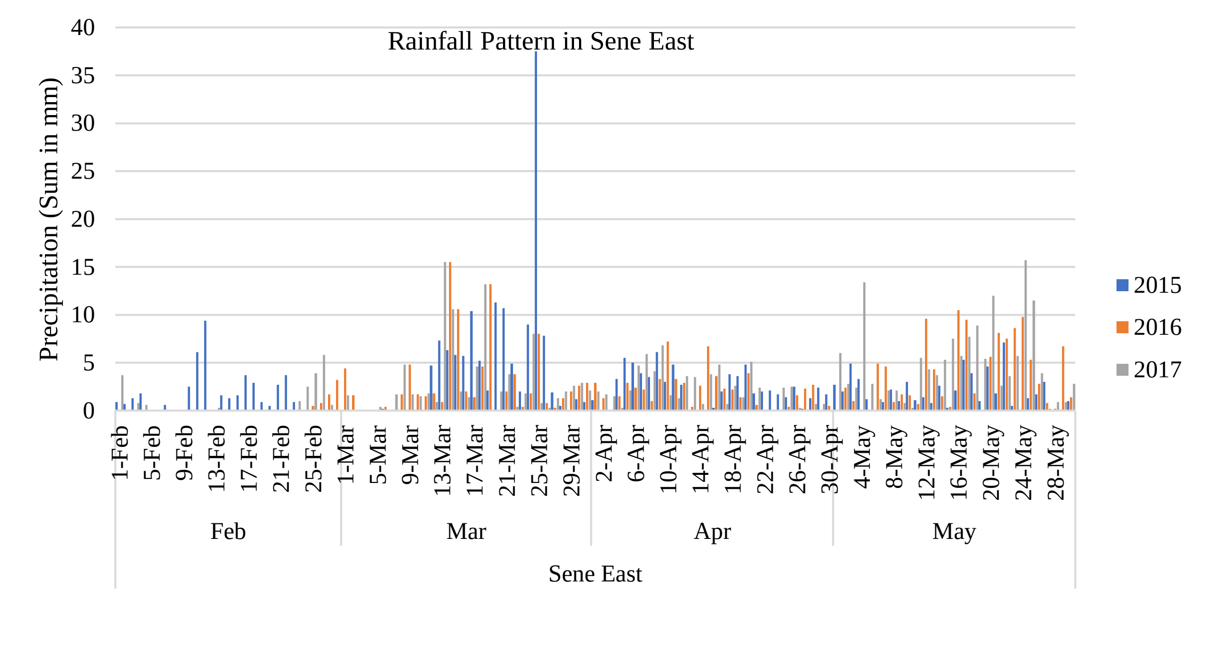

Figure 7 A graph of the Precipitation levels in The First location (Sene East Districts) in the years 2015, 2016 and 2017 from 1st February to 30th May each year. (Data source: Visual Crossing Weather)

4.1.2. Habitat Characteristics Flora and Fauna

The landscape of the district is generally flat and low lying with an average height of 166 meters above sea level. Similar to the characteristics of the other two stopover hotspots, the vegetation of the Sene-East district is predominantly Guinea Savanna woodland with light under growth and scattered trees. The major and economic trees are Shea, dawadawa, baobab, mahogany, neem species among others (Ghana Statistical Service, 2014). These trees are also found in the Northern region and the Savannah region of Ghana where the other two stopover hotspots have been located. Yam, rice, groundnut, maize and cassava are the common food crops grown in the study area on a subsistence base (Bani & Damnyag, 2017). It has however been reported that in the district, agriculture is claiming more land than afforestation activities and the over dependence on charcoal and wood fuel, 'slash-and-burn' agricultural practices, illegal logging and burning of timber trees further threatens the natural forest in the area (Bani & Damnyag, 2017).

Search in literature revealed studies that have surveyed the fauna composition of the Sene East district have mainly focused on areas within the Digya National Park. The Park is inhabited by a range of savannah and forest animals. Dominant amongst these species are the elephant, hippopotamus, buffalo, waterbuck, bushbuck, kob, oribi, duikers, roan antelope, hartebeest, crocodiles, warthog and porcupine (Centre, n.d.; Jachmann *et al.* 2011; Owusu Boi, 2004; Twumasi *et al.* 2005). The area is also inhabited by the olive baboon (*Papio Anubis)*, vervet monkey(*Chlorocebus pygerythrus*), mona monkey (*Cercopithecus mona*), spotted nose monkeys (*Cercopithecus nictitans*) and the black and white colobus (*Colobus*) and patas monkey (*Erythrocebus patas*) (Owusu Boi, 2004). Majority of the studies focused on large mammals and as such there is little known about the entomofauna composition of the area.

4.1.3. Avian Biodiversity

Even though the area is a forest rich area and it is expected to host several fauna resources including birds, the search in literature did not reveal any study or assessment of the biodiversity resources of the area neither did it reveal any survey conducted on the avifauna composition of the area. Studies in the Digya National Park, which is the closest forest reserve to the identified stopover has a wide range of bird species that inhabit the park and has a similar vegetation structure and climatic conditions (Dowsett-Lemaire & Dowsett, 2009). Several bird species including the Red-throated Bee-eater *Merops bulocki*, Swamp Flycatcher *Muscicapa aquatica*, Black-headed Weaver *Ploceus melanocephalus*. The Crowned Eagle *Stephanoaetus coronatus* which is also a known raptor has also been recorded in the Digya National Park. Given the similarities in the vegetation structure and climate, it is not far-fetched that the identified location can inhabit the Red-Footed falcon. There has also been reports of several migratory bird species in the Digya national park (Owusu Boi, 2004).

4.2. Location 2 - Kumbungu

The second stopover sites for the Red-Footed falcon identified in Ghana falls within an area close to Kumbungu, a town in the Northern region of Ghana. The birds, after spending some time in the first location moved to this location from the 25th to the 28th of April, few birds however arrived directly to this site from southern Africa as early as the 15th of April according to the telemetry data. Kumbungu serves as the administrative capital town of the Kumbungu District which covers an area of 1,547 km^2. The Kumbungu District shares boundaries to the north with Mamprugu Moagduri District, Tolon District and North Gonja District to the west, Sagnarigu Municipal to the south and Savelugu Municipal to the east (Abdul-Malik & Mohammed, 2012). The population of the District according to 2021 population and housing census stands at 110,586 with 55,291 males and 55,295 females (Ghana Statistical Service, 2021). The town is prominently known for its farming activities cultivating cereals, tubers, and vegetables including rice, millet, sorghum, groundnut, tomatoes and pepper.

4.2.1. Climatic conditions

As characteristic of the northern part of Ghana, climatic conditions include two seasons that is the dry season between December and April and the wet season between May and November, with an annual average unimodal rainfall of 1,000 mm and the main cropping season stretching throughout May to late October (Quaye *et al.* 2009). Temperature conditions are warm, dry and hazy especially between February and April (Nyamekye *et al.* 2021) with an annual mean of 28 °C and a maximum of 42 °C (Akuoko *et al.* n.d.).

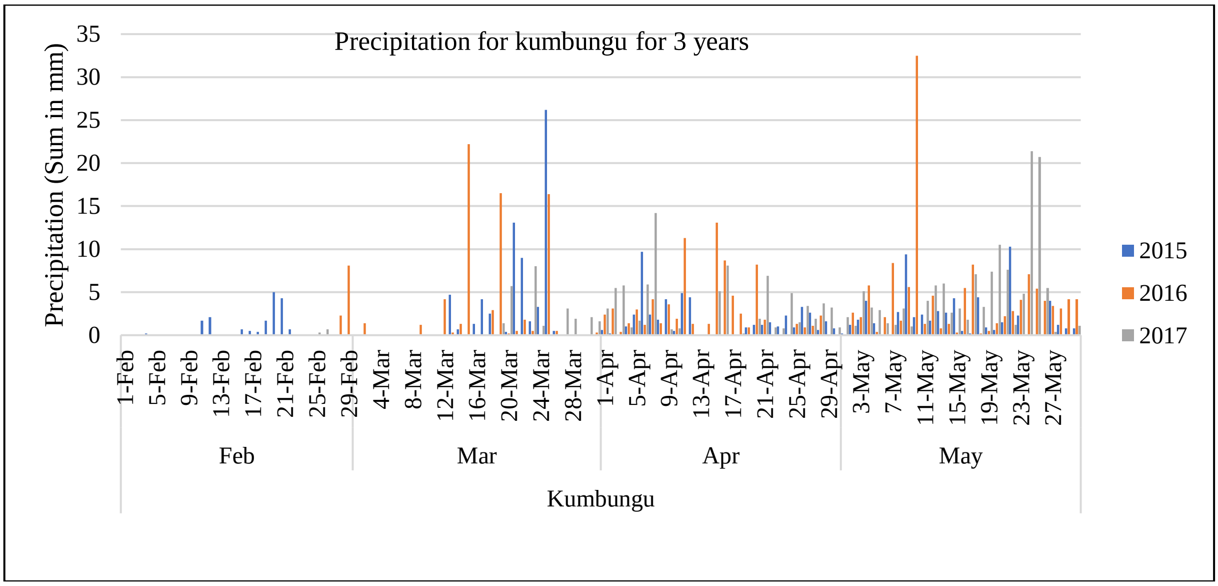

Figure 8: A graph of the Precipitation levels in The Second location (Kumbungu) in the years 2015, 2016 and 2017 from 1st February to 30th May each year.

4.2.2. Habitat Characteristics, flora and fauna resources

The vegetative cover is typical of a Guinea Savanna with isolated trees and tall grass. The soil generally consists of the sandy loam type, except in the lowlands, where alluvial deposits are found (Sutanto *et al.* 2022). Due to the high level of agricultural production in the area, there are several crops grown which contributes to the floral resources of the area. The trees found in the area are drought resistant and hardly shed their leaves completely during the long dry season (Sutanto *et al.* 2022). Most of these are of economic value and serve as important means of livelihood, especially for women. Notable among these are Shea trees (*Vitellaria Paradoxa*, used for making shea butter) and Dawadawa (*Parkia Biglobosa*), that provides seeds used for condimental purposes and many other locally used products (Ansah & Nagbila, 2011).

The district is drained by the White Volta and other smaller rivers and their tributaries with most drying up in the dry season. The area has one of the most prominent and largest gravity-fed public irrigation schemes in the country, the Bontanga Irrigation system. This is built on the tributaries of the White Volta River with an irrigable area of up to 570 ha and a total water requirement of 11,000,000 m^3 per year (Nyadzi, 2020). There are also a number of small-scale irrigation systems in the area (Faulkner *et al.* 2008). These small-scale reservoirs and large-scale irrigation systems provide an all year-round supply of water for farmers which is important during the dry season.

Despite the unique nature of the area, very few studies have been conducted to assess biodiversity resources of the area probably because the area is not known for any conservation value. However, due to the irrigation system and other water bodies in the area, and the high agricultural production, some studies have reported the presence of insect pests of crops (Yahaya *et al.* 2021) as well as mosquito vector species (Akuoko *et al.* n.d.) breeding in the area.

4.2.3. Avian Biodiversity

There is little information regarding bird species that visit area. Search in literature only revealed the presence of domestic birds such as guinea fowls as part of the agricultural activities conducted in the area (Enahoro *et al.* 2021).

4.3. Location 3 – Mole National Park

The third hotspot falls within the Mole National Park of Ghana. Mole National Park (MNP) is the largest and oldest national park in Ghana and is located in the Guinea Savanna Vegetation Zone of West Africa (Nsor *et al.* 2018). It was established as a game reserve in 1958 and upgraded to a National Park in 1971. MNP is a typical guinea savannah forest protected area covering an area of about 4,577 km^2. It is bordered by 33 communities, with a total estimated population of about 35,000–40,000 people (Dakwa, 2018).

4.3.1. Climatic Conditions

Two climatic seasons generally exist in the northern ecological zone of Ghana, namely the dry season (November to April) and the wet season (May to October) (C. W. Kuuder, 2012). The park receives an average annual rainfall of about 1100 mm, 90% of it falls from April to October (Dankwa-Wiredu & Euler, 2002). The dry season, which is mostly characterised by harmattan dry winds, occurs between December and March with an annual mean temperature of 28 °C varying from 26 °C in December to 31 °C in March (Nsor *et al.* 2018). These seasonal variations are important because they directly impact the habitat characteristics of the park and subsequently, resources available for fauna that depends on the park for varied reasons (Naugle *et al.* 2001; Riffell *et al.* 2001)

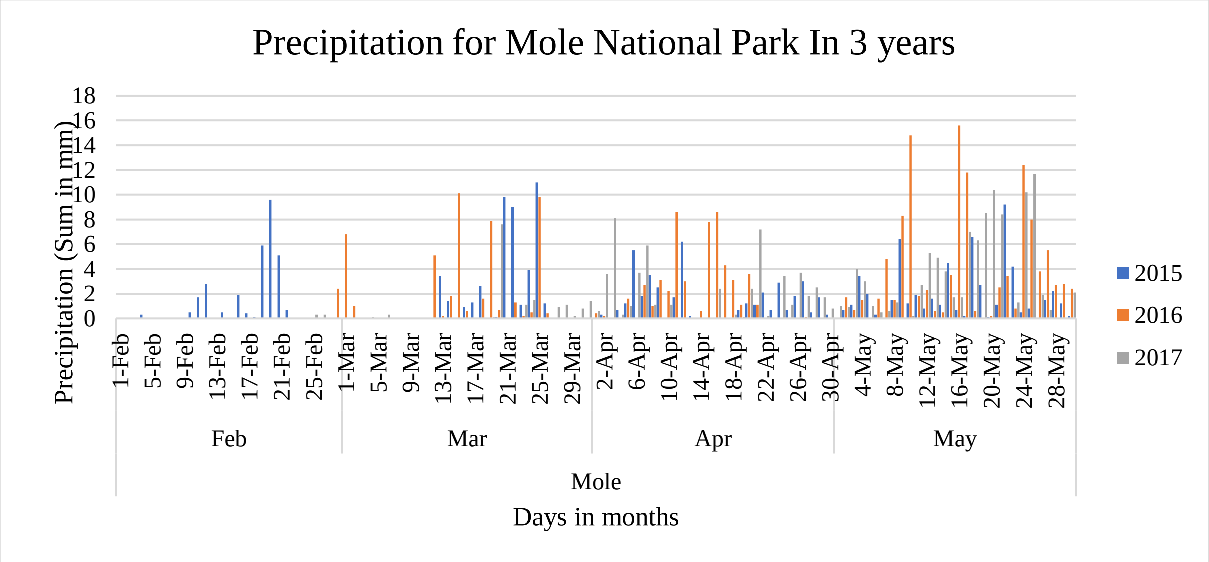

Figure 9: A graph of the daily Precipitation levels in The Third location (Mole National Park) in the years 2015, 2016 and 2017 from the 1st February to 30th May each year

4.3.2 Habitat Characteristics

The MNP has six main habitat types characterised by specific plant species. These are the *Burkea-Terminalia* open savanna woodland with *Vitellaria paradoxa*, *Burkea Terminalia* open savanna woodland with *Detarium microcarpum*, the Anogeissus with *Vitellaria paradoxa*, the boval vegetation (open areas dominated by grass) (*Loudetiopsis kerstingii*, *Polycarpaea tenuifolia*) community on rocky substrates, riverine forest along most of the rivers in the park, and swamp (Schmitt & Adu-Nsiah, 1993).

Most of the park is dominated by open savanna woodland, interspersed with grasslands and riparian forests (Sackey & Hale, 2018). Trees that are relatively widely spaced with patches of grasses and shrubs dominate the woodland habitats. The riparian forest consists of forested areas associated with streams and rivers that have complex ecosystems and provide food, lodging, and travel corridors for both aquatic and terrestrial species in the park (Naiman *et al.* 1998). The grassland is mainly dominated by grasses and sedges, with small trees and shrubs scattered all around (IUCN/PACO, 2010).

The park also has a number of wetlands that serve as a haven for several animals most especially for water birds (Aikins *et al.* 2018a). The most important and prominent wetlands in the park that are easily accessible to the park users include the Dam 1 & 2 wetland, Lana Pool, Haraba Pool and Asibey Pool. Dam 1 & 2 wetland was created by the damming of the Samole

River. There are several waterbodies which flow through the park. The major rivers that drain the park include Mole, Samole, Lovi, Zuo, Polzen and Kulpawn with only Mole, Kulpawn and Polzen flowing permanently. The others usually dry up or are reduced to stagnant pools in the dry season (C. W. Kuuder, 2012). Most of the streams and rivers either take their source from within or drain through the park and empty into the White Volta (Dankwa-Wiredu & Euler, 2002; Sackey & Hale, 2018). The park serves as a major source of headwater for surrounding communities of the park. Water courses are lined with species-rich riparian forest, with closed canopy and dense undergrowth. Grassland and swamps are also common around water holes (Fishpool & Evans, 2001).

4.3.3 Flora and Fauna

Floral resources in the park consists of mainly an open Guinea Savanna woodland with tall trees growing to an average height of 11 m although others can grow up to 22 m tall. Aside tree species that characterise key habitat types, other common tree species are *Terminalia avicenniodes*, *Burkea africana*, *Butyrospermum paradoxum*, *Combretum spp*. and *Isoberlinia doka* are some of the common tree species in the park (Fishpool & Evans, 2001).

Mole National Park holds rich fauna biodiversity, comprising about 94 mammal species, over 300 bird species (Dowsett-Lemaire & Dowsett, 2009; IUCN/PACO, 2010) 33 species of reptiles (Briggs 2007; Riley and Riley 2005). The park is considered a preserve for antelope species including kob (*Kobus kob*), Defassa waterbuck (*Kobus defassa*), roan antelope (*Hippotragus equnus*), hartebeest (*Alcelaphus bucelaphus*), oribi (*Ourebia ourebi*), bushbuck (*Tragelaphus scriptus*), the red duiker (*Cephalophus natalensis*) and the yellow-backed duiker (*Cephalophus sylvicutor*) (Dakwa, 2019).

The rich fauna biodiversity of the park makes it a key destination for tourists across the world. Yearly data between 1998 and 2012 indicated an average of 2,959 domestic and 4,276 foreign tourists visited the park each year whilst yearly maximum numbers of domestic and foreign visitors to the park were 8,048 and 8,759 respectively (Lawer *et al.* 2013). Although charismatic mega-fauna, such as elephants, remains the focus of many of these ecotourists in Mole National Park, birdwatchers are also frequently seen with about 41% of the park visitors expressing interest in birds (C.-J. W. Kuuder *et al.* 2013).

4.3.4 Avian Biodiversity

A number of studies and surveys have established the presence of several species of birds within the park (Agyei-Ohemeng *et al.* 2017; Aikins *et al.* 2018b; Dowsett-Lemaire &

Dowsett, 2009; Sulemana *et al.* 2022). Amongst these species are species that are resident in the park and migratory birds which visit the park in seasons. A number of species of migratory birds have been recorded in the park comprising intra-African migrants and palearctic migrants (Agyei-Ohemeng *et al.* 2017; Aikins *et al.* 2018b). Aikins *et al.* 2018b recorded 5 palearctic migrant waterbirds in the wet season and 9 in the dry season; these birds include *Egretta garzetta*, *Ardea cinerea*, *Tringa ochropus* , *Ardeola rallaides*, *Ardea purpurea*, *Actitis hypoleycos* and *Charadrius forbesi*. This indicates the suitability of the park for different migratory birds all year-round. There is however limited information on the presence of falcons or the Red-footed Falcon in the park, from literature.

4.4. Rainfall and temperature patterns in the 3 Locations.

Figures 13–18. show the rainfall patterns and temperature of the 3 locations in the study years (2015.2016 and 2017) as extracted from Weather cross database. The temperature is almost constant throughout the 3 locations and before during and after the wet season. The first heavy rains however, arrive in the southern part of the country in late March-early April and seems to move northward later in April and May, when the wet season starts and the movements of the birds follows a similar pattern (figures 16 and 17).

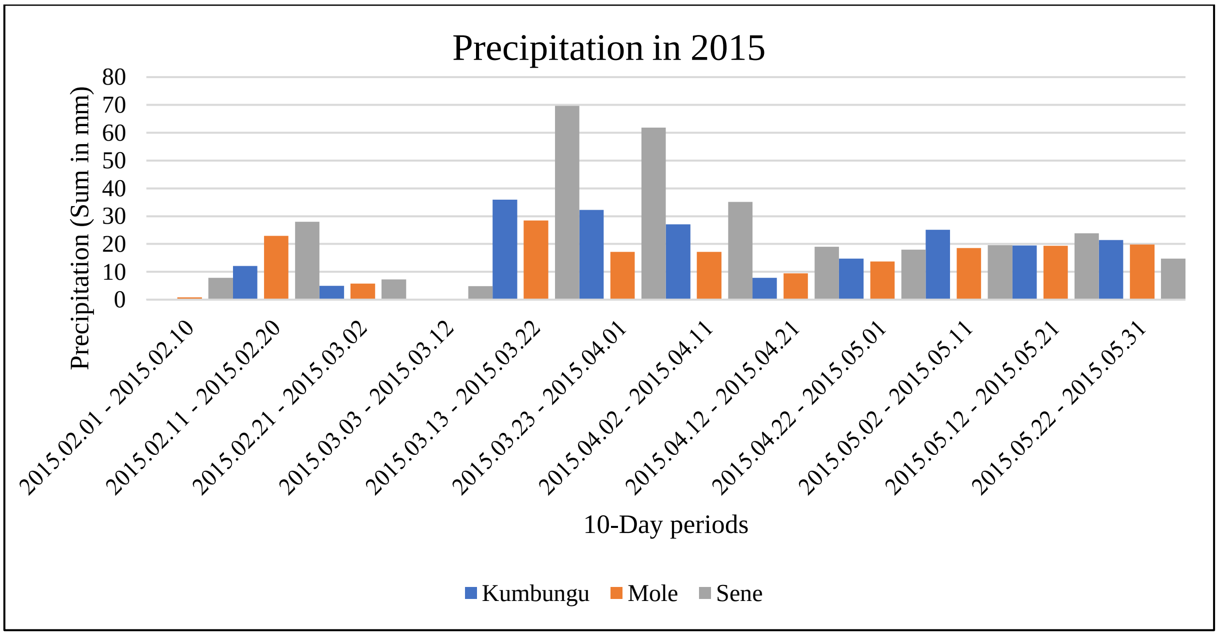

Figure 10: A graph comparing the precipitation of all the 3 locations used by Red-footed Falcons in 2015 as stop over sites in Ghana grouped into periods of 10 days from 1st February to 30th May.

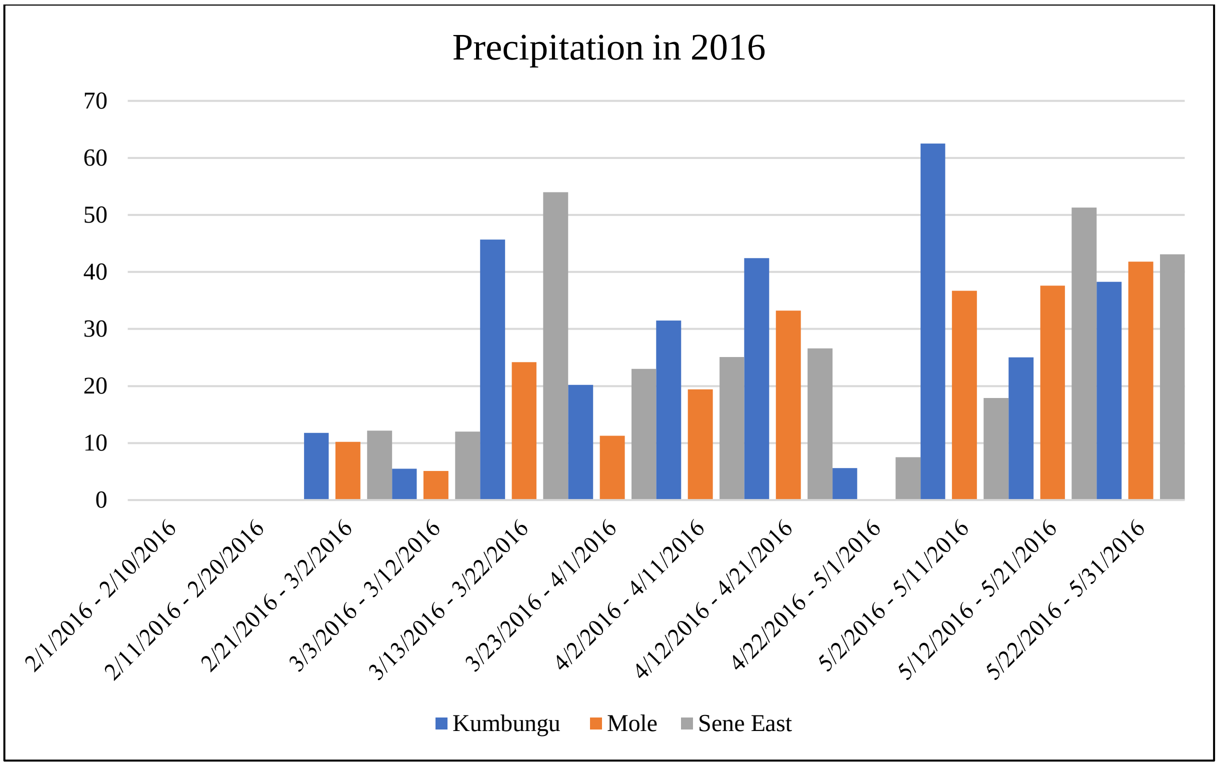

Figure 11. A graph comparing the precipitation of all the 3 locations used by Red-footed Falcons in 2016 as stopover sites in Ghana grouped into periods of 10 days from 1st February to 30th May.

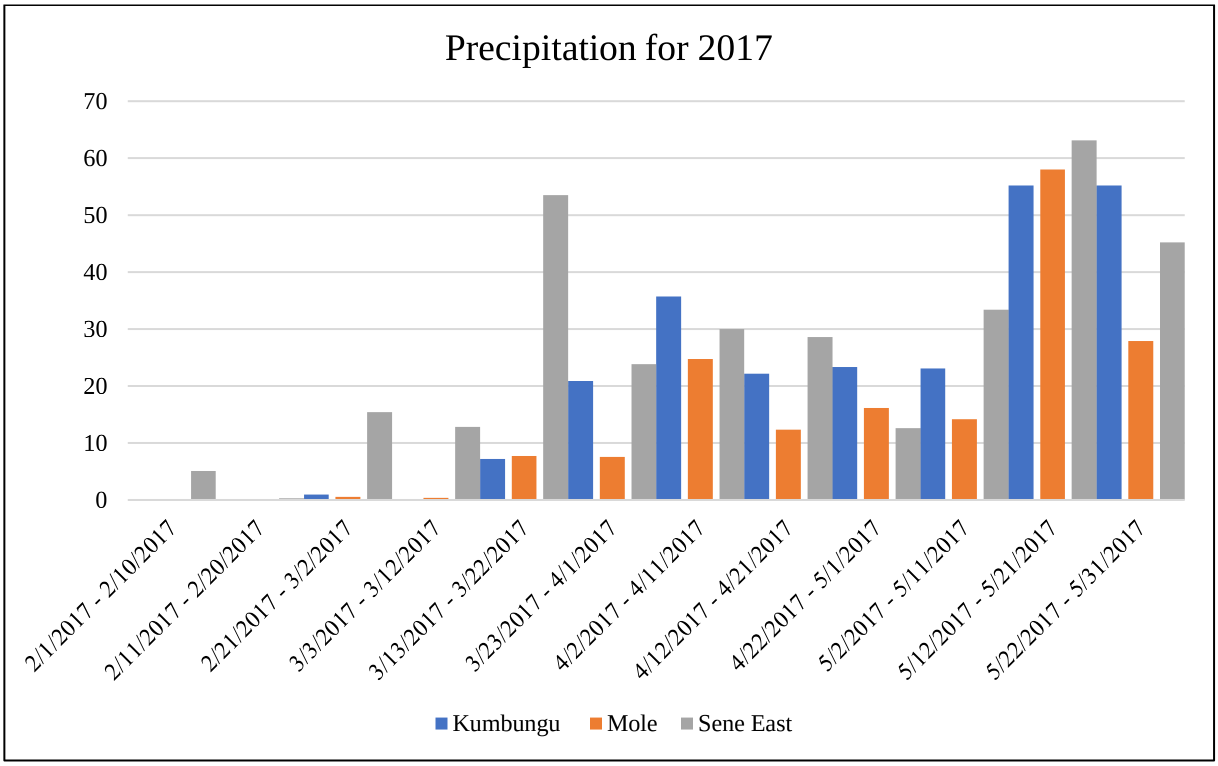

Figure 12: A graph comparing the precipitation of all the 3 locations used by Red-footed Falcons in 2017 as stopover sites in Ghana grouped into periods of 10 days from 1st February to 30th May.

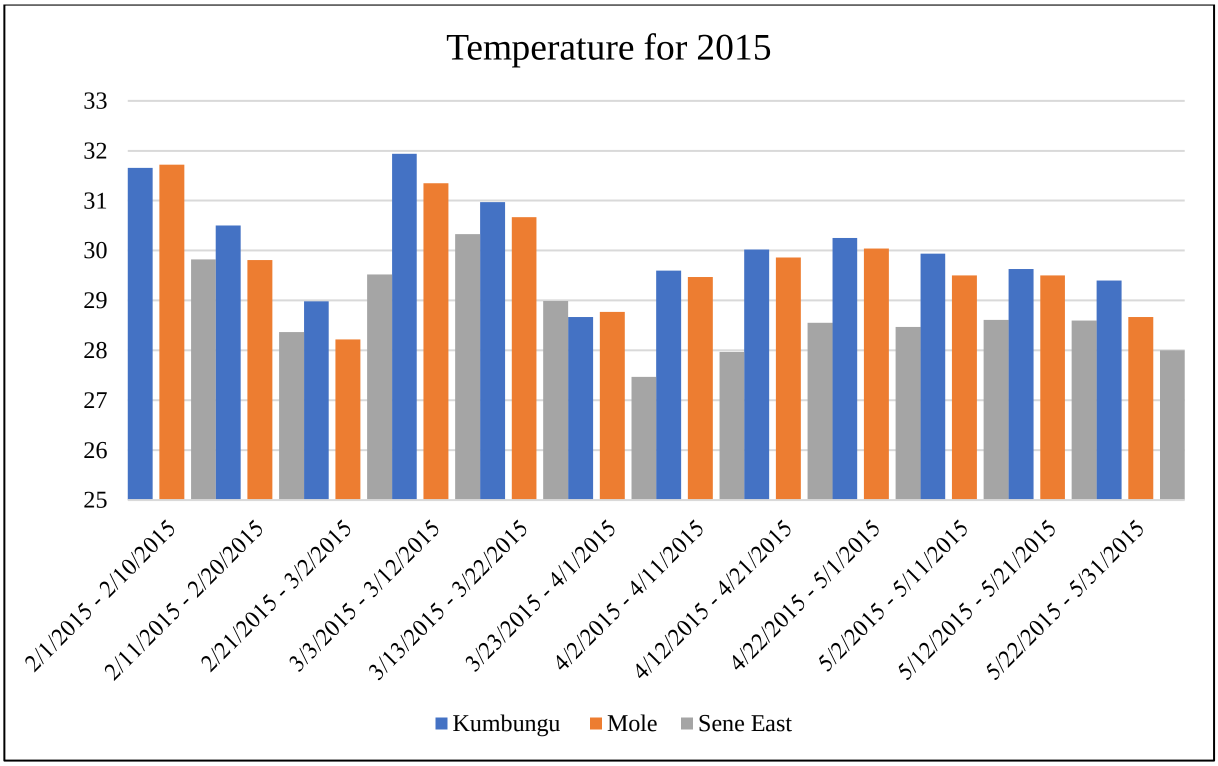

Figure 13. A graph comparing the temperature levels of all the 3 locations used by Red-footed Falcons in 2015 as stop over sites in Ghana

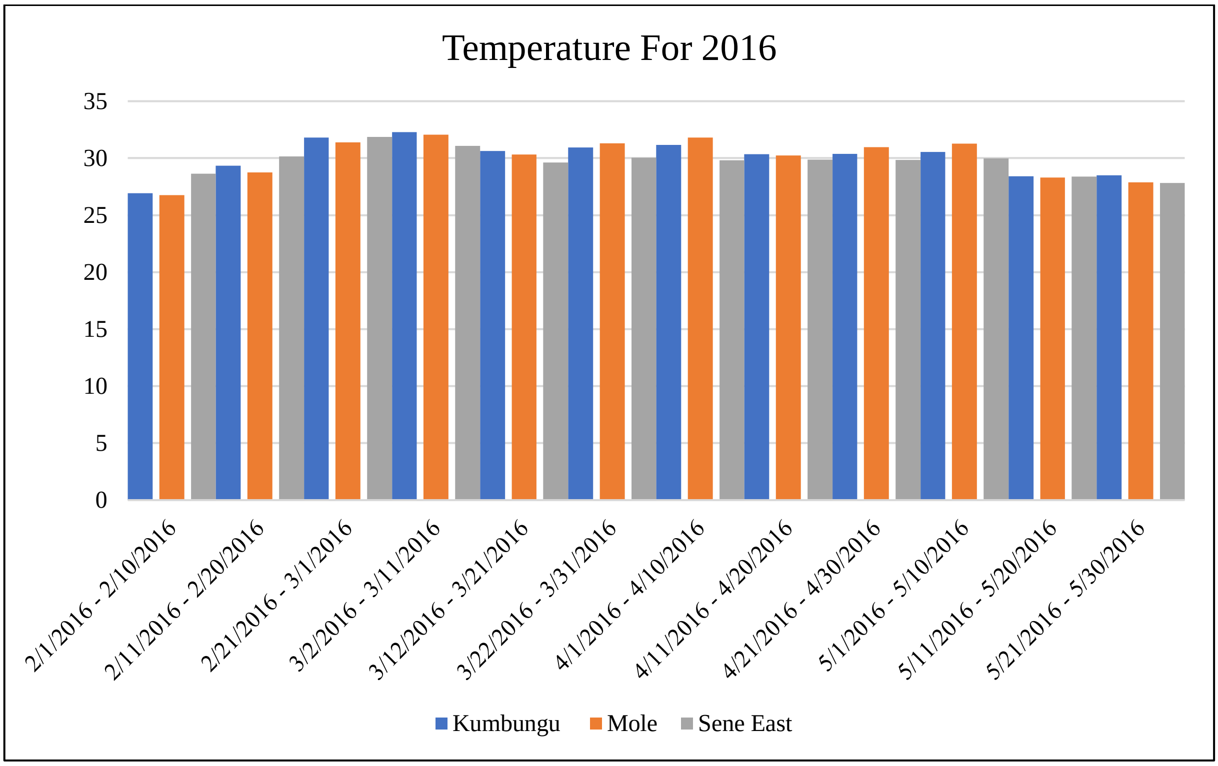

Figure 14. A graph comparing the Precipitation and temperature levels of all the 3 locations used by Red-footed Falcons in 2016 as stop over sites in Ghana

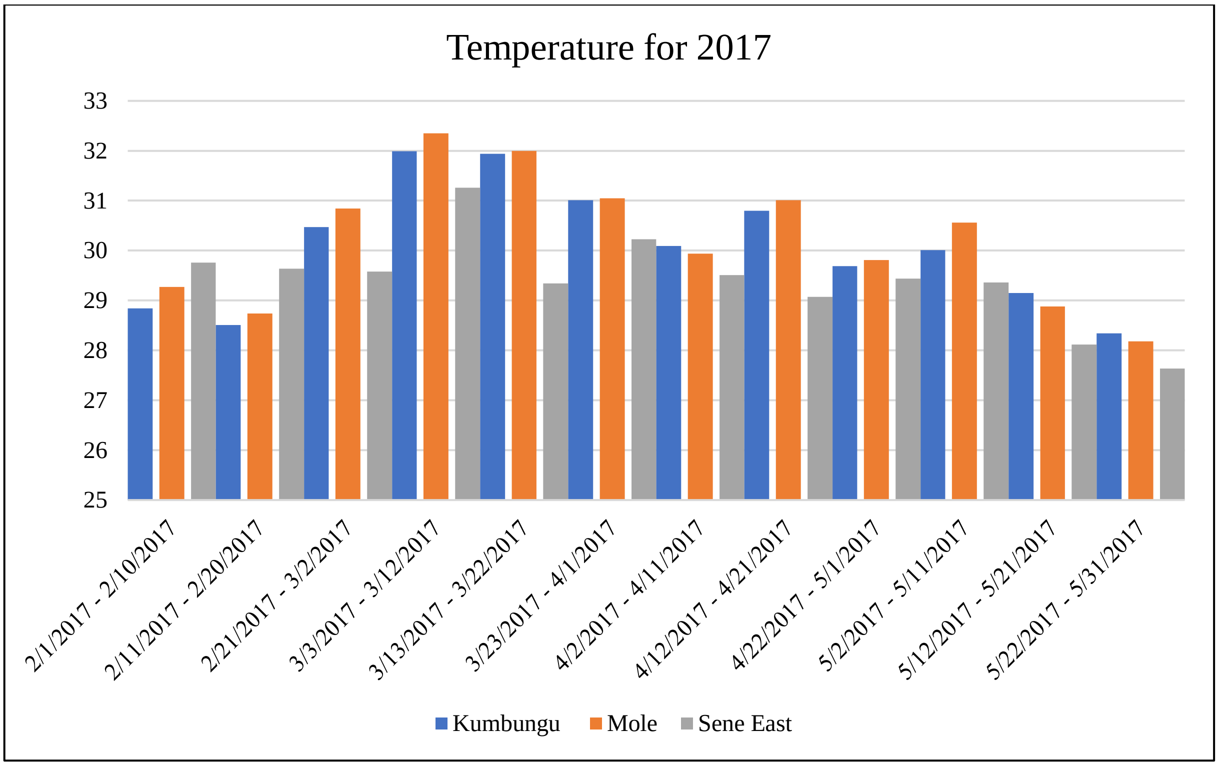

Figure 15: A graph comparing the Precipitation and temperature levels of all the 3 locations used by Red-footed Falcons in 2017 as stop over sites in Ghana (Data source: Visual Crossing Weather)

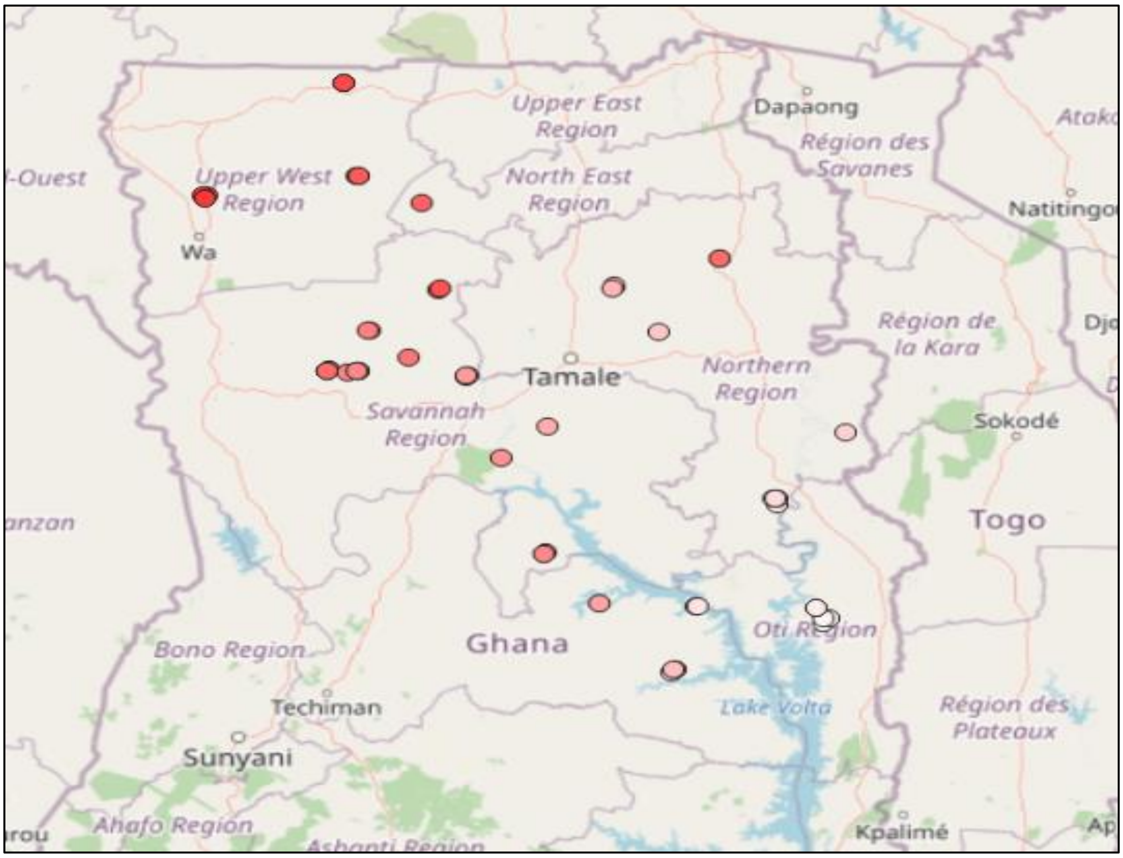

Figure 16 Data from 2015 show temporal displacement of the roosts from SE to NW (from white to red)

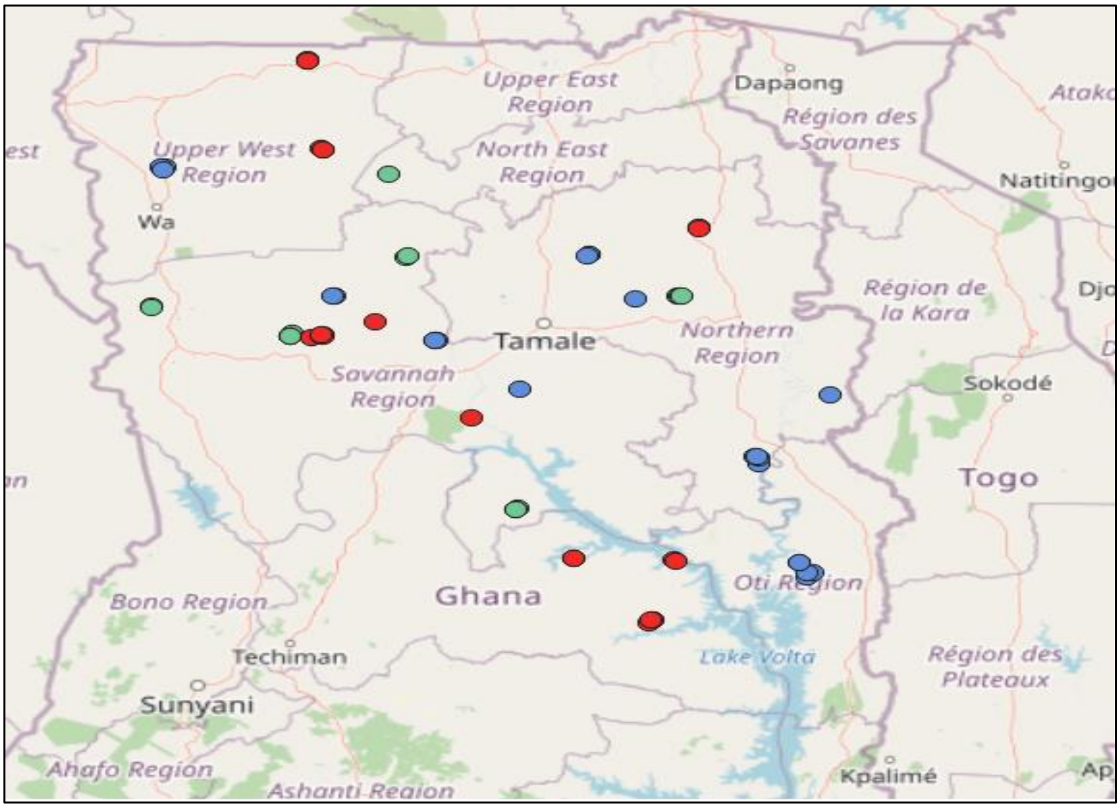

Figure 17. The data from 2015 (3 birds) do not show individual segregation in space, thus the NW movement seems obvious

5. DISCUSSION

Though there is very limited literature on the Red-footed Falcon in Ghana especially in the 3 sites of this study, the presence of other migratory bird species such as the Little Egret (*Egretta garzetta),* Green sandpiper *(Tringa ochropus)* , Squacco heron *(Ardeola rallaides),* and Purple Herons *(Ardea purpurea),* in the case of at least one of the sites seems to indicate the suitability of all three sites as stop over sites for European breeding birds that winter in Africa (Ornithologen-gesellschaft, 1996; Pang *et al.* 2023; BirdLife International, 2023) since there is no significant difference in the habitat and climatic conditions among and within the 3 sites.

The 3 sites seemed to have similar factors in common that could be driving factors for their selection as suitable stopover sites. The most obvious physical characteristic found in common between the 3 sites is their proximity to a natural water body. The first location, named the Sene East Site has within its range the largest made-made lake in the world, that is, The Volta lake, and is again traversed by the Pru and Sene Rivers. These areas which are usually characterized by wetlands on their flanks, serve as an optimum nesting site for birds since many birds are known to next on trees and shrubs adjacent to rivers and wetlands (Kusler, 2004). In location 3 or site 3 which is Mole National park is traversed by 6 different rivers which flow into the white Volta lake (Dankwa-Wiredu & Euler, 2002). Location 2 or site 2 which is the Kumbungu Site is drained by the White Volta and other smaller rivers and their tributaries and also a very prominent network of irrigation systems. . In location 3, which is The Mole National Park, it is traversed by 6 different rivers which flow into the white Volta lake (Dankwa-Wiredu & Euler, 2002). Literature shows that there is a positive correlation between bird indices and in-land waterbody availability and this doesn't stand as a single driving factor but is coupled with the availability of invertebrates and cover for the bird species (Kusler, 2004; Rivers *et al.* 1999). Thus, the rivers are very important in the migration of these birds species as they are rich sources of biodiversity and thus can provide enough food in the form of invertebrates and other prey for the Falcons when they arrive in that area.

With regards to invertebrates in Africa, termites are known to be one of the main insect species eaten as food by the Red-footed Falcons (Orta *et al.* 2014). Northern Ghana is characterised by the presence of a large numbers of termites, (evident by large numbers of termite mounds) due to the climate and the typical guinea savanna vegetation cover of the region. (Nsor *et al.* 2018) These termites are used by farmers in this region as a main source of meal and protein for poultry; some specific species are harvested and used as feed for chicks and guinea fowl (Affedzie-obresi *et al.* 2019). Out of the 9 termite genera that have been described in the northern part of Ghana, the most abundant and the one most used as feeds to poultry birds are the *Trinervitermes* and *Macrotermes* (Affedzie-obresi *et al.* 2019). These are mound building termites that are present in most savannas in western Africa (Affedzie-obresi *et al.* 2019; Huis, 2017). The large presence of *Trinervitermes* (Affedzie-obresi *et al.* 2019) might serve as an abundant source of food for the Red-Footed Falcons and thus explaining their preference for such sites since insectivorous birds are very much attracted to termite mounds in Africa (Moe & Eldegard, 2017).

Also, the timing of the Red-footed Falcon's arrival to these particular sites in Ghana seems to coincide perfectly with the nuptial flight of the termites, that is, between April and May (which is when the first rains appear, switching the seasons from dry to wet season) (Huis, 2017) creating an even more abundant and readily available major food source which in other seasons would have been quite hard to access due to the subterranean nature of these termites (Usher, 1975). The first heavy rains arrive in the southern part of the country in late March-early April and seems to move northward later in April and May, as shown in Figures 13, 14 and 15. Before the wet season, there are almost no rains recorded and average rainfall is around 5.4 mm (from 1st February to the middle of March) and there are also no Red-footed Falcons in the country at this time or before that. But from the middle of March to the beginning of April, Sene East (location 1) which is around the middle belt of the country receives the first heavy rains which coincides with the first arrival of the Red-footed Falcons in the country. And as the heavy rains move northwards, the birds also move along, moving from the South-East part of the country (around Sene East) to the North-West towards Kumbungu and Mole National Park (the 3rd and last location in Ghana). There seems to be a linear relationship between the falcons and the arrival of the first rains in Ghana. If this is the case of the Red-footed Falcon in choosing Ghana as stopover site, then it explains why these western African stopover sites are only used in the return flight back to Europe after wintering in Africa during pre-nuptial migration; because the onset of the rainy season and the first rain around the middle of April and beginning of May (VisualCross Weather Data, 2015) helps provide abundant food sources which serve as good fuel For these birds to continue their journey back to Europe across the Sahara. Habitat selection by avian species in northern Ghana depends on many factors, including: landscape structure, nest predation, competition, intraspecific attraction, food availability, climate and weather changes, diseases, and human activities (Nsor *et al.* 2018), thus this indeed seems like a very well calculated migration loop and not just a random act on the side of the falcons.

Another unique characteristic of all the 3 locations which could be a probable driver for the selection of these sites by the Red-Footed Falcon as stop over sites are the generally high biodiversity value and low human presence of the sites. The 3 locations are largely uninhabited and are large hectares of lands that have minimum human disturbances which makes them very good sites for Red-footed Falcons roosting (P. Palatitz *et al.* 2009, 2018). The 1st location in the Sene East District appears to be a large human-uninhabited area with very minimal human activities taking place since there was almost no studies found or done here; also the proximity of this area to another National Park, Digya National park tends to make this uninhabited area a suitable and safe place for the falcons (Pomeroy *et al.* 2006) to transit before their long journey across the Sahara and Mediterranean. Location 2, Kumbungu, also bears similar characteristics to location 1, but though the Kumbungu district is inhabited by humans; the whole Kumbungu area is a very rural area where most of the populace are peasant farmers and thus large areas of the land are undisturbed or are only used for small scale farming (Ghana Statistical Service, 2021). Another potential driving factor for the selection of this particular site is the farming activities that occur here; the inhabitants of this area are known to mainly farm in Maize, rice, millets, sorghum, groundnut, tomatoes and pepper (Ghana Statistical Service, 2021) which are large magnets of insect species which serve as an abundant food source for the Falcons (Bounas *et al.* 2020; P. Palatitz *et al.* 2018) during their relatively short stay in this area. Location 3, the Mole National park, is Ghana's largest protected area with a size of 4,577 km^2 (Dakwa, 2019; Nsor *et al.* 2018) and this area has been a protected area since 1958 which gives it a close to nature characteristics in both floral and fauna because there are no human activities allowed in this location (except for non-consumptive tourism) and this makes it a good choice for migrating species since predator avoidance (Delingat *et al.* 2006; Pomeroy *et al.* 2006; Warnock, 2010) (in this case humans) and cover are very important factors in the selection of sites by migrating birds (Kusler, 2004).

Temperature, windspeed and direction and precipitation are very important factors in the migration of bird species since these can affect the timing and even route of Migration (Fehérvári *et al.* 2014; P. Palatitz *et al.* 2018). The temperature at all 3 sites were fairly constant in all 3 years of review, with the averages of 28.8 °C, 29.8 °C and 29.8 °C for locations 1,2 and 3 respectively. The daily temperatures hovered closely around these means for all the study period and this seemed to be favourable tropical temperature for the falcons whose migratory nature seems to aim to avoid extreme temperatures (A. Palatitz, 2012; P. Palatitz *et al.* 2018). Rainfall patterns were also not significantly different from each other averaging 2.9 mm, 3.0 mm and 2.3 mm in locations 1, 2 and 3 respectively for all 3 years of review. Though April is usually the start of the rainy season in this region (Ghana Statistical Service, 2021), the rainfall pattern for all the 3 sites remained fairly constant with the lowest record of rain being 0 for all 3 sites and spikes of 15.7 mm, 32.5 mm, and 15.6 mm in locations 1,2,3 respectively. The moderate tropical temperature and fairly constant rainfall patterns could be a driving factor for the Red-footed Falcons to select this northern of Ghana since the southern part of Ghana can have very varying levels of precipitation and temperatures and currents from the ocean (Ghana Statistical Service, 2021). The habitat type in coastal areas are also very different; usually termites are not in sandy or soft soils where mould building is difficult and these could explain why the falcons generally avoided the coastal areas.

6. CONCLUSION

Raptors are indicators of the productivity, health and complexity of an ecosystem. These top of the food chain birds are also used as the measurement of environmental health (Mossop, 2009), and thus their presence or absence in a location provides a lot of information about ecological quality of the place (United Nations Environment Programme (UNEP)/Convention on Migratory Species (CMS), 2012). Red-footed falcons make use of locations with fairly constant environmental conditions, large areas that have close to nature characteristics, areas close to Natural water bodies or wetlands and places with large insect presence; as stopover sites and these places need to be maintained. There may be other driving factors that might not have been captured in this study mainly due to lack of literature, thus more ecological descriptive studies need to done in Northern Ghana to aid in future predictions and also protection of the Red-footed Falcon.

The importance of migratory birds cannot be undermined since they provide many benefits such as pollination, seed dispersal, nutrient concentration and even helping fishermen find fish at sea (United Nations Environment Programme (UNEP)/Convention on Migratory Species (CMS), 2012), these migrants also give key information on changes in climates and seasons by their migration timing (Mossop, 2009), and thus they need to be protected and their habitats and stopovers managed and protected even more.

This is why more studies need to be done especially on the stopover sites of the Red-footed Falcons in Africa since changes in landscape for human development and agriculture are on an extreme rise, not forgetting the effects of global warming which is leading to more warmer and drier periods and wildfires which can decimate entire suitable regions for Red-footed Falcons' stopover. The study of Red-footed Falcons; their biology and migration should also be coupled with the study of other very important bird species such as magpies, Rooks and crows since the reproduction and survival of the Red-footed Falcon depends directly on the nest made by these other birds. When crows and Rooks and Magpies are tagged as nuisance animals and are thus shot, poisoned, trees in which they make their nests are cut by agricultural and game managers, it has a direct effect on the survival of Red-footed Falcons and this can be linked to their increasing decline.

Based on the data we cannot prove that night roosts are permanent over years, but due to the small sample size in 2016 and 2017 we could not exclude it.

7. SUMMARY

Stopovers are very important in the lives of all migratory species as they provide the necessary resources needed by the migrants to fuel their journey. Red-footed Falcons are obligatory migrant species that traverse 3 continents in their annual loop-wise migration. During their migration from their mating and breeding grounds in the lowlands of Eurasia to their wintering grounds in the southern part of Africa through the Mediterranean and then back to Europe, the Falcons make use many stopover sites which are supposed to fuel their energy reserves especially across hostile conditions along their flight, such as the Sahara Desert and the Mediterranean Sea. Stopover sites are not chosen at random; but are considered as locations that have been proven to have optimum survival conditions through the evolutionary history of the migratory species. This qualitative study therefore sought to determine the possible driving factors that influence Red-footed Falcons to choose Western African stopovers, specifically in Northern Ghana. The data used for this study was provided by the Red-Footed falcon Conservation Workgroup of MME Birdlife Hungary and was collected on 28 Red-footed Falcons deployed with 5 grams satellite PTTs from 2009 to 2016. Data analysis was restricted to the movements of these birds in Ghana, West- Africa from 19/04/2015 to 25/04/2016 on 5 individuals. The study revealed that, there were 3 important hotspots in northern Ghana that the birds aggregated every year between April and May. The movements of the Birds in Ghana are from the middle Eastern part to the North-West which seems to coincide with the first heavy rains which also arrive in the southern part of the country in late March-early April and moves northward later in April and May, when the wet season starts. Apart from the rains, other possible driving factors at the 3 locations were the large presence of termites in the areas which suggests an abundant food source for these carnivorous raptors, the proximity of the locations to natural water bodies and wetlands, the generally high biodiversity value and low human presence of the sites, and almost constant tropical temperatures at the sites. There is barely any literature on Red-footed Falcons in Ghana; though Ghana seems to provide suitable and important stopover sites to these birds, thus this study can act as a preliminary work to aid in more studies into the IUCN Vulnerable Red-footed Falcon Species in Western Africa to aid in their Global Conservation.

8. ACKNOWLEDGEMENTS

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