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Feeding Behaviour of the Reef Heron (Egretta Gularis Schistacea)

Ahmed Abdalla Yousif Al-Ali

UAEU

جامعة الإمارات العربيـة المتحدة
United Arab Emirates University

United Arab Emirates University

College of Science

Department of Biology

FEEDING BEHAVIOUR OF THE WESTERN REEF HERON (*Egretta gularis schistacea*)

Ahmed Abdalla Yousif Al-Ali

This thesis is submitted in partial fulfilment of the requirements for the degree of Master of Science in Environmental Sciences

Under the Supervision of Professor Waleed Hamza

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Declaration of Original Work

I, Ahmed Abdallah Yousif Al-Ali, the undersigned, a graduate student at the United Arab Emirates University (UAEU), and the author of this thesis entitled *"Feeding Behaviour of the Western Reef Heron (Egretta gularis schistacea)*", hereby, solemnly declare that this thesis is my own original research work that has been done and prepared by me under the supervision of Professor Waleed Hamza, in the College of Science at UAEU. This work has not previously been presented or published, or formed the basis for the award of any academic degree, diploma or a similar title at this or any other university. Any materials borrowed from other sources (whether published or unpublished) and relied upon or included in my thesis have been properly cited and acknowledged in accordance with appropriate academic conventions. I further declare that there is no potential conflict of interest with respect to the research, data collection, authorship, presentation and/or publication of this thesis.

Student's Signature: ____________ Date: 6/11/2018

Advisory Committee

1) Advisor: Waleed Mohamed Reyad Hamza Aly El-Din

Title: Professor

Department of Biology

College of Science

2) Co-advisor: Sabir Bin Muzaffar

Title: Associate professor

Department of Biology

College of Science

Approval of the Master Thesis

This Master Thesis is approved by the following Examining Committee Members:

1) Advisor (Committee Chair): Waleed Mohamed Reyad Hamza Aly El-Din

   Title: Professor

   Department of Biology

   College of Science

   Signature ____________ Date 6/11/2018

2) Member: Dr. Aaron Henderson

   Title: Assistant Professor

   Department of Biology

   College of Science

   Signature ____________ Date 6/11/2018

3) External Examiner: Dr. Hashim Ahmed Al-Sayed

   Title: Associate professor

   Department of Biology

   University of Bahrain, Bahrain

   Signature ____________ Date 6/11/2018

This Master Thesis is accepted by:

Dean of the College of Science: Professor Ahmed Murad

Signature ______________________ Date 29/ 1/2019

Acting Dean of the College of Graduate Studies: Professor Ali Al-Marzouqi

Signature Ali Hassan Date 30/ 1/2019

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Advisory Committee

1) Advisor: Waleed Mohamed Reyad Hamza Aly El-Din

Title: Professor

Department of Biology

College of Science

2) Co-advisor: Sabir Bin Muzaffar

Title: Associate professor

Department of Biology

College of Science

Abstract

Western Reef Heron (*Egretta egularis*) is a very common coastal resident bird species in the Arabian Gulf. In UAE, the subspecies “*schistacea*” also known as Indian Reef Heron occurs in mangroves inlets and other coastal and inland water bodies along the southern and eastern coast of the country. The present study aims to investigate the bird’s food, feeding behavior, morphs and its relationship with the habitat in Al-Zora Protected Area (Ajman - UAE) by establishing a feeding behavior ethogram and monitor its feeding frequency and its correlation with biotic and abiotic features of the study site. Foraging success rate and foraging efficiency were calculated by observing feeding and successful feeding attempts for 1 minute every 5 minutes for 5 hours every other day for 15 days in two seasons (summer and winter) noticing the two morphs individual count, tidal changes, and time of the day. Data shows that that Western Reef Heron uses 13 feeding behavior with difference in their utilization between seasons and age groups. Feeding is influenced by primarily the tidal movement and not time of the day. Foraging success Ratio is not only different between seasons but also between the two morphs and between age groups. The significant differences in strikes between White and Dark morph opens a perplexing question of crypsis and natural selection possibility with a dilemma between the idea and its statistical analysis. there might be a relation between the sub-species and what morph is predominant. Overall, feeding behavior analysis in this study indicate a very promising possibility for Western Reef Heron to be a highly important bio-indicator species for mangrove and creek inlet ecosystem and its linkage between top avifauna waders predators and marine benthic community.

Keywords: Western Reef Heron, feeding, behavior, foraging efficiency, foraging success ratio, bio-indicator, morph, mangrove habitat.

Title and Abstract (in Arabic)

السلوك الغذائي لغُرنُوق الصّخْر الهندي

الملخص

يعتبر غرنوق الصخر الهندي (إيغريتا غولاريس سكيستاكي) طائر بحري مقيم شائع جدا في دول الخليج العربي. في دولة الإمارات العربية المتحدة، يعتبر غرنوق الصخر الهندي طائر مقيم و شائع جدا في الأخوار و غابات أشجار القرم و السواحل و المستنقعات الداخلية على الساحلين الشرقي و الغربي للدولة .تهدِفُ هذه الدراسة الى التحقق من السلوك الغذائي و تناسب مظهَرَي -مورفولوجيا- غرنوق الصخر الهندي و علاقته بالبيئة في محمية الزورا -عجمان، الإمارات العربية المتحدة- عبر استحداث جدول للسلوك الغذائي و مراقبة تذبذب و تكرار عملية الغذاء و علاقتها بالعناصر البيئية الحية و الغير حية في موقع الدراسة حيث تم حساب نسبة نجاح البحث عن الغذاء و كفاءته عبر مراقبة و رصد محاولات البحث عن الغذاء لمدة دقيقة واحدة كل خمس دقائق خلال خمسة ساعات كل يومين لمدة 15 يوما خلال موسمين (الصيف و الشتاء) مع الأخذ بعين الاعتبار تعداد الأفراد بإختلاف المظهر -المورفولوجيا- (غامق أو أبيض)، حركة المد و الجزر، و الوقت.

تشير البيانات بأن غرنوق الصخر الهندي يستخدم ثلاث عشرة سلوكا غذائيا مع إختلاف في توظيف و استخدام السلوك بين المواسم (الصيف و الشتاء) و الفئة العمرية و تتأثر عملية البحث عن الغذاء بحركة المد و الجزر و لا علاقة لها بالوقت تماما. كما تختلف نسبة نجاح البحث عن الغذاء ليس فقط بين المواسم بل بين المظهرين -المورفولوجيا- (الغامق و الأبيض) و الفئة العمرية كذلك. الاختلاف المعتبر بين محاولات الاصطياد بين المظهرين -المورفولوجيا- (الغامق و الأبيض) يفتح بابا مربكا للتساؤل عن أهمية التخفي و الاختيار الطبيعي في تطور هذا النوع بالرغم من وجود معضلة ربط تلك الفكرة مع الإحصاءات لتعداد المظهرين. قد يكون هناك علاقة بين الفصيلة الفرعية و المظهر المهيمن.

بشكل عام، تحليل بيانات الغذاء و السلوك الغذائي في هذه الدراسة يشير الى إمكانية كون غرنوق الصخر الهندي مؤشر حيوي لجودة البيئة بشكل كبير و علاقته في ربط المفترسات من الطيور الخواضه بالكائنات البحرية القاعية.

مفاهيم البحث الرئيسية: غرنوق الصخر، غذاء، سلوك، فعالية التغذية، نسبة نجاح التغذية.

Acknowledgements

I would like to thank Ajman Government for preserving this amazing wetland and declaring it as a protected area. I also thank Ajman Municipality for their support in granting access to the Protected Area and their constant follow up with any additional requirement whenever it was needed (especially Shaikha Alshehh). I also thank Solidere International for their permission to access the protected area through their establishment as a Developer of areas adjacent to Al-Zora Protected Area. My thanks extend as well to Emirates Bird Records Committee EBRC for the help in providing bird observation data for the site. Those entities help was highly valuable to produce this study.

Dedication

To my parents, beloved sisters and nieces (especially Ghaya), my brother Abdulla, and my supervisors Waleed and Sabir. Following the footsteps of the beloved late Shaikh Zayed Bin Sultan Al Nahyan whose love of nature and environment overwhelmed my heart

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Chapter 1: Introduction

1.1 Overview

Economic activities such as coastal development, desalination plants, dredging, and other human activities create a variety of anthropogenic environmental stressors (Alharbi et al., 2012; Watson-Leung et al., 2017). Direct economic activities, like oil exploitation, tourism, coastal development, recreational fishing and beach-side sports collectively affect the coastal zone (Hamza & Munawar, 2009). This burden of anthropogenic stressors may lead to substantial damage to specific habitats, especially when continuous impacts occur. Wetlands in general and especially mangrove habitats are one of the most disturbed habitats (Etezadifar & Barati, 2013). They can be easily impacted by anthropogenic stressors as they attract people for fishing or leisure activities or even investors to commence lodges or hotels as seen in so many wetlands around the globe. Impacts on the wetlands can hardly be noticed immediately. However, long-term impact of these stressors could lead to non-recoverable degradation and consequently to environmental disaster (Penha-lopes et al., 2011).

UAE environmental laws prohibit any practice that leads to environmental degradation, including degradation of coastal and offshore marine environments, and promote the conservation of biodiversity (UAE-Marine Protection law, 1999).

Mangrove ecosystem may be associated with different aquatic and terrestrial habitats based on the nature of land elevation compared to the sea level and on its exposure to tidal effect (Mitsch & Gosselink, 2015). Some of those habitats are intertidal forested wetland which dominated by mangrove trees and a variety of associated biota. Intertidal mud, sand, and salt flat include both soft and hard-bottom and mangrove trees that support relatively high biodiversity (Ramsar, 2012). It hosts avifauna, fishes, and marine invertebrates throughout the entire structure of the forest and they are believed to have evolved from rainforest trees over 50 million years ago and adapted to become salt tolerant trees. They host not only terrestrial species but also marine species that have become re-adapted to terrestrial environments like species of semi-terrestrial crabs (Duke, 1995).

Birds from the Ardeidae family (like heron and egrets) are examples of waders that are associated with mangrove ecosystems. Healthy heron populations can indicate high quality foraging area as they rely primarily on fishes as their preferred food. Additionally, herons and egrets are top predators that can therefore be considered as indicators for biological richness. Their population density would suggest a productive food web reflecting a healthy environment (Hafner & Fasola, 1992). Therefore, understanding species feeding behavior is important. Studies show that food is a major factor affecting nest site location in herons. Canopy-nesting birds prefer to nest close to feeding areas in favor of more protected nesting sites (Hafner & Fasola, 1992). Etezadifar and Barati (2015) found that food impacts chick growth.

Del Hoyo et al. (2017) described Western Reef Heron as a medium size heron from Ardeidae family which contains around 62 species. It is very closely related to the Little Egret *Egretta garzetta* but differs in terms of ecological niche in mangroves and on reefs. It is around 55 to 65 cm in length and weighs between 280 and 710 g with a wingspan of 86 to 104 cm. It has a distinctive head with long thin neck and bill and yellow legs. As a dimorphic bird, it has a dark and a white morph. Globally, Western Reef Heron is recognized to have three subspecies, namely: *E. g. gularis* occurring in west Africa coastline from Mauritania to Gabon; *E. g. schistacea* occurring in East Africa coastline, Red Sea, Arabian Gulf, and West and South and South East India and Sri Lanka in winter; *E. g.dimorpha* occurring in Madagascar and

Surrounding Islands, Seychelles, East Africa specifically in Somalia to North Mozambique. Differences between the three subspecies varies to include bill curve (more in *E. g. gularis* and *E. g. schistacea*), head shape (more angular in *E. g. gularis* and *E. g. schistacae*), neck (longer and thinner in *E. g. gularis* and *E. g. schistacae*), size (*E. g. schistacae* is the largest), color in dark morph (*E. g. dimorpha* paler than *E. g. gularis* while *E. g. Schistacae* is the palest). It feeds on a variety of resources but mostly aquatic like fishes, amphibians, mollusks. Other than that, it might as well feed on terrestrial insect, spiders, worms and small birds. It is an active feeder with a variety of feeding techniques. It is listed to aggressively defending its feeding territory and aggregate to some extent (in *E. g. gularis*). Its breeding seasons overlap to some extent. *E. g. gularis* breeds from April to July or October while *E. g. schistacae* start earlier from February to October. *E. g. dimorpha* on the other hand breeds from April or July to October. Western Reef Heron can hardly be a migratory bird. *E. g. gularis* and *E. g. schistacae* are mostly resident dispersive or locally migrants where it moves between areas of short distance. *E. g. dimorpha* is considered to be strictly sedentary (Del Hoyo et al., 2017).

The Western Reef Heron subspecies in the UAE is *E. g. schistacae* which is sometimes called the Indian Reef Heron. Pedersen et al. (2017) has described it as a costal resident and inland visitor with a very common abundance. Jennings & Krupp (2010), estimates 500 to 1000 pairs in the UAE (3000 pairs in total throughout Arabia) (Jennings & Krupp, 2010). Both morphs were recorded in coastal areas, mudflats and mangrove forests with inland records as well (Pedersen et al., 2017).

1.2 Literature Review

Food plays a major role in the viability of species. Feeding sites with abundance of food items are very important for chick survival and growth. Furthermore, species feeding behavior can contribute more importantly to the understanding of ecology. They can provide insight for proper management in ecologically significant areas specially with Ardeidae family species. Herons and Egrets can be a very useful indicators of biological richness specially in wetlands because their abundance suggests a highly productive food web and a healthy aquatic environment (Hafner & Fasola, 1992). Species of the Ardeidae family may have feeding behavior that can vary according to the availability of food variation (Kushlan, 1976). Kushlan described 28 types of feeding behavior for 12 species of heron in North America. Their behaviors are split into three categories according to major movement and described with a corresponding number to their listing in Kushlan published paper in 1976. Category 1 “Stand or Stalk Feeding” includes 6 behaviors: 1. Stand and Wait where a heron would stand motionless waiting for a prey to approach. 2. Bill Vibrating is when a crouched poster standing heron submerge its bill tip and rapidly opens and closes it creating a disturbance that could attracts the prey. 3. Baiting is most popular in striated heron where the bird places a bait in the water and stand and wait for the prey to approach. 4. Standing Flycatching where a heron does a typical Stand and Wait but catches flying insect instead of waiting for a prey in the water. 5. Gleaning feeding behavior is picking up prey from objects above the ground or water. 6. Walking Slowly is when a heron moves slowly to stalk a prey. Usually walking slowly behavior ends up with Stand and Wait just before the heron striking otherwise it is considered another behavior in a different group.

Category 2 “Disturb and Chase” includes 12 behaviors. 7. Walk quickly is when the heron disturbs fishes by his quick walk and chase those fishes and strike while flushing them. 8. Running is moving in a running motion from a place to another either where prey movement was seen or running chasing a disturbed prey. 9. Hopping is somehow similar to Running but instead of running to another prey potential place, the bird fly shortly to that place. 10. Leapfrog Feeding is hooping behavior added to it striking for prey instantly upon landing. 11. Wing Flicking is when a bird flicks it wing or wings repeatedly while walking slowly and then stop to look for any disturbed prey resulting from the flicking movement. Usually it resumes walking slowly after an un-successful wing flicking behavior. 12. Open-Wing Feeding is fully extending one or both wings while standing, walking slowly or quickly or running. 13. Underwing Feeding is when a heron walks while doing open wings feeding and hiding its head under its wing shadow and strike disturbed prey. 14. Canopy feeding is when a heron spreads its wings and brings them forward creating a canopy like above its head and start looking for prey. 15. Foot Stirring is when a heron extends one leg forward and vibrate either the foot or the leg from standing or walking and stir the area to attract prey. 16. Foot Raking is when a heron extends one leg forward and vibrate either the foot or the leg to rake the substrate with its toes. 17. Foot Probing is extending the leg to probe the substrate, vegetation or any kind of litter. 18. Foot Paddling is rapidly moves the feet up and down like a paddle motion to disturb prey.

Category 3 “Aerial and Deep-Water Feeding” includes 10 behaviors. 19. Hovering when a heron hovers over a single spot and reaches down with its bill to catch a prey. 20. Hovering Stirring is a bit more complex Hovering where the heron hovers above the water and extend one foot to pats the surface of water or stirs vegetation or floating debris while maintaining striking for pray from hovering. 21.

Dipping is when a heron flies very low above water surface and catches prey while flying without stopping or hovering. 22. Foot Dragging is when a heron flies very low above water surface and its foot and drag them while flying without stopping and caches prey while flying without stopping or hovering. 23. Aerial Flycatching is when a heron pursues and caches insect while flying. 24. Plunging is when a heron dives head first to catch prey from flight or hovering. 25. Diving is when a heron dives head first to catch prey from standing on the shoreline or perched on hanging branches over the water. 26. Feet First Diving is when a heron alights on water feet first from hovering and immediately stabs or strikes for prey. 27. Jumping is when a heron alights on water feet first from perched and immediately stabs or strikes for prey. 28. Swimming Feeding is when a heron catches close by prey while swimming in water usually after wading into a deep-water area. feeding behavior can vary depending on prey types and availability and ecological conditions. None of the heron species uses all 28 behaviors (Kushlan, 1976).

The United Arab Emirates (UAE) is an arid climate country, where all features in marine and shoreline environment are valuable due to the eco-services that they provide. Western Reef Heron is a medium size heron from the genus *Egretta* (Del Hoyo et al., 2017) along with three more species recorded in the United Arab Emirates from the genus *Egretta.* The subspecies *E. g. schistacea* might be the only subspecies in the UAE and known as Indian reef heron (Etezadifar & Barati., 2013; Pedersen et al., 2017). The bird is 55-65 cm in length and weight 280-710 grams with a wingspan of 86-104 cm. Subspecies *E. g. schistacea* specifically is 60 cm in length, 90 cm wingspan (Porter & Aspinall, 2010). The bird is dimorphic with a greater abundance of individuals with white morph (10-50% of the population) (Del Hoyo et al., 2017; Jennings & Krupp, 2010). Apart from the difference in morph colors, both morphs have pale brown to yellowish bill which tend to become reddish in breeding season, dark-olive brownish legs with yellow feet and yellow color extend up the feet sometimes almost to the knee joints but not above that (Porter & Aspinal, 2010) (Figure 1.2.1).

Figure 1.2.1: Western Reef Heron dark morph individual. Standing on a mudflat just before a rising tide notice light feathers on the neck extending to the breast and the very light feathers on the back indicating a typical breeding plumage.

The bird inhabits coastlines and rarely extend inland occurring usually in salt and brackish water with very few records of deep inland observation in water treatment plants (Jennings & Krupp, 2010). It prefers standing still or perched very close to water and wait for its prey to pass by as it captures it with a quick extension of the neck. It is mostly observed in muddy shallow coastlines specially sandbars where it is easier for the bird to look at shallow water and wade to find its prey. Food choice as recorded in Saudi Arabia is primarily fishes of 25-50 mm long while in Kuwait, mudskipper (*Oxudercidae* Family species) is another food choice maybe due to the abundance. It has been rarely documented to eat a dead scorpion in an inland location, Inland bird might aim to freshwater amphibian or invertebrate if abundant (Jennings & Krupp, 2010). In 2006, The bird's abundance in the United Arab Emirates was estimated to be between 500 to 1000 pairs breeding in areas, mostly mangroves, that are away from human inhabitance. Breeding season extend from February to August with little variation between eastern and western Arabia (Jennings & Krupp, 2010).

As mentioned earlier, Western Reef Heron range is Western and Eastern Africa, Arabia, India and Sri-Lanka and uncommon in Southern Europe. Apart from that, it is vagrant elsewhere especially in North America where there are very few records east coast of the United States (in 1983 at Nantucket Island – Massachusetts, in 2006 at Kittery and Portsmouth – Maine, in 2007 at New York) and two records in Canada (2005 – 2009 Newfoundland, 2006 Cape Breton County) (eBird, 2018) (Figure: 1.2.2).

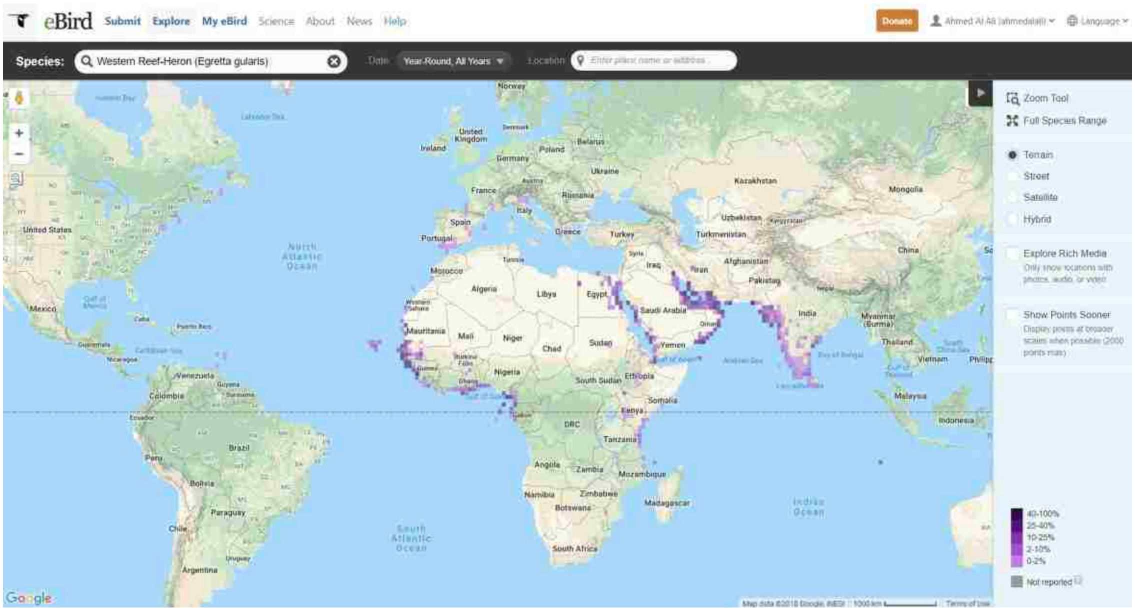

Figure 1.2.2: Western Reef Heron range and sightings abundance. Image provided by eBird (www.ebird.org) and created August 2018.

The only description of Western Reef Heron feeding behavior found in literature to the date is from William E. Davis (1985) descripting it from its vagrant sighting in 1983 in Nantucket island, Massachusetts (studied for 3 days only between 25 and 27 of July). Other than that, all descriptions and ethograms of species from Ardeidae family were from North America and did not include Western Reef Heron (as it is not common in that range). That is why there were no Western Reef Heron specific ethogram or description of its feeding behavior.

1.3 Research Problem

Time Activity Budget for feeding Western Reef Heron (how Western Reef Heron allocate time for feeding) is an important study to understand the bird life cycle. This objective needs a Western Reef Heron feeding behavior ethogram. Globally, species feeding behavior studies particularly species from Ardeidae Family are limited to 16 species as studied by Kushlan (1976) and Abigail et al. (2013). None of the studied 16 species is the Western Reef Heron. Thus, we established an ethogram for Western Reef Heron and examine recorded behaviors in this study against the list of feeding behavior previously recorded in the Ardeidea family species. Time activity budget was used to assesses correlation between foraging activity and time of the day to conclude if time of the day is a factor influencing Western Reef Heron feeding activity.

Foraging Efficiency (FE) by calculating foraging success rate (FSR) is a method that enabled us through statistical analysis to quantify foraging behavior and examine factors -like season, Tide, age group, time of the day- influence on foraging activity.

There are very limited scientific statistical references for Western Reef Heron different morphs distribution (Dark and White) in the region. Jennings & Krupp (2010) mentioned in their book “Atlas of the Breeding Birds of Arabia” that generally there are more white than dark morphs of Western Reef Heron. However, other references from around the world and shows different results. This indicate that morph ratio and frequency might not be consistent in one region. examining Jennings & Krupp statement on Western Reef Heron morphs distribution among population in the Study Area will become a valuable input when it comes to understanding the species distribution across the region. Furthermore, examining differences between the two morphs in foraging efficiency was carried for further inferences. In general, the lack of Western Reef Heron feeding behavior ethogram studies as well as the gab in knowledge regarding feeding behavior of the UAE subspecies have considered an ecological issue that deserve to be studied.

Chapter 2: Methods

2.1 Study Area

Al-Zora protected area, located in Ajman Emirate in the UAE (25°25'33"N 55°28'58"E), was selected as the study area, where mangrove ecosystem and salt marshes are represented according to Mitsch and Gosselink (2015) habitat description. Al-Zora protected area is managed by the Government of Ajman Emirate in the United Arab Emirates. It has an area of 1.95 km^2. The mangrove ecosystem is a suitable fish nursery and it attracts resident and migrant waterbirds. Mangrove trees (*Avicennia marina*) is the only mangrove tree species dominating the site. They provide a suitable shelter and breeding grounds for birds that prefer thick mangrove forests close to a tidal creek. More than 118 bird species have been recorded from this area (Pedersen et al., 2017). Public access was restricted due to a development project of an ecotourism resort and a golf course. Special permission to conduct this thesis fieldwork was granted from Ajman Municipality which is currently managing the protected area and they are aiming to increase the focus of research conducted to better understand the area and provide necessary information for conservation planning and decision-making.

The area has been announced as a Ramsar wetland of international importance in September 2016, which is comprised of multiple wetland types as classified by Ramsar convention. Intertidal forested wetland, Intertidal mud, sand, salt flats, Sand, shingle, or pebble shores, Saline, brackish lakes, and Marsh pools are just examples of wetland habitats listed in the site Ramsar Information Sheet (Ramsar, 2016). The protected area resides at the very end of Ajman Creek which is a tidal creek linking mangrove ecosystem and salt marsh habitat to the coastal water body. Grey mangrove surrounds the border of the tidal creek. The creek bed is stony in the middle of the inlets and soft muddy on the border, due to the deposition of sediments by the low flow rate at the edges.

The site is dense in mangrove with a lot of small channels and inlets extending from the tidal creek. The end of the tidal creek is an open flat land with raised sand hill in the East, mud flat with scattered mangrove small trees and seedlings followed by salt marsh North and South. Large dense mangrove trees bordering the tidal creek in the West.

This area was chosen based on two factors. after approaching multiple authorities who looks after protected areas in the UAE, we received an approval from Ajman Municipality granting us permission to conduct this study in Al-Zora Protected Area. Apart from that and from previous studies suggestions. This is one of the best feeding sites for some species from Ardeidae family representing shallow permanent marshes (Hafner & Fasola, 1992). It is the most area where tidal changes are noticeable especially at high and low tides. Figure 2.1.1 and Figure 2.1.2 show map and satellite imagery of the Protected Area.

Figure 2.1.1: Al-Zora protected area general location. Source: Google Earth

Figure 2.1.2: Al-Zora protected area satellite imagery. Source: Google Earth

In order to manage the study area, it has been designed as a rectangle running north to south to cover all possible ecosystem and habitat. The rectangle area is 70,909 square meters and is evenly split into 8 quadrates 8,863 square meters each. The 4 Eastern quadrates labeled N1, N2, N3, N4 South to North where N indicate near while the 4 Western quadrates labeled F1, F2, F3, F4 South to North where F indicate far. Figure 2.1.3 shows map of the study area and the designated study quadrates.

Figure 2.1.3: Study area. Source: Google Earth

2.2 Research Design

The research was designed following Abigail et al. (2013) in assessing foraging activity using foraging success ratio and foraging efficiency (Rayer, 1998; Abigail et al., 2013). The study covered two seasons (winter and summer) to look at the effect of high verses low temperature influence on feeding. Covering a month in each season was to include a full lunar cycle (29-30 days cycle period) to ensure including the whole tidal flow as Del Hoyo and his team (2017) suggested that in marine areas, feeding rhythms are dictated by tides. The two factors (tides and seasonal variations) were hypothesized as significant factor on the bird feeding behavior. We defined the winter season to be between the months December and January of 2016/2017 while we defined the summer season to be in August 2017 following breeding season which extends from April to June (Jennings & Krupp, 2010). This had also allowed examining differences in attempts between adults and young birds in summer season. Duration was chosen based on temperature history from the National Center of Meteorology in the United Arab Emirates from the analysis of data between 2007 and 2016 where highest temperature was recorded in August while lowest temperature was recorded in December and January (NCM, 1976). Figure 2.2.1 shows air temperature data for Ajman between 2007 and 2016.

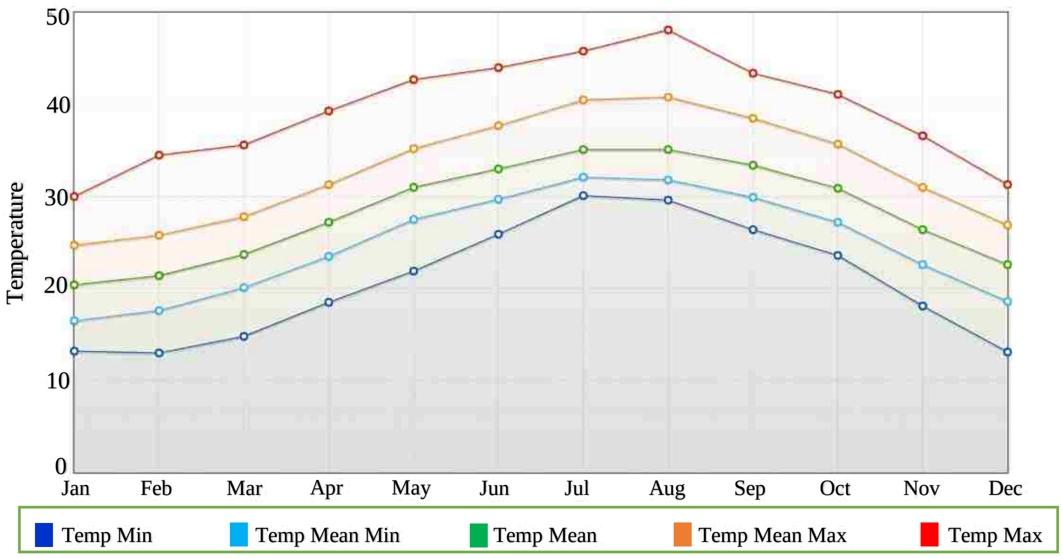

Figure 2.2.1: Temperature recorded in Ajman between 2007 and 2016. NCM, 1976

Throughout the month in every season, observations were recorded every other day as tidal changes can hardly be noticed in consecutive days. Observations were recorded in a window of 5 hours as 1 - minute observations in every 5 - minutes interval. Total of 15 days of observation were recorded in winter and summer, with 61 independent observations each day and 915 records each season, which equals to 1830 records for the whole study period. Observation was made from a fixed vantage point in the eastern center of the study area (to cover the whole area while maintaining a good view of the birds) using an optical scope and binocular (Kowa TS-611 Spotting Scope 60mm with 27X Eyepiece and Nikon 12x42 Binocular). Whenever activity was present, defined by walking around searching for prey (Abigail et al., 2013) or actively feeding from Stand and Wait positioning and not preening or roosting, the observation was recorded vocally using a sound recorder. Basic information and some relevant field notes were recorded in the field log sheet while the voice notes were transcribed later. A DSLR camera with a Telephoto lens was used whenever needed (Canon 7d Mark ii with 600mm Lens).

2.3 Data Collection

Due to the nature of this study and its objectives, data had to be collected from the field. Critical and complementary data were defined based on their impact on the research questions either to confirm or to investigate them especially tidal influences on the bird feeding behavior. Critical data were defined based on the deduction of the feeding behavior of the bird while complementary data were defined as data that may impact the food or feeding behavior of the bird. Fish data was used by sampling fishes from a catch using a 30 cm height net with 5 meter length and a 1 cm eye opening. Due to the nature of the site which is very fine substrate making the mud almost imposable to wade in, sampling was from an adjacent site close to the study area.

2.4 Avifauna Community Recording

In order to standardize field observations and to insert the present study records within the global electronic free access data base (Citizen Science project-bird.com), the present study has adopted the technique known as "Point count method" where, species abundance and population densities are recorded based on the given list of this technique (Zhang & Zhang, 2012). The list of observations used in this technique is satisfying multiple statistical inferences like Relative Abundance and other complementary statistical analysis. It also allows possible comparisons between previous, actual and future observations within the same location (Figure 2.4.1).

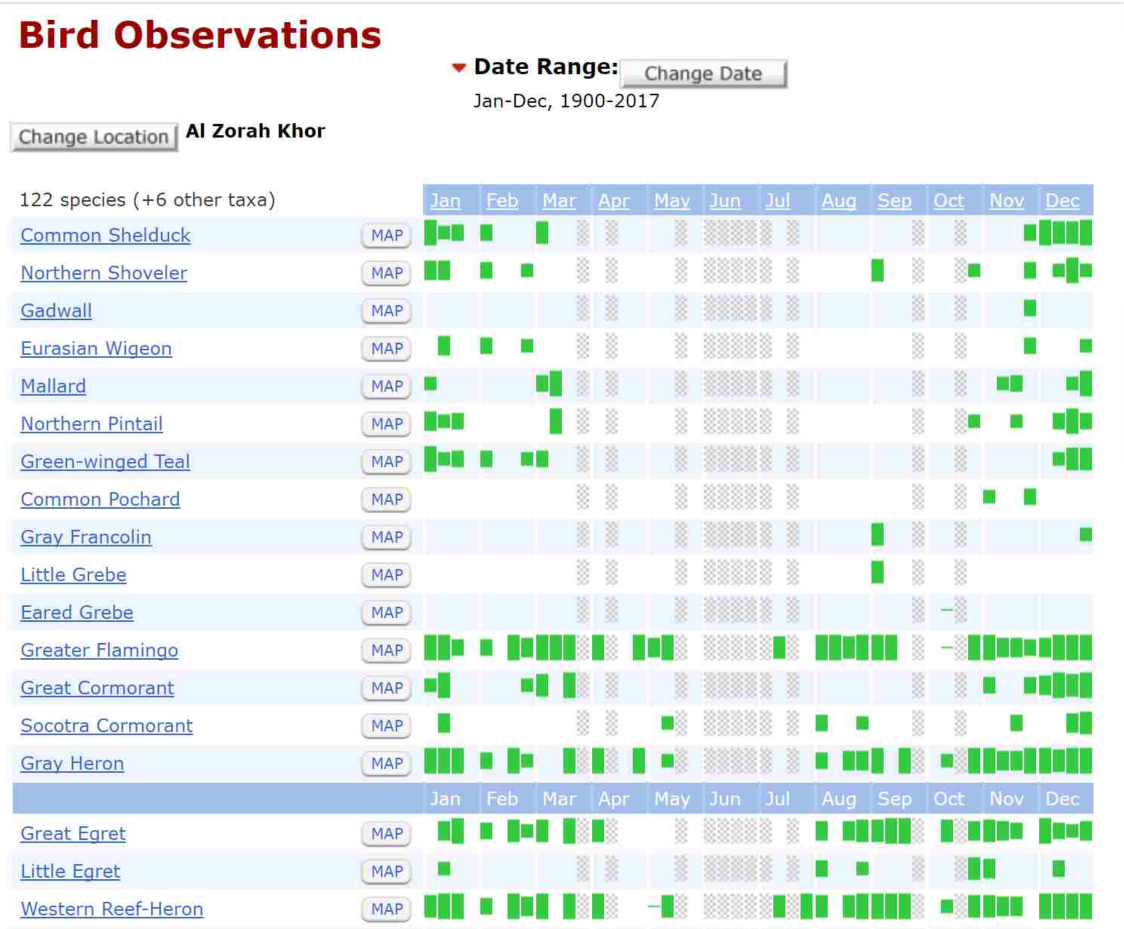

Figure 2.4.1: Bar chart for Al-Zora site (citizen science project). Image provided by eBird (www.ebird.org) and created, 2017.

2.5 Observation Procedures

The observation started at 07:30 a.m. for one minute. At the start, a single feeding bird is randomly selected to be observed from the group of the feeding birds. Idle (preening or roosting) or not feeding birds were ignored. As a bird is selected, the voice recorder was started and the observation through the optical scope is described for one minute. All observational information was loudly pronounced to assure accuracy. Order of information is usually followed as in the data sheet template but not necessarily followed especially if critical data were obvious and needed recording (example; strikes and feeding behavior). After one minute, the observation was stopped, and the rest of time was used to study the biodiversity and quantify other species. The next observation would start at 07:35 a.m. for one minute following the same procedure. The following observation was at 07:40 a.m. and so on. Observations were systematically recorded until the last observation at 12:30 p.m. The observations would be concluded at 12:31 p.m. with few environmental data recorded in the field log (air temperature during the study period and end tidal period). The voice notes were transcribed afterward to the result datasheet and any media was archived accordingly. The same procedure was followed throughout the whole study period.

2.6 Statistical Analysis

Using IBM SPSS Statistics (Version 25) statistical software (1989-2017), Multiple descriptive and statistical tests were conducted based on the objectives requirements while trying to extrapolate as much quantitative variables as possible despite the nature of some variables that were highly difficult to collect without disturbing the birds or the site. Those variables (water level for example) were collected qualitatively -categorical- for the sole purpose of avoiding disturbance and therefore increase the probability of accuracy in the critical data collection.

Foraging success ratio (FSR) was calculated by dividing successful strikes (successful feeding attempts) over the total number of strikes (feeding attempts) using the following formula $FSR = \frac{Successful\,Strikes}{Total\,Strikes}$ following the process of Abigail et al. (2013). Foraging Efficiency (FE) is the percentage representation of FSR. Descriptive statistics on Tide and Western Reef Heron presence and feeding activity was assessed by calculating observations on Falling and Rising tides. Western Reef Heron was either [Present/Absent] and [Feeding/Not Feeding] and then calculate the percentage of every case by the formula $p = n\frac{100}{915}$ where n is the count of cases and 915 is the total number of observations in every season. FSR was calculated for every age group in every season separately. Then, a grand total table was designed to include both seasons records by considering mean value using the following formula $FSR\ Age\ Groups = \frac{FSR}{n} * 100$.

To test the differences in Strikes in both dark and white morphs, Strikes were calculated at first for each season separately and then added up to a total number. Because observation was at random, different number of observed birds was recorded in the two morphs (Dark and White). Thus, mean value was calculated by the formula: $Mean\ of\ Strikes = \frac{Total\ strikes}{Number\ of\ observations}$

All data sets were tested for normal distribution (Normality testing) and Shapiro-Wilk test result was used to decide the proper test method required for the statistical analysis. four tests were conducted to test the data set for significance. Non-Parametric 2 Related Sample test was used to assess the following: 1- Foraging success ratio between summer and winter observed feeding population. 2- Differences in morph population (Dark and White) in summer season. 3- Strike differences in the two morphs (Dark and White). The other test used was Paired Sample Test to examine the differences in morph population (Dark and White) in winter season.

Chapter 3: Results

3.1 Statistical Analysis

The present study observations have shown that, summer avifauna community consisted of 53 species while winter avifauna community consisted of 70 species. Lists of species recorded in summer and winter seasons can be found in the Appendices chapter. Out of all observations, 338 had Western Reef Heron present in the study area (18.5%). Out of the observations of herons, 114 observations were of feeding birds (33.7%). Western Reef Heron individual records in summer season summed up to 148 with highest single day count of 29 individuals while winter season records had a total count of 479 with highest single day count of 57 individuals. Figure 3.1.1 illustrate Number of Western Reef Heron recorded every observation day for summer and winter seasons.

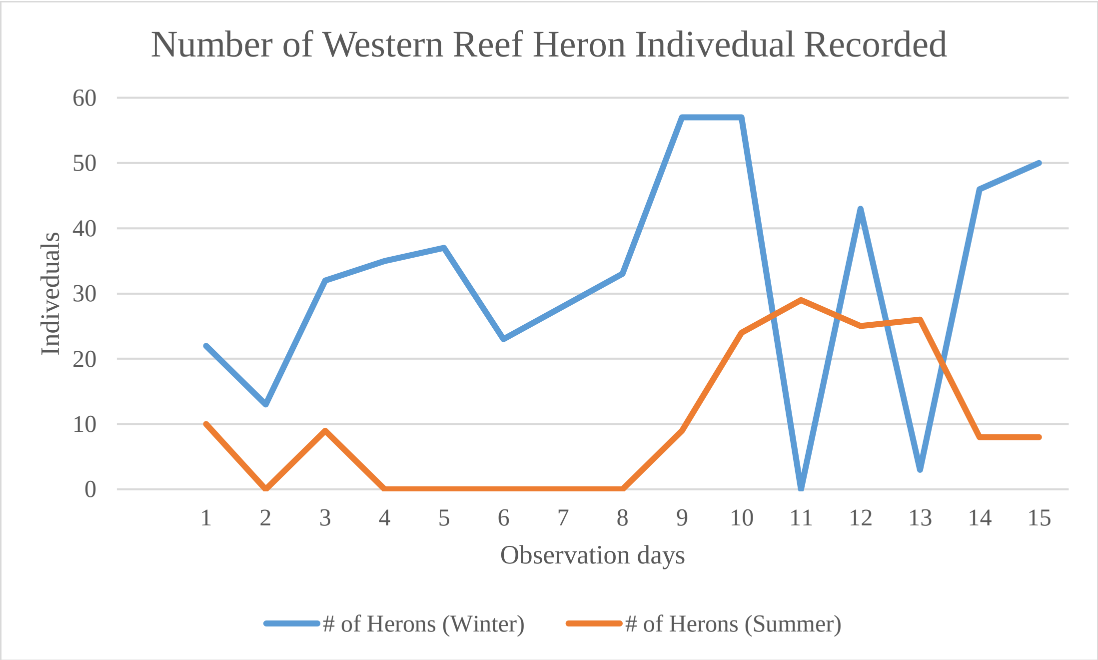

Figure 3.1.1: Number of Western Reef Heron recorded every observation day for summer and winter seasons

Lowest tide in summer was 0.2 m while in winter was 0.8 m. Highest tide in summer was 1.7 Meters and in winter was 2 Meters all within the observation time frame (from 7:30 a.m. until 12:30 p.m.) (Figures 3.1.2 and 3.1.3).

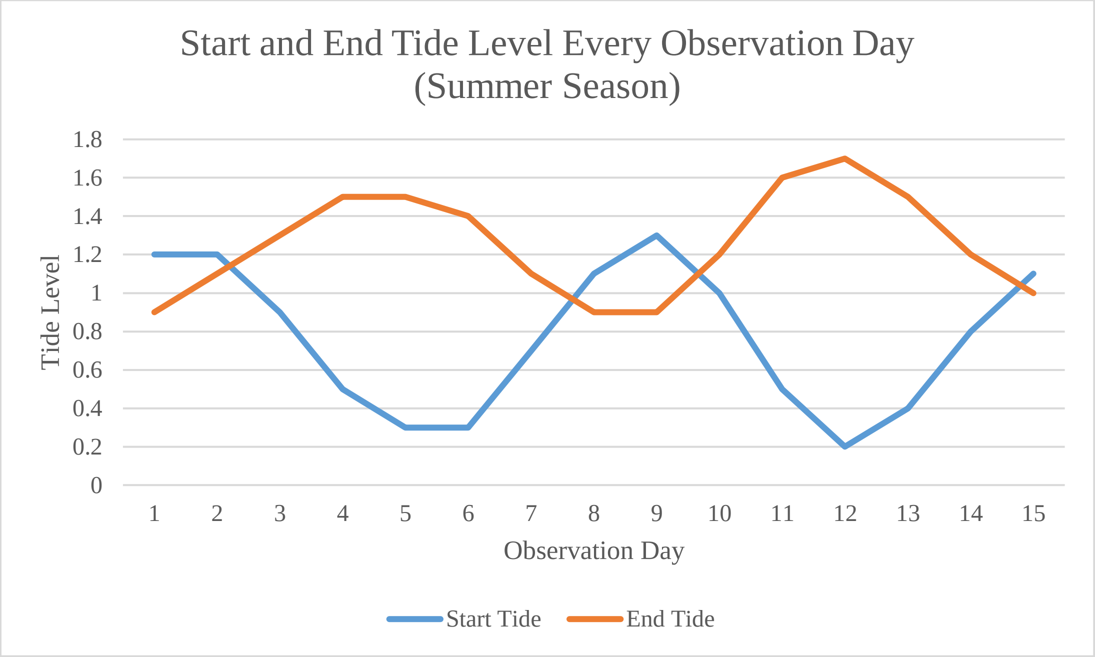

Figure 3.1.2: Start and end tide level every observation day in summer season

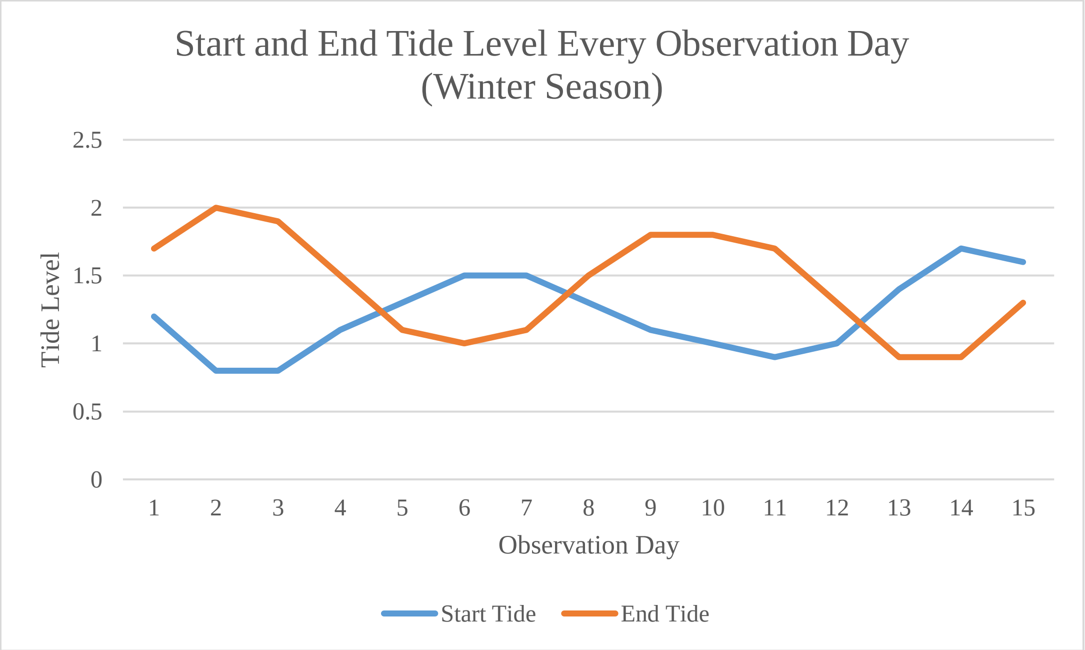

Figure 3.1.3: Start and end tide level every observation day in winter season

Only 122 observations of Group feeding birds recorded where Western Reef Heron and other birds including other Western Reef Heron individuals feed in a single area close to each other either. Out of the 122 observations, only 16 observations were of conspecific or interspecific aggression. List of group-feeding species and aggression against species can be found in the appendices (App 2). The majority of Western Reef Heron were found to be feeding while they were wading in the water and very little observations were recorded for Western Reef Heron individuals feeding while walking on salt marsh habitats.

All birds were found to feed from water and no observation were recorded for herons trying to feed from salt marsh organisms except for a single incident where a heron on a high tide looked like it was snatching insects from above a mangrove tree leaves. The bird was far away for any definite confirmation of insect presence. Figure 3.1.4 shows a group of herons aggregate waiting for feeding chance.

Figure 3.1.4: Group of Western Reef Heron of both morphs and age groups at the start of rising tide awaiting prey to start feeding.

3.2 Time Activity Budget and Ethogram

Overall, the present study has confirmed that 13 feeding behaviors were used by Western Reef Heron out of the 28 previously recorded feeding behaviors by Kushlan (1976). Those behaviors were: Stand and Wait (Figure 3.2.1), Bill Vibration, Standing Flycatching, Walking Slowly, Walking Quickly, Running, Hopping, Leapfrog Feeding, Open-Wing Feeding, Canopy Feeding (Figure 3.2.2), Foot Raking, Dipping (Figure 3.2.3), Feet First Diving. Table 3.2.1 shows recorded feeding behaviors in Western Reef Heron from the 28 feeding behavior listed by Kushlan (1976).

Table 3.2.1: Ethogram of feeding behaviors used by Western Reef Heron

#	**Behaviors in Kushlan literature.**	**Recorded**		#	**Behavior**	**Recorded**	
		Yes	**No**			**Yes**	**No**
1	Stand and Wait	X		**15**	Foot Stirring		X
2	Bill Vibration	X		**16**	Foot Raking	X	
3	Baiting		X	**17**	Foot Probing		X
4	Standing Flycatching	X		**18**	Food Paddling		X
5	Gleaning		X	**19**	hovering		X
6	Walking S1owly	X		**20**	Hovering Stirring		X
7	Walking Quickly	X		**21**	Dipping	X	
8	Running	X		**22**	Foot Dragging		X
9	Hopping	X		**23**	Aerial Flycatching		X
10	Leapfrog Feeding	X		**24**	Plunging		X
11	Wing Flicking		X	**25**	Diving		X
12	Open-Wing Feeding	X		**26**	Feet First Diving	X	
13	Underwing Feeding		X	**27**	Jumping		X
14	Canopy Feeding	X		**28**	Swimming Feeding		X

Figure 3.2.1: Stand and Wait. Typical category a stand (stalk) feeding behavior.

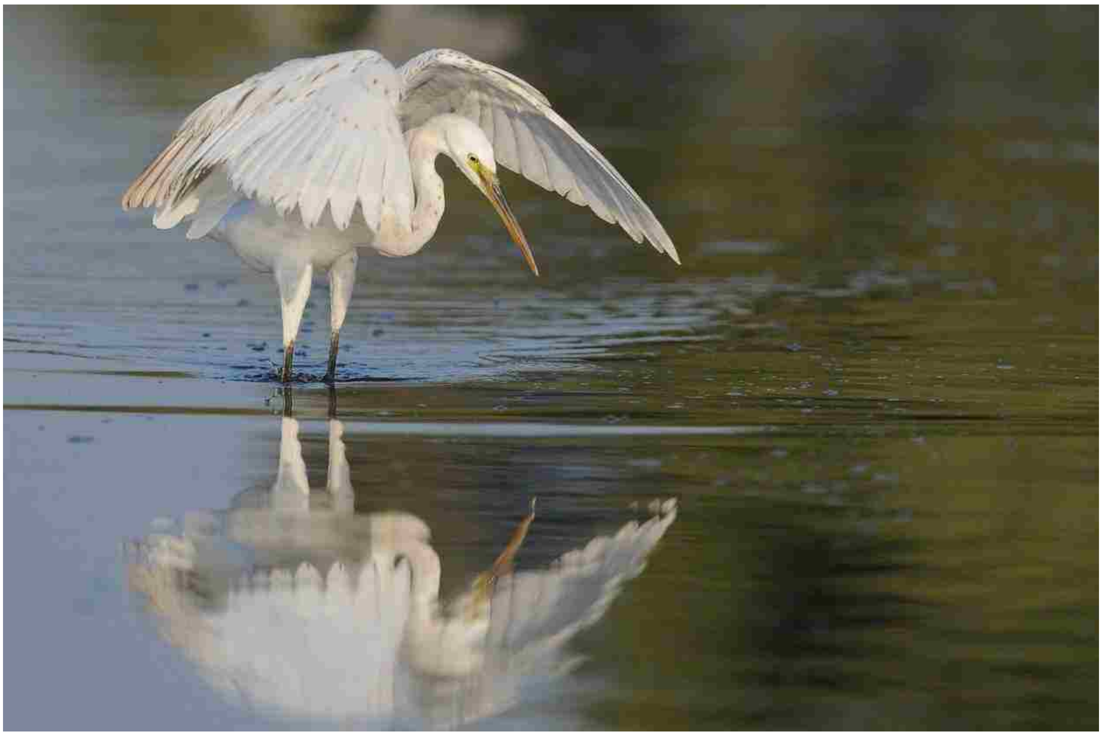

Figure 3.2.2: Canopy feeding, a rare feeding behavior observer only once

Figure 3.2.3: Dipping, a rare feeding behavior observed only once

Those 13 feeding behaviors are spread through the three categories. Category A: Stand (Stalk) had 4 behaviors recorded which are Stand and Wait, bill vibration, standing flycatching, and walking slowly. Category B: Disturb and Chase had 7 behaviors recorded which are walking quickly, running, hopping, leapfrog feeding, open-wing feeding, canopy feeding, and foot raking. Category C: Aerial and Deep Water Feeding had only 2 behaviors recorded which are dipping and feet first diving.

Table 3.2.2: Recorded feeding behaviors in three categories

	Categories		
#	**A: Stand (Stalk)**	**B: Disturb and Chase**	**C: Aerial and Deep Water Feeding**
1	Stand and Wait	Walking Quickly	Dipping
2	Bill Vibrating	Running	Feet First Diving
3	Walking Slowly	Hopping	
4	Standing Flycatching	Leapfrog Feeding	
5		Open-Wing Feeding	
6		Canopy Feeding	
7		Foot Raking	

3.3 Foraging Time Budget

Influence of time of day on foraging was assessed visually using the Figures 3.3.1, 3.3.2, and 3.3.3. Listing the result of feeding activity and time of the day in a graph helped checking if there is a systematic approach of foraging or is it random. In doing so, there was a clearer picture on what biotic factors like fishes or other birds or abiotic factors like tide, temperature, and season influencing Western Reef Heron foraging activity. Figures 3.3.4 and 3.3.5 shows strike and successful strike for a prey.

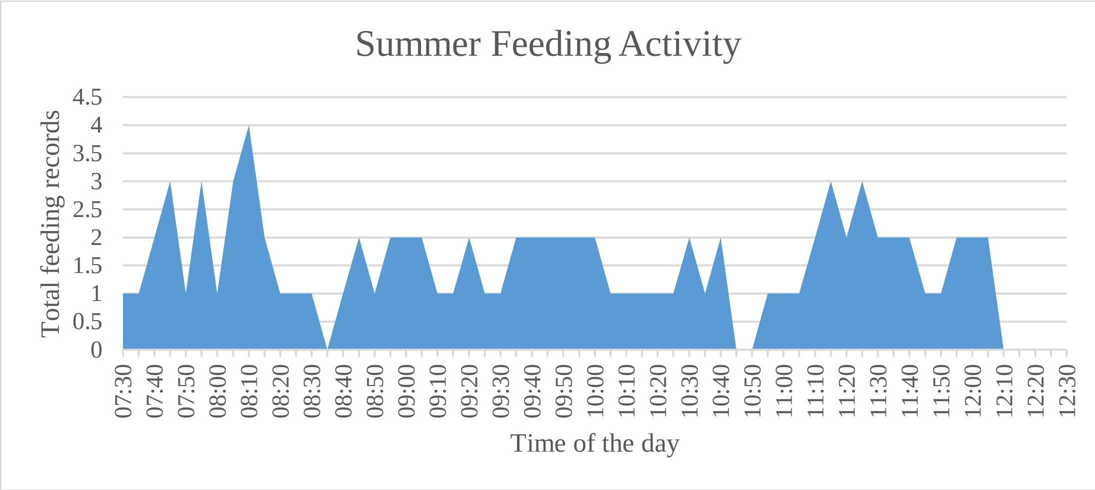

Figure 3.3.1: Summer feeding activity (time of the day x feeding activity recorded) across the whole season's observation period

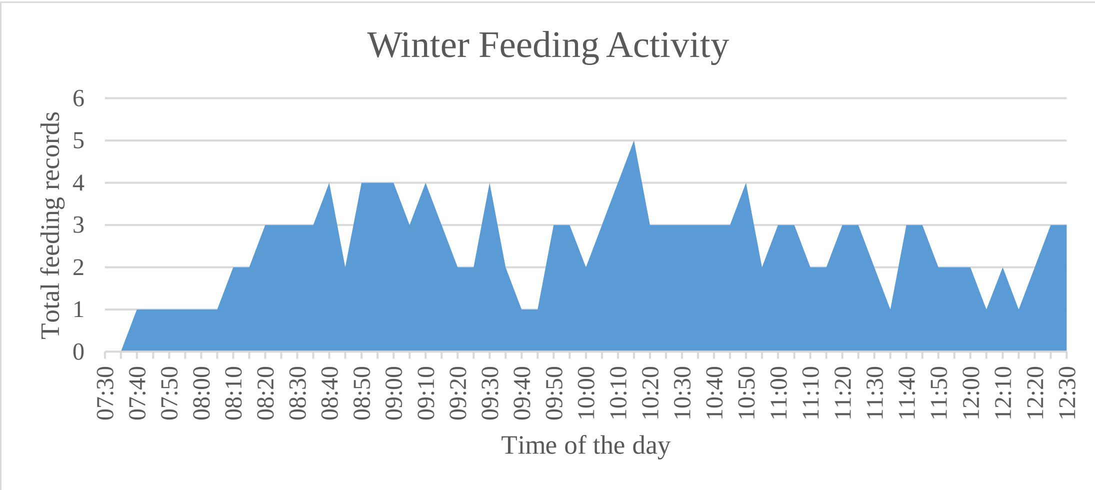

Figure 3.3.2: Winter feeding activity (time of the day x feeding activity recorded) across the whole season's observation period

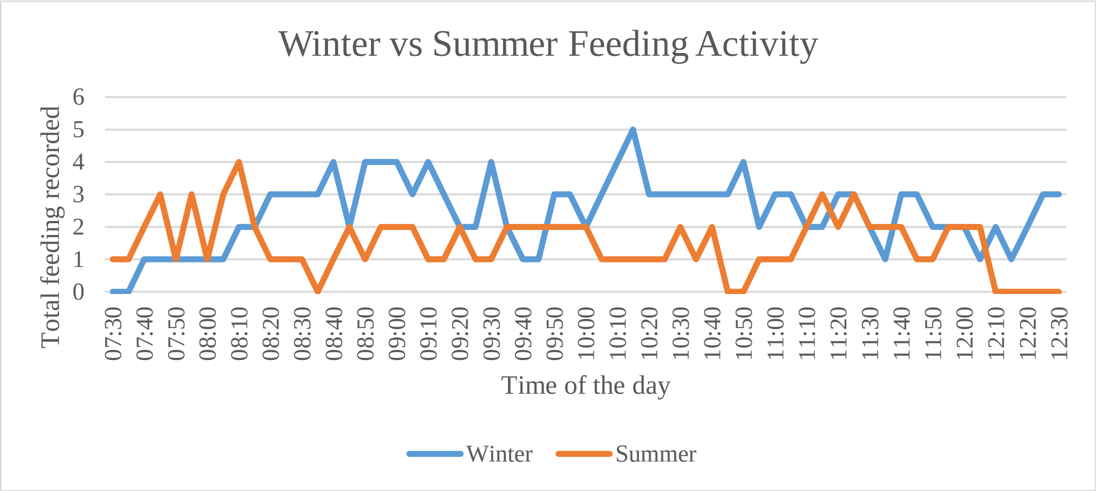

Figure 3.3.3: Winter vs. summer feeding activity (time of the day x feeding activity recorded) across the whole season's observation period.

Figure 3.3.4: Strike for a prey

Figure 3.3.5: Successful strike. Catching a prey (small fish)

3.4 Foraging Success Ratio (FSR) and Foraging Efficiency (FE)

Table 3.4.1 lists the mean value of FSR and FE in both seasons. FSR was lower in summer compared to winter. However, the difference was not statistically significant (Wilcoxon Rank Test, p=0.462).

Table 3.4.1: Mean value of summer and winter FSR and FE

	Summer	Winter
Sample Size	89	149
FSR	0.136	0.152
FE	13.3 %	17.4%

3.5 Foraging Success Ratio across multiple factors

Examining other factors which might influence foraging activity across both seasons was made separately as listed below.

3.5.1 Tidal Influence on Western Reef Heron Presence and Feeding Activity

Two Criteria were assessed (Table 3.5.1.1) in examining the tidal influence on Western Reef Heron presence and feeding activity which were 1- Present (on high and low tide) 2- Feeding (In high and low tide) 3- Present but not feeding (on high and low tide).

Table 3.5.1.1: Winter and summer case statistics sorted based on seasons

Season	Tide	Case	# of Observation	Percentage
Winter	Rising	Present	229	25.0
		Feeding	120	13.1
		Present & Not Feeding	109	11.9
	Falling	Present	110	12.0
		Feeding	29	3.2
		Present & Not Feeding	81	8.9
Summer	Rising	Present	182	19.9
		Feeding	62	6.8
		Present & Not Feeding	120	13.1
	Falling	Present	114	12.5
		Feeding	27	3.0
		Present & Not Feeding	87	9.5

Another table with a total number of activities observed in both seasons was commenced to highlight the activity in general instead of seasonal activities (Table 3.5.1.2).

Table 3.5.1.2: Winter and summer case statistics sorted based on tide

Tide	Case	# of Observation	Percentage
Rising	Present	411	22.5%
	Feeding	182	9.9%
	Present & Not Feeding	229	12.5%
Falling	Present	224	12.2%
	Feeding	56	3.1%
	Present & Not Feeding	168	9.2%

For comparison, data was sorted by the case and Percentage was illustrated by the different tides (Table 3.5.1.3) while Figures (3.5.1.1), (3.5.1.2), and (3.5.1.3) illustrate cases separately.

Table 3.5.1.3: Winter and summer tide statistics sorted based on presence/feeding case.

Case	Tide	Percentage
Present	**Rising**	22.5%
	Falling	12.2%
Feeding	**Rising**	9.9%
	Falling	3.1%
Present & Not feed	**Rising**	12.5%
	Falling	9.2%

In many cases, birds who just arrives to the study area and in the middle of the day was observed to stay put and preen or sometimes sleep. In other occasion they were feeding. Timing of the feeding was assessed visually using Figures 3.5.1.1, 3.5.1.2, and 3.5.1.3. influence of time of day on foraging was related to the Western Reef Heron presence of feeding activity. It was related on tide and if it was rising or falling.

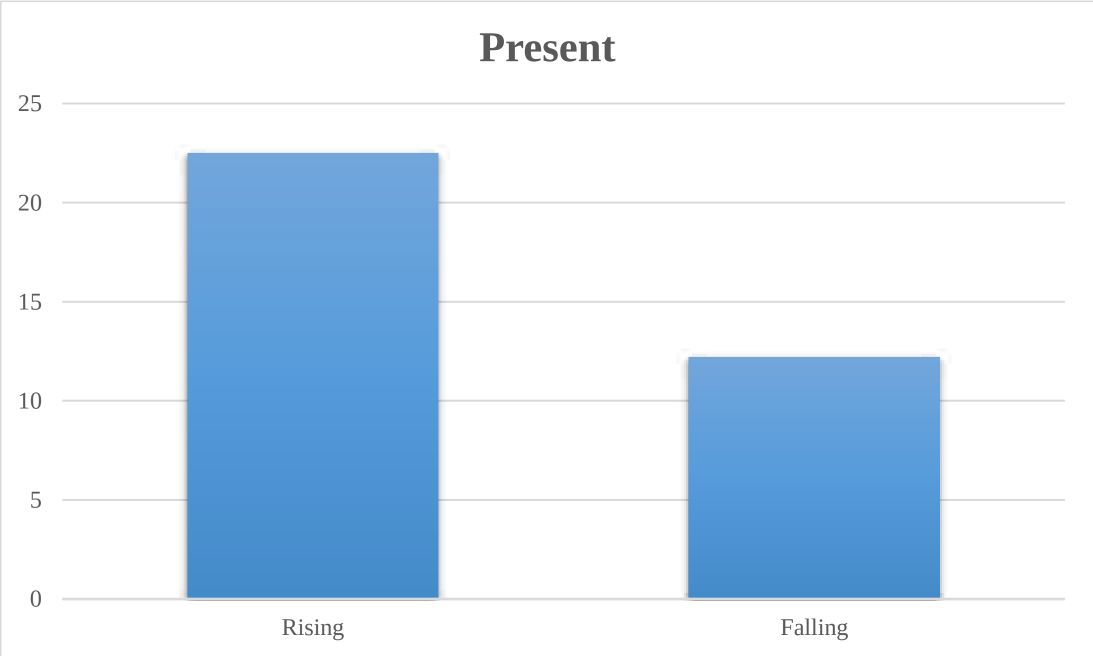

Figure 3.5.1.1: Percentage of records of present birds on rising and falling tide

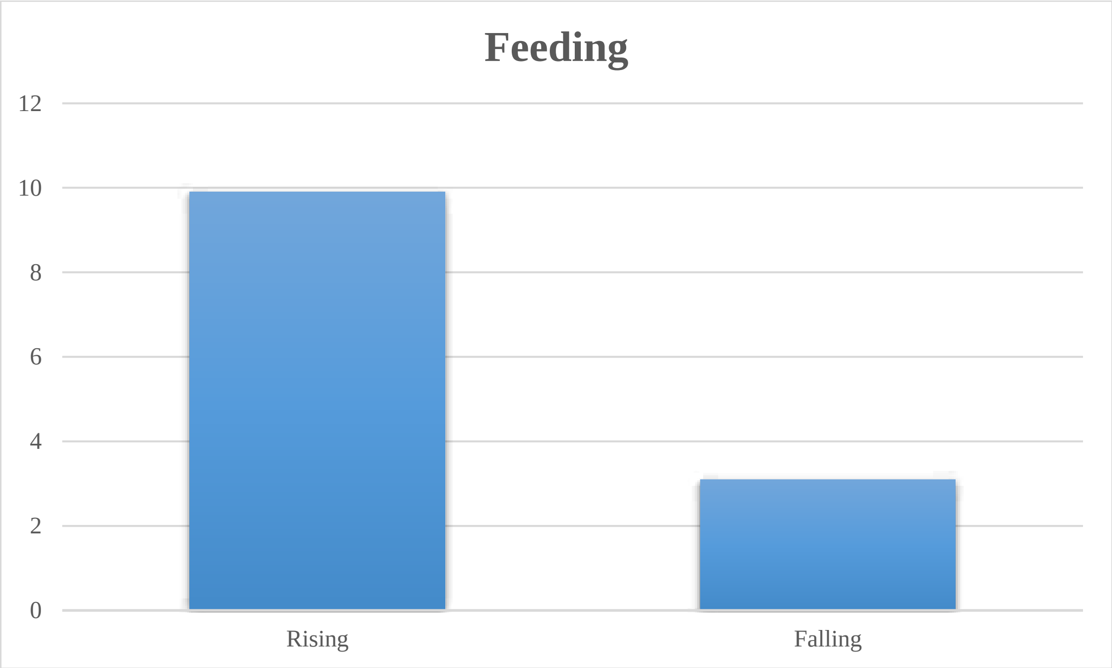

Figure 3.5.1.2: Percentage of records of feeding birds on rising and falling tide

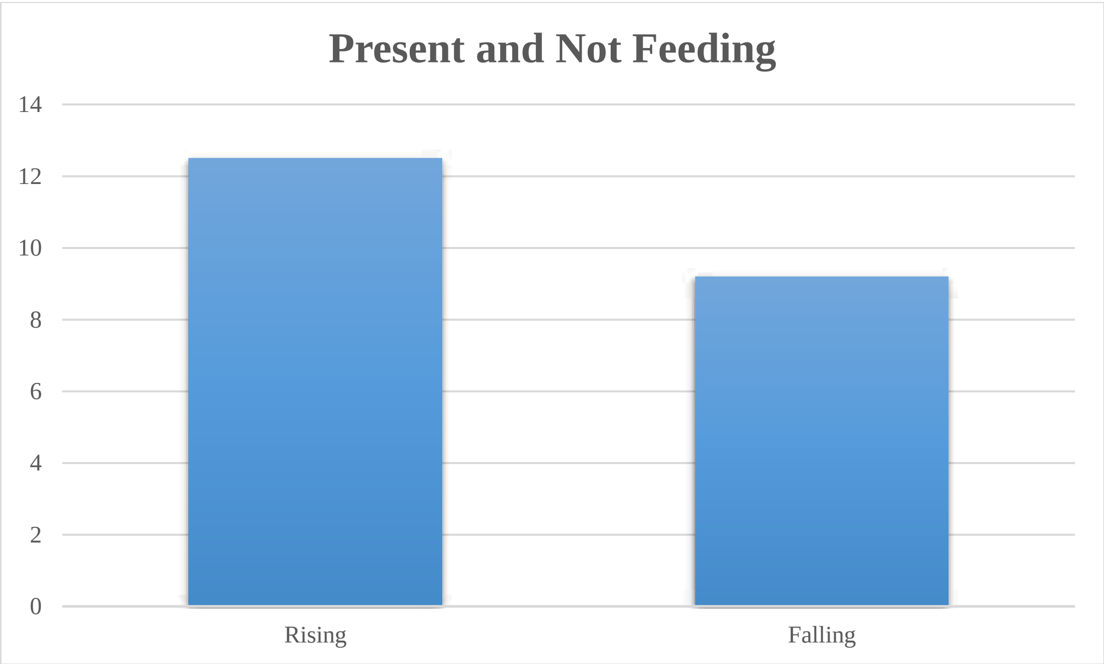

Figure 3.5.1.3: Percentage of records of present and not feeding birds on rising and falling tide.

3.5.2 Foraging success Ratio across Age Groups.

Age groups were different between the two seasons due to breeding time. In summer, four age groups were recorded. Juvenile, Sub-Adults, Adults, and Adults in breeding plumage. In winter, and due to the above-mentioned reason. There were no Juveniles. Tables 3.5.2.1 and 3.5.2.2 list FSR for every age group in summer and winter.

Table 3.5.2.1: Foraging success ratio across the two seasons by age group

Age Group	Summer FSR	Winter FSR
Juveniles	0.41	Not Available
Sub-Adults	0.32	0.62
Adults	0.81	0.18
Adults in breeding plumage	1.64	0

Summer and winter data had to be combined to sum up age group FSR. Because observation was at random, number of age group individual observation varies. Thus, a standardization formula had to be used for this table -described in section 2.6 Statistical Analysis). Table 3.5.2.2 lists FSR for every age group from the total observation in both seasons.

Table 3.5.2.2: Grand total foraging success ratio by age group

Age Group	**FSR**
Juveniles	0.41
Sub-Adults	0.25
Adults	0.15
Adults in breeding plumage	0.96

3.5.3 Foraging Success Ratio Across Dark and White Morphs

FSR was calculated for every morph in every season (Table 3.5.3.1). A grand total table included both season morph birds was established as well (Table 3.5.3.2). From the tables, FSR was higher in white morph in both seasons and overall.

Table 3.5.3.1: Foraging success ratio across the two seasons by morph

	Summer	Winter
Dark Morph	0.18	0.24
White Morph	0.49	0.44

Table 3.5.3.2: Grand total foraging success ratio by morph

	Dark Morph	White Morph
FSR	0.10	0.27

3.6 Foraging Area Utilization

Feeding area was recorded with every feeding activity. The number of cases was added and graphed for every season (Figures 3.6.1 and 3.6.2). The graphs show that in summer and winter, quadrate F2 was heavily demanded on when feeding followed by quadrate F1 then quadrate N1. Both seasons were combined together in one graph (Figure 3.6.3) to illustrate the similarities and differences together. Finally, a total foraging area utilization was graphed to highlight the most area utilized by Western Reef Heron (Figure 3.6.4) which indicate a more demand on specific quadrates (F2, F1, N1) than the rest of quadrates. It might be because of the food availability which attract small fishes (the prey) or the quadrate condition is more suitable for Western Reef Heron feeding than the other quadrates (Kushlan, 1976). Studying the differences between those quadrates can provide an insight of why Western Reef Heron prefer certain sites for feeding.

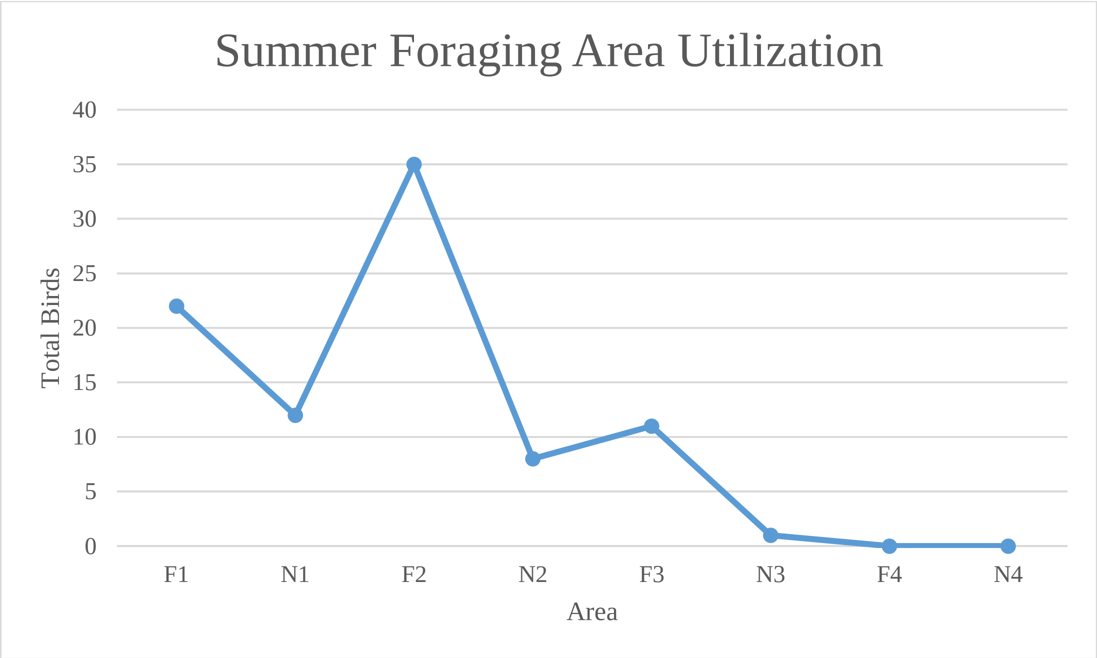

Figure 3.6.1: Summer foraging area utilization by Western Reef Heron

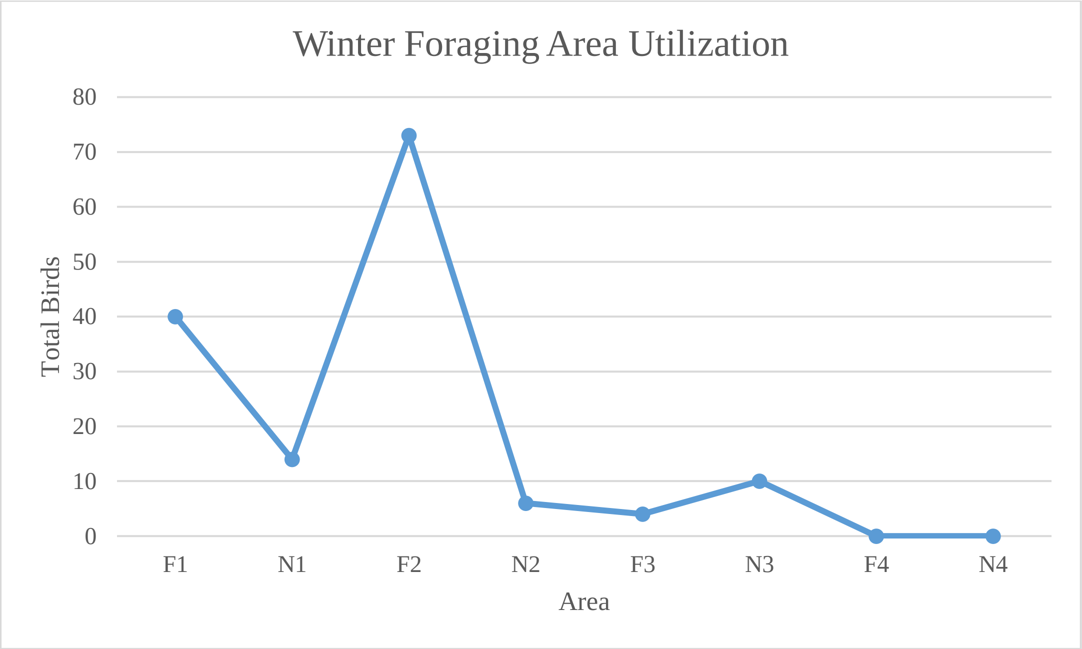

Figure 3.6.2: Winter foraging area utilization by Western Reef Heron

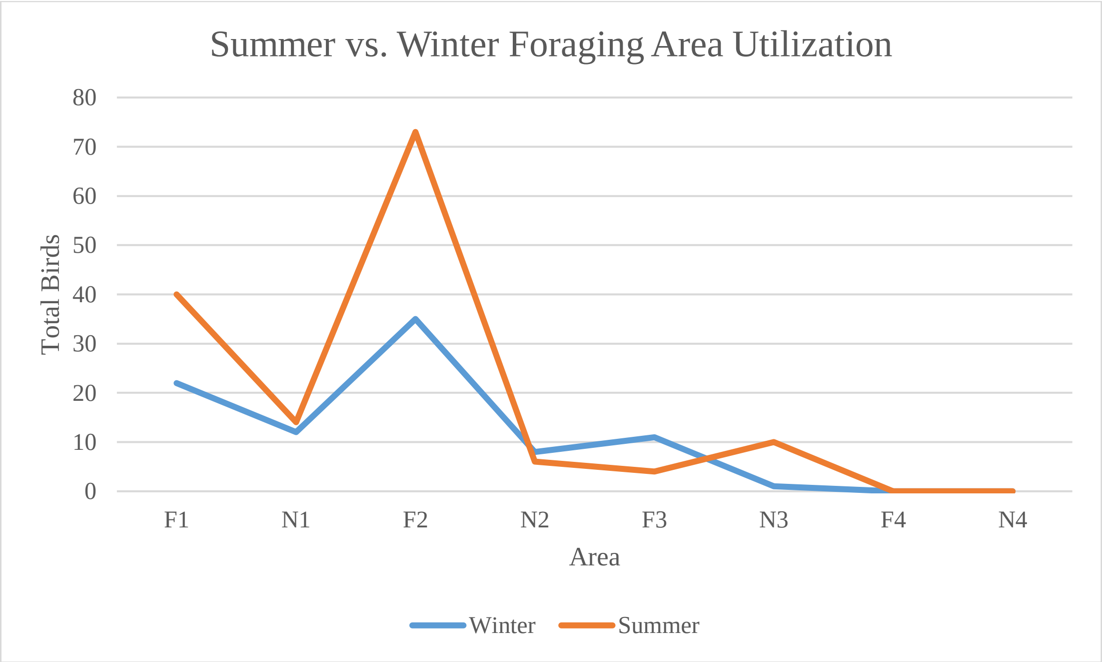

Figure 3.6.3: Summer vs. winter foraging area utilization by Western Reef Heron

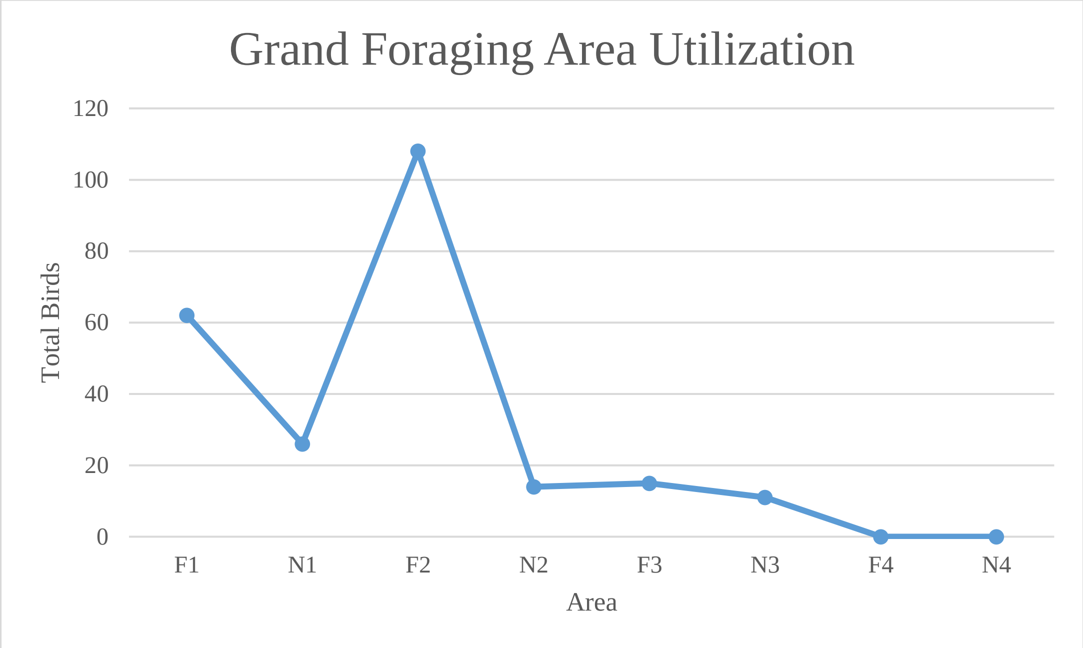

Figure 3.6.4: Grand foraging area utilization by Western Reef Heron

3.7 Foraging Behavioral Utilization

Tables 3.7.1 and 3.7.2 shows the frequency and percentage of total usage of every recorded feeding behavior in both seasons. Data shows that the most two used behaviors in summer are Walking Quickly and Stand and Wait (respectively) while in winter, the most two used behaviors are Stand and Wait and Walking Slowly (respectively). A Grand total table is listed below with data from both seasons (Table 3.7.3) shows that the most three used behaviors are Stand and Wait, Walking Slowly, and Walking Quickly (respectively).

Table 3.7.1: Summer foraging behavioral utilization

Summer		
Behavior	**Frequency**	**Percentage**
Stand and Wait	92	28.1%
Standing Flycatching	9	2.7%
Walking Slowly	93	28.4%
Walking Quickly	62	18.9%
Running	11	3.3%
Hopping	3	0.9%
Leapfrog Feeding	7	2.1%
Open-Wing Feeding	36	11%
Foot Raking	14	4.2%
Total Frequency	327	

Table 3.7.2: Winter foraging behavioral utilization

Winter		
Behavior	**Frequency**	**Percentage**
Stand and Wait	158	38.9%
Bill Vibration	2	0.4%
Walking Slowly	151	37.1%
Walking Quickly	36	8.8%
Hopping	2	0.4%
Leapfrog Feeding	1	0.2%
Canopy Feeding	1	0.2%
Foot Raking	48	11.8%
Dipping	1	0.2%
Feet First Diving	1	0.2%
Total Frequency	406	

Table 3.7.3: Grand total foraging behavioral utilization

Grand Total		
Behavior	**Frequency**	**Percentage**
Stand and Wait	250	38.8%
Bill Vibration	2	0.3%
Standing Flycatching	9	1.2%
Walking Slowly	244	37.9
Walking Quickly	98	15.2
Running	11	1.7%
Hopping	5	0.7%
Leapfrog Feeding	8	1.2%
Open-Wing Feeding	41	6.3%
Canopy Feeding	1	0.1
Foot Raking	62	4.6%
Dipping	1	0.1%
Feet First Diving	1	0.1%
Total Frequency	643	

Number of behavior usage between age groups was assessed by calculating how many behaviors does each group uses, how many times does it used it, and what percentage out of the whole usage does it represent. In winter season, breeding plumage adult and young birds are not present in the population as Western Reef Heron breeding season almost extend to summer, Thus, it was only Sub-Adult and Adult birds were present in winter. Sub-Adult birds used 4 feeding behavior which are -in descending order- Stand and Wait, Walking Slowly, Foot Raking, Walking Quickly. In Foot Raking, splitting the behavior between the two legs (Right and Left), Sub-Adults used their right leg more than their left leg. Adult birds used 11 feeding behavior which are -in descending order-: Stand and Wait, Walking Slowly, Foot Raking, Walking Quickly, Open-Wing Feeding, Bill Vibration, Hopping, Leapfrog Feeding, Canopy Feeding, Dipping, Feet First Diving. In Foot Raking, splitting the behavior between the two feet (Right and Left), Adults had no preference using one foot more than another. Interesting enough, both foots were used equally. In shared behavior usage, both Sub-Adult and Adult birds used the same descending order of behavior usage which are: Stand and Wait, Walking Slowly, Foot Raking, Walking Quickly. Yet, Sub-Adult birds used less behaviors that Adult birds (Table 3.7.4).

Table 3.7.4: Feeding behavior frequencies and percentage of different age group in winter season

Winter				
Behavior	Frequency		Percentage	
	Sub-Adult	Adult	Sub-Adult	Adult
Stand and Wait	48	110	41.03	38.06
Bill Vibration	0	2	0.00	0.69
Walking Slowly	43	108	36.75	37.37
Walking Quickly	12	24	10.26	8.30
Hopping	0	2	0.00	0.69
Leapfrog Feeding	0	1	0.00	0.35
Open-Wing Feeding	0	5	0.00	1.73
Canopy Feeding	0	1	0.00	0.35
Foot Raking	14	34	11.97	11.76
Foot Raking – Right	9	17	7.69	5.88
Foot Raking – Left	5	17	4.27	5.88
Dipping	0	1	0.00	0.35
Feet First Diving	0	1	0.00	0.35
Total Frequency	117	289		
# of Behaviors	4	11		

In summer, all four age groups were recorded feeding even young birds which were observed feeding by their own. Young birds used only 7 behaviors which are -In descending order- Stand and Wait, Walking Slowly, Walking Quickly, Open-Wing

Feeding, Running, Hopping, Leapfrog Feeding. Sub-Adult birds used 8 behaviors which are -in descending order- Stand and Wait, Walking Slowly, Walking Quickly, Open-Wing Feeding, Foot Raking -birds favored using right foot more than left foot-, Running, Leapfrog Feeding, Hopping. Adult birds used also 8 behaviors which are -In descending order- Walking Slowly, Stand and Wait, Walking Quickly, Open-Wing Feeding, Foot Raking - birds favored using left foot more than right foot-, Running, Hopping, Leapfrog Feeding. Adults in Breeding Plumage used 7 behaviors which are -in descending order- Standing Fly-catching, Walking Slowly, Stand and Wait, Walking Quickly, Open-Wing Feeding, Foot Raking -birds used both feet equally-, Running. In shared behavior usage, all 4 age groups used behaviors in different percentage. However, it is clear across all age groups that the most 4 used behaviors are Stand and Wait, Walking Slowly, Walking Quickly, and Open-Wing Feeding. Differences were also noticeable. Standing Fly-catching was only used in Adults in Breeding Plumage. Hopping and Leapfrog Feeding was never observed used by Adult birds in Breeding Plumage. In contrast, foot Raking was never observed used by Young birds (Tables 3.7.5 and 3.7.6). Maybe there is an influence of social learning in waders were young birds start to learn feeding behavior by observing older birds as Slagsvold & Wiebe (2011) suggested.

Table 3.7.5: Feeding behavior usage frequency for different age group in summer season

	Summer			
	Frequencies			
	Young	Sub-Adult	Adult	Adult Breeding
Sample Size	18	38	38	9
Recorded Behavior				
Behavior 01 (Stand and Wait)	17	35	33	7
Behavior 04 Standing Flycatching	0	0	0	9
Behavior 06 (Walking Slowly)	17	33	35	8
Behavior 07 (Walking Quickly)	12	22	22	6
Behavior 08 (Running)	3	5	2	1
Behavior 09 (Hopping)	1	1	1	0
Behavior 10 (Leapfrog Feeding)	1	5	1	0
Behavior 12 (Open-Wing Feeding)	8	12	14	2
Behavior 16 (foot Raking)	0	7	5	2
Behavior 16.1 (Foot Raking - Right)	0	5	2	1
Behavior 16 .2 (Foot Raking - Left)	0	2	3	1
Total	59	120	113	35
# Behaviors	7	8	8	7

Table 3.7.6: Feeding behavior usage percentage for different age group in summer season.

	Summer			
	Percentage			
Recorded Behavior	**Young**	**Sub-Adult**	**Adult**	**Adult Breeding**
Stand and Wait	28.8 %	29.1	29.2 %	20 %
Standing Flycatching	0 %	0 %	0 %	25.7 %
Walking Slowly	28.8 %	27.5	30.9 %	22.8 %
Walking Quickly	20.3 %	18.3	19.4 %	17.1 %
Running	5 %	4.1 %	1.7 %	2.8 %
Hopping	1.6 %	0.8 %	0.8 %	0 %
Leapfrog Feeding	1.6 %	4.1 %	0.8 %	0 %
Open-Wing Feeding	13.5 %	10 %	12.3 %	5.7 %
foot Raking	0%	5.7%	4.3%	5.6%
Foot Raking – Right	0 %	4.1 %	1.7 %	2.8 %
Foot Raking - Left	0 %	1.6 %	2.6 %	2.8%

3.8 Morph

In summer, out of the 148 Western Reef Heron individuals, 122 birds were in Dark Morph and 26 were in White Morph. In percentage, Dark morph was 82.43% of the population in contrast White morph was 17.57% only. Ratio wise, Dark to White Ratio is 61:13. Winter Season 479 individuals were 376 Dark Morph birds while White Morph birds were only 103. In percentage, Dark morph were 78.5% of the population and White morph were only 21.5%. Ratio of Dark to White individuals is 376:103.

In both season, there was no way a Greater Common Divider could be calculated to simplify the ratio. Table 3.8.1 shows number of herons in different morphs recorded all over the area and not specifically feeding in both summer and winter seasons.

Table 3.8.1: Heron morph ratio and percentage in winter and summer seasons

Winter				
Date	**Dark**	**White**	**Greatest Common Divisor**	**Ratio**
12/12/2016	14	8	2	7:4
14/12/2016	8	5	1	8:5
16/12/2016	24	8	8	3:1
18/12/2016	27	8	1	27:8
20/12/2016	28	9	1	28:9
22/12/2016	17	6	1	17:6
24/12/2016	20	8	4	5:2
26/12/2016	28	5	1	28:5
28/12/2016	43	14	1	43:14
30/12/2016	51	6	3	17:2
01/01/2017	0	0	0	0
03/01/2017	34	9	1	34:9
05/01/2017	3	0	3	1:0
07/01/2017	38	8	2	19:4
09/01/2017	41	9	1	41:9

		Percentage
Dark	376	78.50
White	103	21.50
Total Birds	479	

Summer				
Date	**Dark**	**White**	**Greatest Common Divisor**	**Ratio**
01/08/2017	8	2	2	4:1
03/08/2017	0	0	0	0
05/08/2017	6	3	3	2:1
07/08/2017	0	0	0	0
09/08/2017	0	0	0	0
11/08/2017	0	0	0	0
13/08/2017	0	0	0	0
15/08/2017	0	0	0	0
17/08/2017	7	2	1	7:2
19/08/2017	19	5	1	19:5
21/08/2017	24	5	1	24:5
23/08/2017	21	4	1	21:4
25/08/2017	23	3	1	23:3
27/08/2017	7	1	1	7:1
29/08/2017	7	1	1	7:1

		Percentage
Dark	122	82.43
White	26	17.57
Total Birds	148	

Statistically, there is a significant difference between dark and white morphs in winter season (Paired samples test, p=0.00 a=0.05). Similarly, in summer where statistical test result shows significant differences (Wilcoxon signed ranks test, p=0.007 a=0.05).

3.9 Strikes in Different Morphs

In winter season, total number of dark morph feeding observations were 67 with a total of 222 strikes while White morph feeding observations were 39 with a total of 205 strikes. While, in summer season, total number of dark morph feeding observations were 46 with a total of 158 strikes while White morph feeding observations were 19 with a total of 104 strikes below is statistics table (Table 3.9.1). Statistically, wilicoxon sighned ranks test shows significant differences in strikes between dark and white morphs despite the deductive difference (p=0.027 a=0.05).

Table 3.9.1: Number of observations, strikes, mean value for both morphs in both seasons

	Winter		Summer	
	Dark	**White**	**Dark**	**White**
Observations	67	39	46	19
Strikes	222	205	158	104
Mean	3.31	5.25	3.43	5.47

3.10 Western Reef Heron Relative Abundance

Relative Abundance of Western Reef Heron was calculated in each observation day against waterbirds. Relative Abundance in winter ranged from 0 to 24.8 while in summer it ranged from 0 to 13.2 (Table 3.10.1).

Table 3.10.1: Relative abundance of Western Reef Heron in different seasons

Winter Relative Abundancy				
Date	Western Reef Heron	All Birds	waterbirds	Relative Abundancy
12/12/2016	22	449	434	5.1
14/12/2016	13	499	476	2.7
16/12/2016	32	580	492	6.5
18/12/2016	35	813	768	4.6
20/12/2016	37	415	366	10.1
22/12/2016	23	497	454	5.1
24/12/2016	28	507	474	5.9
26/12/2016	33	422	364	9.1
28/12/2016	57	292	230	24.8
30/12/2016	57	563	526	10.8
01/01/2017	0	357	324	0.0
03/01/2017	43	437	410	10.5
05/01/2017	3	244	224	1.3
07/01/2017	46	514	473	9.7
09/01/2017	50	737	696	7.2

Table 3.10.1: Relative abundance of Western Reef Heron in different seasons (continued)

Summer Relative Abundancy				
Date	Western Reef Heron	All Birds	waterbirds	Relative Abundancy
01/08/2017	10	174	152	6.6
03/08/2017	0	223	207	0.0
05/08/2017	9	278	249	3.6
07/08/2017	0	278	257	0.0
09/08/2017	0	58	69	0.0
11/08/2017	0	106	87	0.0
13/08/2017	0	113	101	0.0
15/08/2017	0	109	96	0.0
17/08/2017	9	155	146	6.2
19/08/2017	24	446	429	5.6
21/08/2017	29	246	219	13.2
23/08/2017	25	296	256	9.8
25/08/2017	26	290	275	9.5
27/08/2017	8	241	230	3.5
29/08/2017	8	271	255	3.1

Calculation of Mean of Relative Abundance for each season results are 7.1 in winter and 4.9 in summer.

3.11 Fish Sampling

The sampling of fishing yield four species. Table 3.11.1 lists the species followed by Figures 3.11.1, 3.11.2, 3.11.3, 3.11.4 which are photographs of the sampled fishes.

Table 3.11.1: Species sampled in the site adjacent to the study area

Fish Species Sampled.
(Arabian Pupfish) *Aphanius dispar dispar*
(Yellowfin Seabream) *Acanthopagrus lotus*
(Jarbua) *Terapn jarbua*
(Blacktip Mojarra) *Gerres hyena*

Figure 3.11.1: (Arabian Pupfish) *Aphanius dispar dispar*

Figure 3.11.2: (Yellowfin Seabream) *Acanthopagrus lotus*

Figure 3.11.3: (Jarbua) *Terapn jarbua*

Figure 3.11.4: (Blacktip Mojarra) *Gerres hyena*

Chapter 4: Discussion

The mangrove habitat is among the most productive and biogeochemically active ecosystem (Barbier et al., 2011). This fragile ecosystem is one of the most disturbed habitats mostly due to intense human activities (Etezadifar & Barati, 2013). According to Barbier and his team (as cited in Valiela et. al. 2001 and FAO, 2007), mangroves trees are currently disappearing at the rate of 1 - 2% annually (Etezadifar & Barati, 2013). The ecosystem hosts a variety of organisms that act as a bioindicators. Macroinvertebrates can provide a valuable information on habitat quality as they are sensitive to changes in habitat quality. Mangrove roots itself may serve as a sensitive bio-indicator for metal pollution in estuarine systems (Barbier et al., 2011). One other overlooked factor is birds, especially coastal birds. Mangrove ecosystem support important concentration of bird's species specially waders like Herons (Etezadifar & Barati, 2013). Selecting the most sensitive species may provide earlier indication of changes in the system arising from anthropogenic pressures as it is highly exposed to pollution of different sources. Not only development along adjacent or nearby coastline impact the ecosystem. Litter, Plastic, or other pollutant like diesel, fluids or other chemicals that drive from the only source of the water inlet (The Sea) imbalance that ecosystem too. Human non-industrial induced pollution impacts the ecosystem as well. Pollution like Noise pollution and visually alien constructions have an impact on ecosystems too. Mangrove habitat is stressed already from all-natural factors impacting its stability. Climate change, acidification, hypoxia, sea level rise and salinization are all factors that influence many coastal Living biota and the ecosystem in general (Cannicci et al., 2012). The improper management of development project wastes and waste disposal degrade the mangrove ecosystems in leading to a sever imbalance and loss of food web elements.

The present study showed that the avifauna of Al-Zora was more diverse in winter than summer. This is an indication of generally improved conditions in winter, when temperatures become mild and migratory as well as resident birds arrive in the region and accumulate in coastal areas including mangroves (Jennings & Krupp, 2010). Matsunaga (2000) found that the number of Grey Herons (*Ardea cinerea*) increased from spring to summer in coastal areas in Japan, consistent with improving weather conditions (extremely cold winters to moderate summers). This was related to increasing food abundance in the Japanese summers resulting in aggregation of Grey Herons and other Ardeidae (Matsunaga, 2000). Similarly in the present study, Western Reef Heron population also increased in winter in my study. Western Reef Herons disperse widely at times of low food abundance or harsh weather and are known to return to areas with high food abundance when weather patterns improve (Kushlan and Hancock, 2005). Western Reef Heron is nationally classified as coastal resident and inland visitor (Pedersen et al., 2017) although many authors consider them to be a partial migrant (Kushlan & Hancock, 2005; Jennings & Krupp, 2010). The increased abundance can be explained by short-distance migration or by the influence of fish movement in creeks. The summers in the Middle East are extremely harsh, causing declines in food abundance for many resident birds throughout the region (Jennings & Krupp, 2010). Subsequent to summer, the approaching winter brings milder temperatures with an increase in the production of food in various ecosystems. Thus, the increase in Western Reef Herons in winter could be attributed to better weather conditions and increased food abundance in coastal habitats of UAE which needs a study to estimate abundance of fish and benthos between summer and winter, especially in the mangroves and associated mudflats.

Diversity in behavioral utilization was somehow high. The study found that Western Reef Heron in the study area uses 13 behavior which is 46.2% of the feeding behavior ethogram by Kushlan (1976). The most used behaviors were Stand and Wait and Walking Slowly. This is consistent with the known visual acuity and efficiency of striking of Western Reef Herons (Katzir & Intrator, 1987). Western Reef Herons typically have high levels of visual acuity that corrects for refraction of light when attacking submerged prey. The hunting posture is split into a ‘pre-strike’ position where the head is arched at an angle of 60°. This is then followed by the actual ‘strike’ at high velocity (up to 270 cm/s) which results in capture of prey (Katzir and Intrator 1987). Since Western Reef Heron was not in any of the found literature that were studying feeding behavioral utilization in Ardeidae species family, comparison with other species from the same family had to be commenced. Hitoshi (1996) shows similar adoption of both behaviors from our finding in Grey Heron, Intermediate Egret *Egretta intermedia*, and les adoption of Stand and Wait behavior but with frequent Walking Slowly in Great White Egret *Egretta alba modesta* and Little Egret (Tojo, 1996). Cattle egret *Bubulcus ibis* was not recorded in the tidal flats in Tojo research and noticeably it did not use Stand and Wait behavior in the habitat where it was recorded “Farmland”. Kent (1986) study shows Little Blue Heron *Egretta caerulea* to use Walking Slowly behavior solely. Result of the present study was similar to Quinney and Smith (1980) results studying adult and juvenile Great Blue Heron *Ardea Herodias* as well. Since the only difference were in Cattle egrets lacking use of Stand and Wait behavior paying attention to its niche, Stand and Wait behavior is an ambush practice to hunt fast moving prey like fishes thus it wasn’t used by Cattle egrets in farmlands. With those comparisons and the known visual acuity and efficiency of striking of Western Reef Herons (Katzir & Intrator, 1987), Feeding behavior is case sensitive where a heron or egret will utilize the use of a behavior or multiple behaviors based on the habitat or prey condition.

Foraging behavior utilization between different age-grope showed ascending number of used behaviors as the bird age increased. Slagsvold and Wiebe (2011) explained how foraging behavior can be transmitted over generation as young birds learn from their parent and subsequently transmit what they learned to their offspring later in life. The fact that young birds used less behaviors than sub-adult birds while both sub-adults and adults used the same number of behaviors might indicate that social learning start early in the bird life cycle and stops as the bird reaches sub-adult stage. This study indicate that there might be social learning of foraging behaviors in Western Reef Heron (Slagsvold & Wiebe, 2011).

There is a clear relation between foraging behavior and tidal movements. More Western Reef Herons were present (feeding or non-feeding) in larger numbers during the rising tide than falling tide. This is consistent with other studies relating to tidal effects on foraging efficiency in herons and bitterns. For example, Grey Herons increase in numbers at low tide and decrease in numbers at high tide, presumably taking advantage of inter-tide lag periods (Matsunaga, 2000). This pattern is observed in other herons and in other shorebirds, such as Sanderlings (*Calidris alba*) (Conners et al., 1986; Richner, 1986). It is suggested that tidal lag periods aid in exposing the maximum amounts of small prey from the benthic communities as well as force small fishes into shallower areas (Conners et al., 1986; Richner, 1986; Matsunaga, 2000; Kushlan & Hancock, 2005), allowing shallow water coastal foragers to take advantage of this diurnal increase in food, as observed in Western Reef Herons.

The numerically higher foraging efficiency in winter might be because of the hypothesized increased food abundance in winter. With the hypothesis of better weather condition influence on Western Reef Heron population in winter, there might be a relation between foraging efficiency and food availability. The more food available in the site, the more efficiently Western Reef Heron feed. Comparing result of the present study with other Ardeidae species, foraging efficiency in the Western Reef Heron was lower than other species. For example, Kent (1986) showed that Little Blue Heron, Snowy Egret, (*Egretta thula*), Tricolored Heron, (*Egretta tricolor*) had 59.0%, 42.8% and 33.0% strike efficiencies respectively, compared to the 13.3% in summer and 17.8% in winter for Western Reef Herons in my study. Some of these differences could be attributed to inter-species differences (Kent, 1986; Kushlan and Hancock, 2005). Great Blue Herons foraging success changed with group size, with birds feeding in larger flocks having higher efficiency (Quinney & Smith, 1980). However, there was no sign of the mentioned relationship in the Western Reef Herons in the current study. Each of the species above have slightly different choice of food and they effectively partition their habitat to avoid resource competition (Kent, 1986). We suggest that the generally low visibility due to the high sediment content of the water possibly caused the further reduction in foraging efficiency in Western Reef Herons in the current study.

Feeding efficiency across age groups showed differences between the two seasons paying attention that winter Season did not contain any juvenile as breeding season is late spring to early summer. Breeding Adults had higher FSR in summer than winter. This might be because of the nutritional needs for mating or parental care supply as breeding occurs in summer in Western Reef Herons in the Middle Eastern region (Jennings & Krupp, 2010) and this is associated with more energy invested in preparation for breeding (Kushlan & Hancock, 2005). Adults in non-breeding plumage had similar results too where feeding efficiency was higher in summer than winter and this observation cannot be readily explained, and we suggest that other factors could be involved that requires further study.

The ongoing debate of weather the Western Reef Heron is just another form of Little Egret specially the white morph makes studying this species behavior and niches important (Jennings & Krupp, 2010; Del Hoyo et al., 2017; Dubois & Yésou, 1995). This might be why almost all Western Reef Heron morph ratio quantification focuses on white morph ratio in the studied population. More dark-morph Western Reef Herons than white-morphs were present in the study area. This result contradicts with Jennings & Krupp statement that in general, white morph probably dominates the population in Arabia (Jennings & Krupp, 2010). The same contradict were found with Del Hoyo and his team (2017) who despite stating that white-morph ratio is generally between 10-50% in *E. g schistacea*, it can rise up to 80% in Palestine (Del Hoyo et al., 2017). In contrast, comparing our findings with other literature. White-morph ratio in both seasons falls right between the ratio from Bahrain, North Egypt, and Pakistan (19 – 25%) (Dubois & Yésou, 1995). The same publication discus how low were white-morph ratio (less than 1%) among Senegal, Gambia and Mauritania population which is mentioned as well by Del Hoyo and his team. While Jennings & Krupp and Del Hoyo and his team were way better in describing the bird, its abundance, and other biological information, they lacked the scientific quantification references like what is found in Dubois & Yésou (1995) research. Looking closely to how sub-species are distributed geographically and the percentage of white-morph amount those geographically distinct populations, We deduce that white-morph is predominant in *E. g. gularis* while dark-morph is the predominant morph in *E. g. schistacea*. further studies are mandatory to better understand the ratio composition especially for eastern population were no quantification of morph ratio studies were found.

Assessing FSR in the two morphs of Western Reef Heron (dark and white) was very interesting. White morphs had higher feeding efficiency compared to dark morph Western Reef Herons. Similarly, white morph Western Reef Herons had larger number of strikes compared to dark morph Western Reef Herons. White morph Pacific Reef Herons (*Egretta sacra*) used aerial hunting techniques to find prey in the Cook Islands (Rowher 1990). In comparison, dark morphs of Pacific Reef Herons hunted using walking or running on reefs (Rowher 1990), comparable to the most commonly used feeding strategy observed in our study. It has been suggested that crypsis or the ability to blend with the background may aid in foraging success or due to protection against predation (Caldwell, 1986; Rowher, 1990). This could then increase the number of individuals of the morph that is favorably selected. Therefore, selection of one morph over another could be under pressure from different sources as well. Caldwell (1986) showed that white morphs of Little Blue Herons were subject to greater number of predatory attacks (from raptors) in Panama because they were more visible, compared to dark morphs. Rowher (1990) suggested that feeding efficiency in dark morphs was higher due to better blending against the back ground, making the darker morphs harder to see from under water (by the prey species). We suggest that crypsis in dark morphs was advantageous over white morphs of Western Reef Herons in the current study resulting in more dark morphs than white morphs of Western Reef Herons. Dark morphs are likely to blend more with the dark background of mangrove areas or against foggy or cloudy skies. This hypothesis needs to be studied further although there is support from other studies (e.g. Rowher 1990).

Western Reef Heron was feeding on fishes almost all the time with only one sighting where it was trying to feed on insects as described in the behavior “standing flycatching”. The four species of fishes that were identified from the sample collected from the study area adjacent site -due to the difficulties of sampling the study site itself- had two species matching the photographed species Western Reef Heron was feeding on (Arabian Pupfish *Aphanius dispar dispar* and Blacktip Mojarra *Gerres hyena*). Despite those Western Reef Heron photos eating fishs photos were from the study area, Fish samples were from an adjacent site where the birds were not monitored. so, it has been found that these species may or may not be available at the study area where birds were monitored. Fish species data were not quantitative and the list of species must be considered as observation only especially when all other carried data were quantified. Despite that, there is a clear indication that Western Reef Heron will feed on fishes that reach up to its bill-length in size.

Western Reef Heron movement for feeding can indicate high quality mangrove and mudflat habitats supported by benthic organisms and coastal small fish species. Because pollution mainly impact benthic organisms faster than others, the abundance of Western Reef Heron and its feeding behavior -if monitored regularly- can become an indicator of ecosystem health and thus a high potential of becoming an important bio-indicator linking the avifauna predators with benthic community in such a fragile mangrove intertidal ecosystem. If monitored closely, it can form a baseline activity level that will help in any habitat monitoring plan to either make sure everything is in equilibrium status or a problem arise in the site and requires a sampling and more field work.

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Appendix

App 1: List of birds recorded in winter and summer with total individual count at Al-Zora.

Winter			**Summer**	
Specie Name	**Total Individual**		**Specie Name**	**Total Individual**
Common Shelduck *Tadorna tadorna*	196		Red-crested Pochard *Netta rufina*	1
Northern Shoveler *Spatula clypeata*	85		Northern Pintail *Anas acuta*	2
Eurasian Wigeon *Mareca penelope*	1		Greater Flamingo *Phoenicopterus roseus*	832
Mallard *Anas platyrhynchos*	22		Grey Heron *Ardea cinerea*	13
Northern Pintail *Anas acuta*	179		Great White Egret *Ardea alba*	22
Eurasian Teal Anas *crecca crecca/nimia*	154		Little Egret *Egretta garzetta*	4
Grey Francolin *Francolinus pondicerianus*	2		Western Reef-Heron *Egretta gularis*	148
Greater Flamingo *Phoenicopterus roseus*	2025		Cattle Egret *Bubulcus ibis*	1
Great Cormorant *Phalacrocorax carbo*	841		Squacco Heron *Ardeola ralloides*	1
Socotra Cormorant *Phalacrocorax nigrogularis*	2		Striated Heron *Butorides striata*	5
Grey Heron *Ardea cinerea*	54		Common Moorhen *Gallinula chloropus*	2
Great White Egret *Ardea alba*	62		Black-winged Stilt *Himantopus himantopus*	251
Little Egret *Egretta garzetta*	1		Eurasian Oystercatcher *Haematopus ostralegus*	11
Western Reef-Heron *Egretta gularis*	479		Grey Plover *Pluvialis squatarola*	167
Striated Heron *Butorides striata*	2		Red-wattled Lapwing *Vanellus indicus*	33
Glossy Ibis *Plegadis falcinellus*	14		Kentish Plover *Charadrius alexandrinus*	17
Eurasian Spoonbill *Platalea leucorodia*	80		Lesser Sand Plover *Charadrius mongolus*	52
Osprey *Pandion haliaetus*	6		Common Ringed Plover *Charadrius hiaticula*	17
Greater Spotted Eagle *Clanga clanga*	1		Whimbrel *Numenius phaeopus*	49
Western Marsh Harrier *Circus aeruginosus*	40		Eurasian Curlew *Numenius arquata*	16
Common Moorhen *Gallinula chloropus*	31		Bar-tailed Godwit *Limosa lapponica*	270

Winter			Summer	
Specie Name	**Total Individual**		**Specie Name**	**Total Individual**
Black-winged Stilt *Himantopus himantopus*	431		Black-tailed Godwit *Limosa limosa*	12
Pied Avocet *Recurvirostra avosetta*	15		Ruddy Turnstone *Arenaria interpres*	67
Eurasian Oystercatcher *Haematopus ostralegus*	13		Curlew Sandpiper *Calidris ferruginea*	531
Grey Plover *Pluvialis squatarola*	614		Little Stint *Calidris minuta*	13
Red-wattled Lapwing *Vanellus indicus*	20		Common Greenshank *Tringa nebularia*	33
Greater Sand Plover *Charadrius leschenaultii*	130		Common Redshank *Tringa totanus*	241
Lesser Sand Plover *Charadrius mongolus*	2		Crab-Plover *Dromas ardeola*	3
Kentish Plover *Charadrius alexandrinus*	35		Slender-billed Gull *Chroicocephalus genei*	142
Common Ringed Plover *Charadrius hiaticula*	61		Lesser Black-backed Gull *Larus fuscus*	3
Whimbrel *Numenius phaeopus*	17		Gull-billed Tern *Gelochelidon nilotica*	1
Eurasian Curlew *Numenius arquata*	20		Caspian Tern *Hydroprogne caspia*	42
Bar-tailed Godwit *Limosa lapponica*	273		Feral Pigeon *Columba livia* (Feral Pigeon)	5
Black-tailed Godwit *Limosa limosa*	81		Collared Dove *Streptopelia decaocto*	75
Ruddy Turnstone *Arenaria interpres*	7		Laughing Dove *Streptopelia senegalensis*	21
Ruff *Calidris pugnax*	9		Ring-necked Parakeet *Psittacula krameri*	1
Curlew Sandpiper *Calidris ferruginea*	227		House Crow *Corvus splendens*	2
Dunlin *Calidris alpina*	35		Eurasian Hoopoe *Upupa epops*	1
Little Stint *Calidris minuta*	21		Graceful Prinia *Prinia gracilis*	2
Common Greenshank *Tringa nebularia*	39		Indian Silverbill *Euodice malabarica*	6
Marsh Sandpiper *Tringa stagnatilis*	3		Greater Sand Plover *Charadrius leschenaultii*	6
Common Redshank *Tringa totanus*	250		Barn Swallow *Hirundo rustica*	3
Black-headed Gull *Chroicocephalus ridibundus*	190		Green Bee-eater *Merops orientalis*	1
Slender-billed Gull *Chroicocephalus genei*	3		Pale Crag Martin) *Ptyonoprogne fuligula*	1
Caspian Tern *Hydroprogne caspia*	27		Red-vented Bulbul *Pycnonotus cafer*	6

Winter			Summer	
Specie Name	**Total Individual**		**Specie Name**	**Total Individual**
Collared Dove *Streptopelia decaocto*	120		White-eared Bulbul *Pycnonotus leucotis*	24
Laughing Dove *Streptopelia senegalensis*	36		Clamorous Reed Warbler *Acrocephalus stentoreus*	2
Pallid Swift *Apus pallidus*	11		Graceful Prinia *Prinia gracilis*	15
Eurasian Hoopoe *Upupa epops*	5		Asian Pied Starling *Gracupica contra*	19
Green Bee-eater *Merops orientalis*	15		Common Myna *Acridotheres tristis*	30
Ring-necked Parakeet *Psittacula krameri*	4		Purple Sunbird *Cinnyris asiaticus*	4
Indian Roller *Coracias benghalensis*	5		House Sparrow *Passer domesticus*	18
House Crow *Corvus splendens*	46		Indian Silverbill *Euodice malabarica*	40
Brown-necked Raven *Corvus ruficollis*	2			
Daurian Shrike *Lanius isabellinus*	1			
Crested Lark *Galerida cristata*	1			
Red-vented Bulbul *Pycnonotus cafer*	1			
White-eared Bulbul *Pycnonotus leucotis*	28			
Common Chiffchaff *Phylloscopus collybita*	6			
Clamorous Reed Warbler *Acrocephalus stentoreus*	30			
Graceful Prinia *Prinia gracilis*	41			
Eurasian Blackcap *Sylvia atricapilla*	5			
Bluethroat *Luscinia svecica*	8			
Asian Pied Starling *Gracupica contra*	35			
Common Myna *Acridotheres tristis*	20			
Bank Myna *Acridotheres ginginianus*	11			
Purple Sunbird *Cinnyris asiaticus*	6			
Pied Wagtail/White Wagtail *Motacilla alba*	1			
House Sparrow *Passer domesticus*	13			
Indian Silverbill *Euodice malabarica*	75			

App 2: List of group feeding company species and aggression against species

Feeding Group Company Species	**Aggression**
Common Shelduck *Tadorna tadorna*	N
Mallard *Anas platyrhynchos*	N
Greater Flamingo *Phoenicopterus roseus*	Y
Great Cormorant *Phalacrocorax carbo*	N
Grey Heron *Ardea cinereal*	Y
Great White Egret *Ardea alba*	Y
Little Egret *Egretta garzetta*	N
Western Reef-Heron *Egretta gularis*	Y
Eurasian Spoonbill *Platalea leucorodia*	N
Black-winged Stilt *Himantopus himantopus*	Y
Whimbrel *Numenius phaeopus*	N
Bar-tailed Godwit *Limosa lapponica*	N
Common Greenshank *Tringa nebularia*	N
Common Redshank *Tringa totanus*	N
Slender-billed Gull *Chroicocephalus genei*	N
gull-billed Gull *Gelochelidon nilotica*	N
Caspian Tern *Hydroprogne caspia*	N

App 3: List of Critical and Complementary Data Collected

Data	**Description**
Bird Feeding	Record if the bird is feeding in the study area
Strikes	The number of attempts to catch a prey by striking the water.
Successful Strikes	The number of attempts to catch a prey with actual success in catching a prey
Tide Level	The condition of the tide if rising or falling.
Time	The time of the observation from the observation window in the increment of 5 minute (The one minute of observation)

complementary Data Collected

Data	**Description**
Observation #	Observation are numbered in a system of two segments. The first segment is the observation day (from 1 to 15 – 15 days of observation. The second segment is the number of observation in that day (from 1 to 61 – 61 observations in a single day).
Date	The date of the observation day (in Day. Month. Year).
Starting Tide	The tide level at the start of the observation day (at 07:30).
Ending Tide	The tide level at the end of the observation day (at 07:30).
Bird Present	Record if the bird is Present in the study area. (Yes, No)
Feeding Area	Area code of where the observed feeding bird is (F1, N1, F2, N2, F3, N3, F4, N4)
Bird Morph	Morph of the observed feeding bird (Adult, Sub-adult, Young).
Plumage	Plumage of the observed bird (Breeding, Non-breeding).

App 3: List of Critical and Complementary Data Collected (Continued)	
Data	**Description**
Walking Surface	Nature of the surface the observed feeding bird walks on (Water, Land).
Water level	Water level in respect to the observed feeding birds legs (low=from feet
Feeding From	Feeding from water or land (to cover all possible food option – fishes or land dwelling organisms like mollusks or mud skippers).
Behaviors	Specify which behavior is used for feeding out of the three groups of behavior (Stand or Stalk, Disturb and Chase, Arial and Deep water feeding) which totals 28 behaviors.
Feeding Company	If other species are in the close surrounding of the feeding Western Reef Heron.
Aggression	If aggression is noticed against other species while feeding.
Feeding Company Species	Which other species surround the Western Reef Heron while feeding.
Starting Temperature	The temperature at the start of the observation period taken from closest weather station (Ajman) which belongs to the national center of meteorology and Seismology.
Ending Temperature	The temperature at the end of the observation period taken from closest weather station (Ajman) which belongs to the national center of meteorology and Seismology.

App 3: List of Critical and Complementary Data Collected (Continued)	
Data	**Description**
Cloud Coverage	Cloud coverage percentage estimated.
Humidity	The humidity at the start of the observation period taken from closest weather station (Ajman) which belongs to the national center of meteorology and Seismology.
Wind Speed	The speed of the wind at the end of the observation period taken from closest weather station (Ajman) which belongs to the national center of meteorology and Seismology.
Wind Direction	The direction of the wind at the end of the observation period taken from closest weather station (Ajman) which belongs to the national center of meteorology and Seismology.

App 4: Descriptive analysis of all feeding Western Reef Heron strikes in winter and summer.

Winter				Summer			
Strikes	Successful Strikes	FSR	Foraging Efficiency FE (%)	Strikes	Successful Strikes	FSR	Foraging Efficency FE (%)
0	0	0.0	0.0	2	0	0.0	0.0
3	0	0.0	0.0	4	4	1.0	100.0
1	0	0.0	0.0	4	1	0.3	25.0
11	0	0.0	0.0	1	1	1.0	100.0
13	3	0.2	23.1	1	0	0.0	0.0
5	0	0.0	0.0	6	1	0.2	16.7
9	2	0.2	22.2	1	1	1.0	100.0
7	3	0.4	42.9	1	0	0.0	0.0
2	1	0.5	50.0	4	0	0.0	0.0
4	0	0.0	0.0	4	2	0.5	50.0
4	2	0.5	50.0	7	0	0.0	0.0
3	1	0.3	33.3	19	0	0.0	0.0
4	1	0.3	25.0	0	0	0.0	0.0
0	0	0.0	0.0	18	0	0.0	0.0
0	0	0.0	0.0	3	0	0.0	0.0
0	0	0.0	0.0	4	1	0.3	25.0
1	0	0.0	0.0	15	1	0.1	6.7
8	0	0.0	0.0	1	0	0.0	0.0
0	0	0.0	0.0	3	1	0.3	33.3
22	0	0.0	0.0	1	0	0.0	0.0
1	0	0.0	0.0	1	0	0.0	0.0
0	0	0.0	0.0	4	0	0.0	0.0

Winter				Summer			
Strikes	Successful Strikes	FSR	Foraging Efficiency FE (%)	Strikes	Successful Strikes	FSR	Foraging Efficency FE (%)
9	0	0.0	0.0	0	0	0.0	0.0
0	0	0.0	0.0	1	0	0.0	0.0
0	0	0.0	0.0	1	0	0.0	0.0
0	0	0.0	0.0	3	0	0.0	0.0
0	0	0.0	0.0	0	0	0.0	0.0
0	0	0.0	0.0	5	1	0.2	20.0
0	0	0.0	0.0	9	1	0.1	11.1
6	2	0.3	33.3	2	0	0.0	0.0
4	2	0.5	50.0	1	0	0.0	0.0
11	5	0.5	45.5	0	0	0.0	0.0
8	3	0.4	37.5	1	0	0.0	0.0
8	2	0.3	25.0	0	0	0.0	0.0
4	2	0.5	50.0	0	0	0.0	0.0
10	3	0.3	30.0	0	0	0.0	0.0
8	2	0.3	25.0	3	0	0.0	0.0
3	1	0.3	33.3	1	0	0.0	0.0
9	3	0.3	33.3	2	1	0.5	50.0
2	1	0.5	50.0	3	1	0.3	33.3
3	1	0.3	33.3	3	2	0.7	66.7
6	1	0.2	16.7	0	0	0.0	0.0
3	0	0.0	0.0	3	0	0.0	0.0
1	0	0.0	0.0	2	0	0.0	0.0
2	1	0.5	50.0	4	0	0.0	0.0
9	2	0.2	22.2	0	0	0.0	0.0

Winter				Summer			
Strikes	Successful Strikes	FSR	Foraging Efficiency FE (%)	Strikes	Successful Strikes	FSR	Foraging Efficency FE (%)
8	0	0.0	0.0	0	0	0.0	0.0
4	0	0.0	0.0	2	1	0.5	50.0
3	0	0.0	0.0	1	0	0.0	0.0
5	0	0.0	0.0	0	0	0.0	0.0
3	0	0.0	0.0	3	0	0.0	0.0
9	0	0.0	0.0	2	1	0.5	50.0
6	0	0.0	0.0	0	0	0.0	0.0
11	1	0.1	9.1	7	0	0.0	0.0
4	1	0.3	25.0	3	2	0.7	66.7
5	0	0.0	0.0	3	0	0.0	0.0
3	0	0.0	0.0	3	0	0.0	0.0
2	0	0.0	0.0	0	0	0.0	0.0
2	0	0.0	0.0	6	1	0.2	16.7
5	2	0.4	40.0	0	0	0.0	0.0
5	0	0.0	0.0	2	0	0.0	0.0
2	0	0.0	0.0	3	0	0.0	0.0
2	0	0.0	0.0	2	1	0.5	50.0
4	0	0.0	0.0	3	1	0.3	33.3
1	1	1.0	100.0	0	0	0.0	0.0
3	0	0.0	0.0	0	0	0.0	0.0
2	0	0.0	0.0	1	1	1.0	100.0
1	0	0.0	0.0	3	0	0.0	0.0
4	0	0.0	0.0	3	1	0.3	33.3
1	1	1.0	100.0	2	1	0.5	50.0

Winter			
Strikes	Successful Strikes	FSR	Foraging Efficiency FE (%)
7	1	0.1	14.3
1	0	0.0	0.0
1	0	0.0	0.0
1	1	1.0	100.0
1	1	1.0	100.0
0	0	0.0	0.0
0	0	0.0	0.0
0	0	0.0	0.0
0	0	0.0	0.0
4	1	0.3	25.0
1	0	0.0	0.0
0	0	0.0	0.0
3	0	0.0	0.0
2	1	0.5	50.0
0	0	0.0	0.0
0	0	0.0	0.0
2	0	0.0	0.0
0	0	0.0	0.0
0	0	0.0	0.0
1	1	1.0	100.0
1	0	0.0	0.0
0	0	0.0	0.0
0	0	0.0	0.0
1	0	0.0	0.0

Summer			
Strikes	Successful Strikes	FSR	Foraging Efficency FE (%)
4	1	0.3	25.0
3	1	0.3	33.3
1	0	0.0	0.0
4	1	0.3	25.0
0	0	0.0	0.0
5	1	0.2	20.0
0	0	0.0	0.0
0	0	0.0	0.0
0	0	0.0	0.0
0	0	0.0	0.0
0	0	0.0	0.0
0	0	0.0	0.0
1	0	0.0	0.0
0	0	0.0	0.0
4	0	0.0	0.0
0	0	0.0	0.0
11	0	0.0	0.0
4	0	0.0	0.0
2	0	0.0	0.0

Winter			
Strikes	Successful Strikes	FSR	Foraging Efficiency FE (%)
0	0	0.0	0.0
5	1	0.2	20.0
1	0	0.0	0.0
0	0	0.0	0.0
0	0	0.0	0.0
6	3	0.5	50.0
2	1	0.5	50.0
8	5	0.6	62.5
8	2	0.3	25.0
1	1	1.0	100.0
4	0	0.0	0.0
1	0	0.0	0.0
4	1	0.3	25.0
4	0	0.0	0.0
2	2	1.0	100.0
0	0	0.0	0.0
0	0	0.0	0.0
0	0	0.0	0.0
1	0	0.0	0.0
5	0	0.0	0.0
1	0	0.0	0.0
8	2	0.3	25.0
3	2	0.7	66.7

Winter			
Strikes	Successful Strikes	FSR	Foraging Efficiency FE (%)
2	1	0.5	50.0
4	2	0.5	50.0
3	3	1.0	100.0
2	0	0.0	0.0
3	0	0.0	0.0
5	2	0.4	40.0
3	0	0.0	0.0
1	1	1.0	100.0
1	1	1.0	100.0
0	0	0.0	0.0
0	0	0.0	0.0
2	0	0.0	0.0
4	1	0.3	25.0
1	0	0.0	0.0
1	1	1.0	100.0
0	0	0.0	0.0
0	0	0.0	0.0
2	0	0.0	0.0
0	0	0.0	0.0
0	0	0.0	0.0
0	0	0.0	0.0
1	0	0.0	0.0
1	0	0.0	0.0

Winter			
Strikes	Successful Strikes	FSR	Foraging Efficiency FE (%)
0	0	0.0	0.0
0	0	0.0	0.0
0	0	0.0	0.0
0	0	0.0	0.0
1	1	1.0	100.0
0	0	0.0	0.0
0	0	0.0	0.0
1	0	0.0	0.0
0	0	0.0	0.0

	Winter	Summer
Sample Size	149	89
mean of ratio	0.152	0.136
Percentage of Efficiency	17.4	13.3