The Cream-coloured Courser (*Cursorius cursor)*: The relationship between habitat preference and behaviour: A case study of geodiversity underpinning biodiversity in Lanzarote.

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Abstract

The Cream-coloured Courser (*Cursorius cursor)* is a poorly studied bird species with limited knowledge of its general biology and behaviours. Their distribution spans most of the Middle-East, northern Africa and the two easternmost islands of the Canary archipelago, Fuerteventura and Lanzarote. The aim of this research is to determine whether Cream-coloured Coursers have a habitat preference within the semi-desert environments of Lanzarote and to determine the behavioural relationship it has with its preferred habitat. Abiotic and biotic habitat features were sampled at 25 sites of known regular Cream-coloured Courser occurrences and 25 sites where Coursers have never been seen. These sites were located using the knowledge of the conservation group *Desert watch*. Results showed that the Cream-coloured Coursers preferred areas with higher percentage cover of *A.tenuifolius* and *C.tomentosa* and avoided areas with higher percentage cover of *L.arborescens* and tall shrubs ($p<0.05$). Comparison of observed Courser behaviour and habitat features between sites showed that significant behavioural changes were not affected by habitat features. Few studies have been done on the habitat preferences of the Cream-coloured Courser meaning that this study adds a proportionally large amount of research to this research area increasing the reliability of results as a base for conservation and management strategies. A science communication leaflet on the Cream-coloured Courser alongside this study adds an important conservation tool for use by the *Desert Watch* group to increase awareness of the Cream-coloured Courser to tourists and the public in Lanzarote.

Acknowledgements

I would like to thank Cynthia Burek for her patience, understanding and indispensable support she has given me as my supervisor. I would also like to show my gratitude to the warm hearted members of the *Desert Watch* for sharing their wealth of knowledge, time and kindness with me during my time in Lanzarote. I also show my appreciation to the Island Council of Lanzarote for supporting my research. And to my fellow students who will forever have my thanks.

Contents

1. Introduction

1.1. Biology, behaviour and distribution

The Cream-coloured Courser (*Cursorius cursor*) is a poorly studied bird species and information about its general biology and behaviours is limited (Palomino, Seoane, Carrascal, & Alonso, 2008). This absence of basic accurate data and research makes it difficult for more advanced research to be performed. Consequently, conservation efforts become difficult with uncertain outcomes and effectiveness. It is, however, known that the Cream-coloured Courser is a medium-sized insectivorous bird from the Glareolidae family (Traba et al., 2013) that feeds by walking or running intermittently while pausing to search for or catch prey items (Del, Elliot, & Sargetal, 1996). Del, Elliot & Sargetal (1996) also state that the birds can catch insects in flight or dig for food with their beak. Breeding information on the Canary Island populations is limited though clutches of eggs are usually laid between March and early April each year, with some eggs laid in early February with chicks, being nidifugous, leave the nest shortly after hatching (González, 1999). The adult Coursers lay their eggs in a shallow scrape on bare ground without nesting material (Cortés-Avizanda et al., 2009) with a brood size of usually two eggs (The IUCN Red List, 2016; González, 1999).

The distribution of the Cream-coloured Courser (*Figure 1.1.*) ranges from the Canary Islands to Pakistan, west to east, and from Turkmenistan to Kenya, north to south, occasionally occurring in Europe (Traba et al., 2013; Palomino et al., 2008; González, 1999; Rahmani, 1989). Within the Canary Islands they are present on the eastern islands of Fuerteventura, Gran Canaria and Lazarote. However, on Gran Canaria, they are believed not to breed (Palomino et al., 2008; González, 1999) or are possibly extinct (The IUCN Red List, 2016).

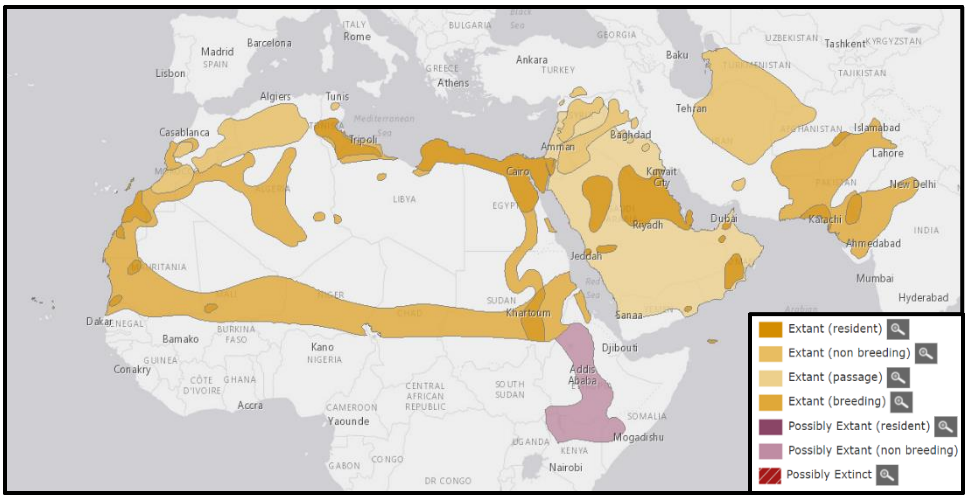


Figure 1.1. **World distribution map of Cream-coloured Coursers. Taken from IUCN (2016)**

1.2. Species status and threats

The Cream-coloured Courser is currently classified as Least Concern on The IUCN Red List of Threatened Species (2016) due to its large distribution range which does not approach the perceived thresholds for Vulnerable under the range size criterion (Extent of Occurrence <20,000 km^2 combined with a declining or fluctuating range size, habitat extent/quality, or population size and a small number of locations or severe fragmentation).

Although Cream-coloured Coursers are classified as Least Concern they are still affected by a number of threats. The Canary Islands have extensive growth of road networks, urban developments and uncontrolled tourist development, except on Lanzarote which has strict planning laws (following the pioneering conservation work of Cesar Manrique in the 1970s-90s), that has caused the destruction and fragmentation of the Courser's habitats. Urbanisation and infrastructure (such as windfarms and roads) and the associated problems (such as off road driving, human presence/disturbances, noise and litter pollution) destroy, infringe upon and deteriorate the steppe habitats in which the Coursers live (González, 1999).

The amount of goat grazing in Lanzarote's desert environments has increased over recent decades (Gangoso, Donázar, Scholz, Palacios, & Hiraldo, 2006). Studies have shown that the presence and uncontrolled grazing of goat herds negatively affects the biomass and diversity of wildlife (Gangoso, Donázar, Scholz, Palacios, & Hiraldo, 2006; Donlan, Tershy, & Croll, 2002; González, 1999) due to herds causing permanent soil erosion. This is seen as a conservation issue for many wild species (Rodriguez, Soto, Hernndez, Mendoza, González, Padrón, Chávez, 1993). However, as Palomino, Seoane, Carrascal, & Alonso (2008) point out, Cream-coloured Coursers may be less affected by goat grazing compared to other species as it prefers soils with low vegetation cover. Therefore, the Coursers are probably the only species in the arid areas of Fuerteventura and Lanzarote that are not negatively affected by soil erosion by goat grazing. Nevertheless, it is unlikely that the presence of large goat herds does not disturb the Coursers particularly during breeding season. Cream-coloured Coursers nest on the ground (Cortés-Avizanda, Carrete, Serrano, & Donázar, 2009) where there is no protection from trampling. Courser chicks, although precocious, are flightless and have little defence against being trampled. The effects of goat grazing on Cream-coloured Coursers, however, is yet to be studied or quantified.

1.3. Conservation

The Canary Islands are part of Spain and therefore subject to the European Bird Directive which aims to protect all 500 wild bird species which naturally occur in the European Union (European Commission, 2016). Lanzarote is also a UNESCO Global Biosphere as well as a recently recognised UNESCO Global Geopark (2015). The island therefore has a lot of recognised conservation status. A species action plan for Cream-coloured Coursers in Europe written in 1999 (González, 1999) stated actions that should take priority when conserving Cream-coloured Coursers. Those which were considered highest priority included the designation of protected and special protected areas (SPAs) and the approval of management plans that are currently declared protected areas. Actions considered to be high priority included defining critical areas particularly in the Eastern Canary Islands; restriction and control of vehicle movement in critical areas; grazing control; prevention of any critical habitat alteration; further research on Cream-coloured Coursers; regular monitoring and census of Courser population and raising awareness of the ban on off-road driving through campaigning. Specific studies researching the Cream-coloured Coursers with the aim of improving the understanding of their conservation are limited (Palomino et al., 2008; Traba et al., 2013), but there is research which includes them within a wider scope (Gliddon & Aspinall, 1997) such as steppe birds (Traba, García de la Morena, Morales, & Suárez, 2007) or ground nesting species (Cortés-Avizanda et al,. 2009).

1.4. Habitat preference

1.4.1. Habitat preferences in birds

Birds have preferences of habitats with qualities that best cater to the species specific behavioural traits and survival strategies such as appropriate food resources, vegetation, breeding sites and safety against predators (Palomino, Seoane, Carrascal, & Alonso, 2008). In temperate areas it has been demonstrated in a wide range of studies that vegetation traits within a habitat are considered one of the main features for habitat preference among birds living in pasturelands, shrublands, woodlands or a broad range covering multiple habitat types within an environment (Palomino et al., 2008; Battin & Lawler, 2006; Gottschalk, Huettmann, & Ehlers, 2005; Jones, 2001).

1.4.2. Habitat preferences in Cream-coloured Coursers

Only a few studies on habitat preference of the Cream-coloured Courser have been done previously. Traba et al., (2013) studied them along with the Black Bellied Sandgrouse (*Pterocles orientalis*) and the Stone Curlew (*Burhinus Oedicnemus*) in arid areas of Morocco, North Africa. Their results confirmed that the three species showed spatial segregation with the two insectivorous species, Cream-coloured Courser and Stone Curlew, showing less distinction between each other which contributes to reduce potential competition. Their study also indicates that abiotic factors (topography and lithology) are more important in habitat selection for the three species than biotic factors. This is an example of geodiversity underpinning biodiversity (Burek, 2001).

Palomino et al. (2008) studied the habitat preference of the Cream-coloured Courser on the two easternmost islands of the Canary Islands, Fuerteventura and Lanzarote, Spain, which both hold stable populations. They showed that both island populations presented strong habitat selection patterns. The Courser had the highest probability of occurrence at locations with relatively flat terrain (maximum slope steepness <11%), below 197m above sea level, scarce shrub cover less than 16% and rock cover less than 23%. The only human disturbance that was considered in the study (dirt tracks, urban developments, agriculture) to show a clear negative effect on the occurrence of the Cream-coloured Courser was tarmac roads. The study also suggested that fine grained habitat features are not directly related to vegetation structure but do largely determine habitat selection of birds in arid environments.

1.5. Conservation impacts

Detailed knowledge of a population's relationship with its natural habitat is essential for effective conservation of wild populations. Knowing which habitats are used in higher frequencies allows for the most important biotic and abiotic environmental features to be determined. This in turn helps to determine the appropriate features to conserve in order to maintain a favourable conservation status (Cañadas, Sagarminaga, De Stephanis, Urquiola, & Hammond, 2005). Conserving the preferred habitat of a species is a crucial part of maintaining its conservation status as habitat loss is one of the greatest threats to species survival. Habitat loss causes population declines with smaller populations being less likely to be preserved over time (Mills, 2007). Doherty, Naugle, Walker, & Graham (2008) also state that it is important to consider the variation of environmental features in a habitat and the change of a species preference due to variable behavioural changes. This can be according to time of year, food availability, amount of competition, predation risk and critical life stages. It is essential to consider these factors in the development of planning conservation management. One theory in the field of bird biogeography suggests that biotic interactions such as competition or predation and habitat features such as the lithology or vegetation cover, restrict the distribution within species at small population scales while abiotic factors are the main causes effecting the distribution and abundance of species at large population scales (Newton, 2003).

1.6. Research aims

The overall aim of this research is to determine whether Cream-coloured Coursers (*Cursorius cursor*) have a preferred habitat within the semi-desert environments of Lanzarote. This will be achieved by determining sites where they are often found and sites where they have never been seen. These different sites are then sampled to record appropriate biotic and abiotic factors that may influence the selection of the habitat by the Cream-coloured Courser. The two site categories can then be compared to determine which biotic and abiotic factors affect habitat preference and which are most important. This knowledge could help in determining which critical sites need more conservation effort and could make conservation more effective in the semi-desert environments of Lanzarote with implications for wider conservation efforts.

The aim of the behavioural study is to determine what relationship the Cream-coloured Courser has with its preferred habitat and to see if the frequencies of particular behaviours change when nearing the limits of their preferred habitat features. Using focal sampling as a behavioural sampling technique will record the rate of different behaviours at individual sites which can then be compared with the biotic and abiotic samples to possibly see which behaviours are related to different habitat features. Understanding the relationship between behaviours and habitat could help in predicting how environmental changes or damage could affect the Cream-coloured Coursers behaviour and population density or distribution reactions. This knowledge could help by making conservation more effective by determining critical sites which need more conservation effort for clearer and ultimately more successful conservation and management strategies.

1.6.1. Hypothesis

H_0: Cream-coloured Coursers do not have a significant habitat preference based on abiotic habitat features.
H_1: Cream-coloured Coursers do have a significant habitat preference based on abiotic habitat features.

H_0: Cream-coloured Coursers do not have a significant habitat preference based on biotic habitat features.
H_1: Cream-coloured Coursers do have a significant habitat preference based on biotic habitat features.

H_0: Cream-coloured Coursers do not show significant behavioural differences at locations with significantly different habitat features.
H_1: Cream-coloured Coursers do show significant behavioural differences at locations with significantly different habitat features.

2. Methods

2.1. Study location

Lanzarote (*Figure 2.1.1.*) is the easternmost island of the Spanish Canary archipelago approximately 120km off the coast of north-west Africa (N29°2'50.48", W13°35'25.55") (Palomino et al., 2008). It covers roughly 846^2km with 142,000 human residents and around 1,900,000 tourists per year (Martín-Cejas & Sánchez, 2010).

Figure 2.1.1. **Overview of the island of Lanzarote.**

From the 30th of August to the 20th of September sediment, vegetation and behavioural samples were taken within the semi-desert habitat south-west of Famara (*Figure 2.1.2.)* (N29°6'55.33", 13°33'52.47"). This semi-desert habitat is used by goat herders as grazing lands, tourist walking and birding tours and off-road vehicle driving with an approximate surface area of 16000m^2.

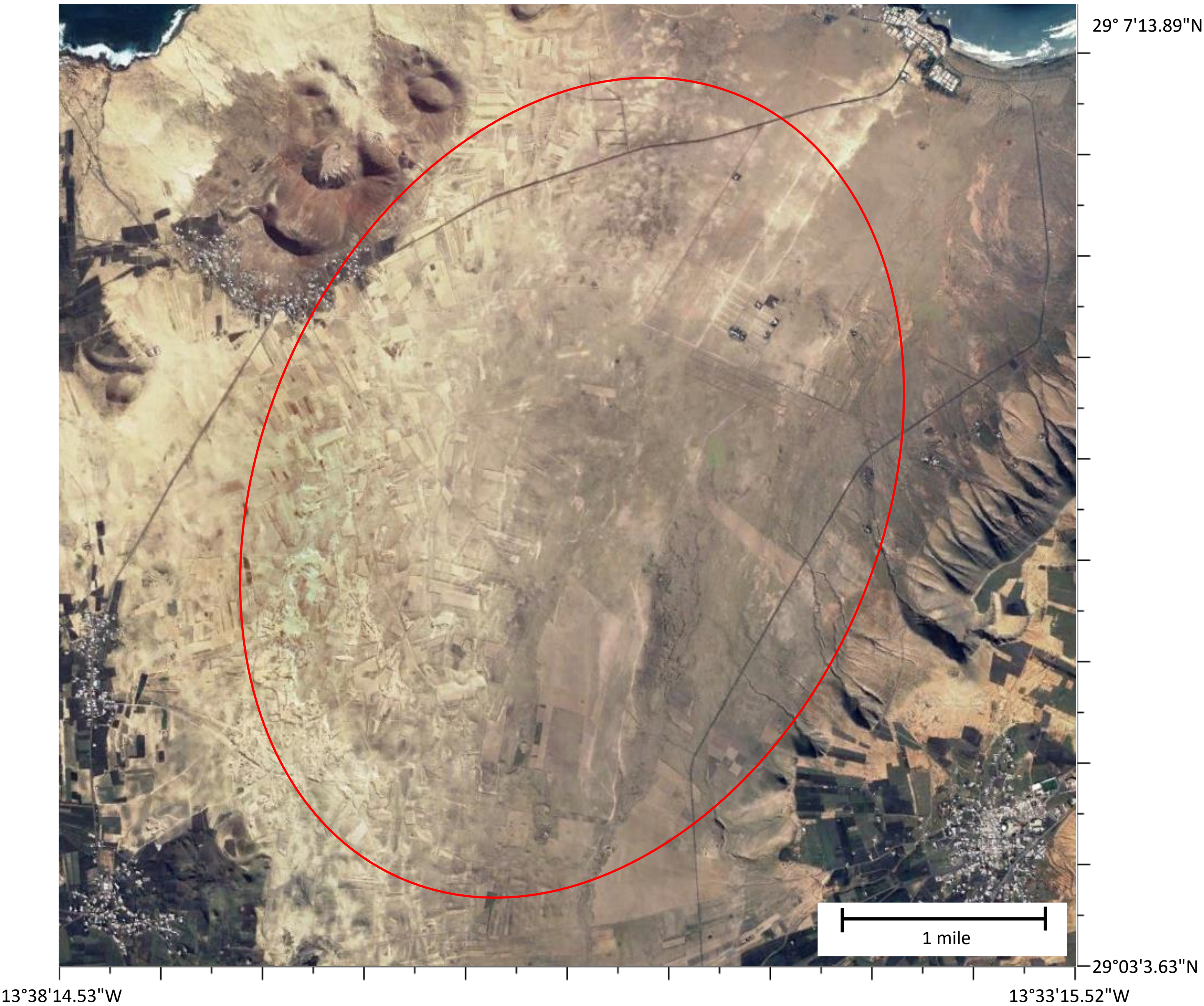


Figure 2.1.2. **Overview of the semi-desert study area in the north of Lanzarote, south-west of Famara.**

2.2. Pilot study

One week starting from 9th of July was dedicated to exploring possibilities of study areas and which species to use for the research. At this point in the research design, it was clear that the study would be based on habitat preferences of a bird species in the semi-desert environments of Lanzarote. However, which species and the appropriate study location was difficult to decide without doing a rough first hand survey of Lanzarote with particular objectives in mind. The qualities that were looked for when deciding on suitable study sites included ease of access; the ability to receive permission for research on the site; and reliable views of target bird species. Three species were originally considered: Stone-curlew (*Burhinus oedicnemus*), Houbara bustard (*Chlamydotis undulata*) and Cream-coloured Courser (*Cursorius cursor*). The Stone-curlew was discounted as they are nocturnal birds and thus show limited behaviour during the day. Houbara Bustards, although not too hard to find as well as seeming to show a relatively strong habitat preference, were only found as single individuals or a pair and were distributed thinly through the semi-desert. They also reacted strongly to the off-road vehicle with most either fleeing or hiding. This unnatural behaviour would have not helped towards understanding their habitat preference. The Cream-coloured Courser, conversely, showed very little concern for the vehicle and continued natural behaviours such as feeding and preening while being observed. This, along with their often large group size, was why it was picked as the study species. It was decided that the study area was the semi-desert habitat south-west of Famara (N29°6'55.33", 13°33'52.47") as it contains groups of Coursers and is close enough to acquire sediment samples from a bicycle thus reducing the environmental impact of the research.

2.3. Sampling techniques

2.3.1 Sediment and vegetation sampling

Using the knowledge of the conservation group *Desert Watch* and employees of the outdoor touring company *Lanzarote Active Club*, 25 sites of known regular Cream-Coloured Courser occurrences and 25 sites where Coursers have never been seen were mapped using a handheld GPS device. At these sites, named positive and negative sites respectively, sediment samples were taken within randomly selected 0.5 metre quadrat placements (*Figure 2.3.*). Random quadrat sample sites were determined by tossing a quadrat within the area in which the Coursers had been regularly or never seen. Sediment samples were taken by removing a small amount of surface sediment from within the quadrat with the open edge of a plastic re-sealable bag. In each quadrat the following data was also recorded: grain size range (µm), average pebble size (mm), pebble percentage cover, shell percentage cover, individual plant species cover and GPS location. Average shrub height (cm) was also recorded within a five metre radius of the quadrat at each site. Size fractions for sampling grain size of sand was determined using a laminated visual comparator grain size scale and a hand lens (Jones, Duck, Reed & Weyers, 2000).

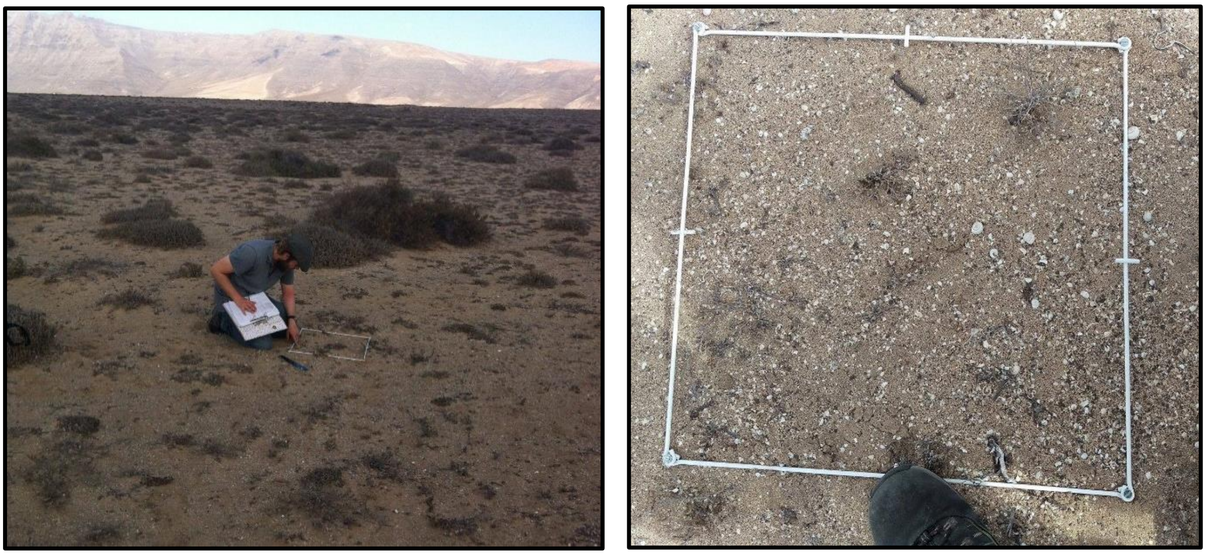


Figure 2.3. A and B. **Taking sediment and vegetation samples (A) and example quadrat (B).**

2.3.2. Behavioural observations

Using an off-road vehicle, the positive sites were visited and observed for groups of Coursers. If coursers were found they were watched and the following things were recorded before the behavioural observations: date, time, GPS location, and group size. Focal sampling was then performed on each individual of the group, using binoculars or a field scope (*Figure 2.4.A*), while another person kept track of individuals' movements to reduce the chances of repeated individual observations. Observations lasted for one minute within which all behaviours were recorded onto a tally based data sheet including pecking, digging, running, calling, vigilance, resting and any particular behaviours not previously thought of (Ethogram shown in Appendix).

Figure 2.4. A and B. **Taking behavioural observations with binoculars inside an off-road car (A) and *Cursorius cursor* showing pecking behaviour (B).**

2.4. Science communication leaflet

A science communication leaflet (*Appendix* C) was made alongside this study in affiliation with the *Desert Watch* conservation group. The leaflet is a bilingual information leaflet describing the identification, ecology and main threats of the Cream-coloured Courser along with general conservation on Lanzarote and an overview of the *Desert Watch* conservation group. All text is written with both English and Spanish translations that are made to be easily distinguishable though the use of two different text and background colours. The information included was researched from peer reviewed scientific papers with pictures taken by the *Desert Watch* group.

2.5. Analysis

Statistical analysis of data was conducted using SPSS statistics version 23 programme (2014). Kruskal-Wallis and Mann-Whitney U tests were used to compare biotic and abiotic factors in the 25 positive sites to determine if there was any significant difference between factors over the two site types. Mann-Whitney U tests were also used to compare observed behaviours of 40 *Cursorius cursor* individuals over nine locations to determine whether there was any significance between the locations. Calling behaviour had been excluded from analysis as no such behaviours were recorded. Mann-Whitney U tests were again used to determine which behavioural, biotic and abiotic factors were the most significantly different in locations that were themselves significantly different. All tests were carried out with a significance level of <0.05.

3. Results

3.1. Abiotic factors

Mann-Whitney U tests were conducted to compare abiotic factors in 25 positive and negative sites to determine if there was any significant difference between factors over the two site types.

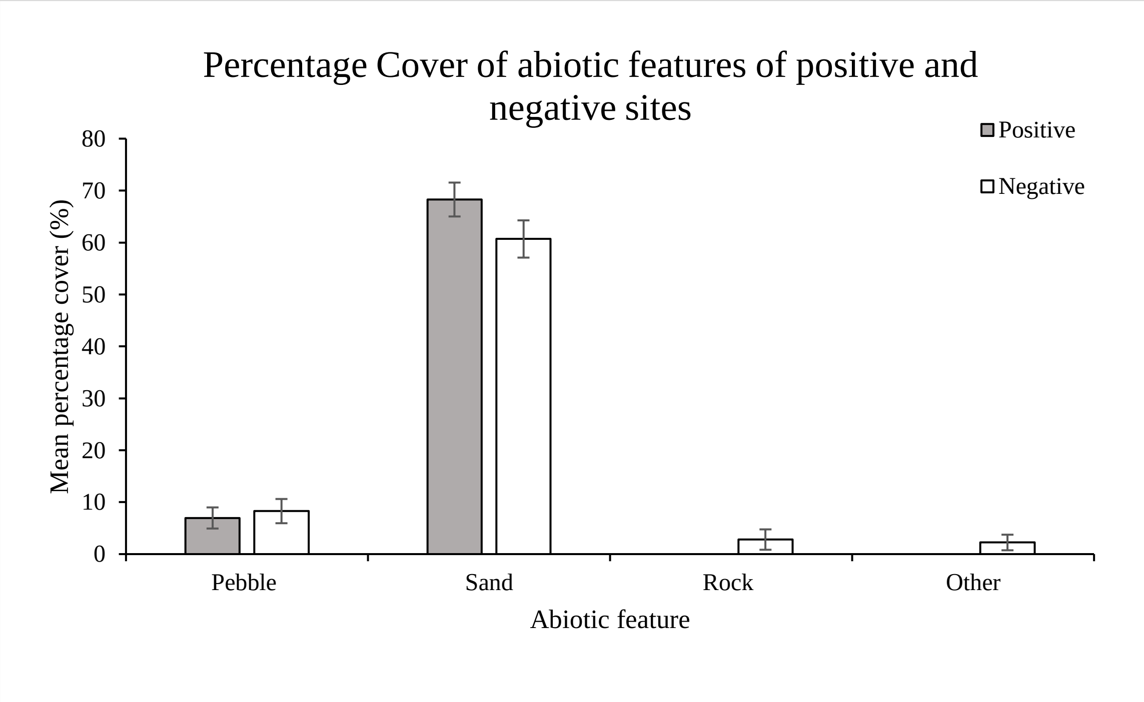


***Figure 3.1.1.* Percentage cover of abiotic features (pebble, sand, rock and other) based on samples from both positive and negative sites taken from semi-desert environment in Lanzarote with standard error (SE) bars.**

This Mann-Whitney U test was conducted to determine any significant difference between percentage covers of pebble, sand, rock and other at positive and negative sites (*Figure 3.1.1.*). These percentage covers: pebble (MWU = 280, P = 0.512), sand (MWU = 229.5, P = 0.107), rock (MWU = 287.5, P = 0.153) and other (MWU = 275, P = 0.077) were found to be not significantly different. Although not significantly different, rock and other was only found to occur on negative sites with none being found on positive ones.

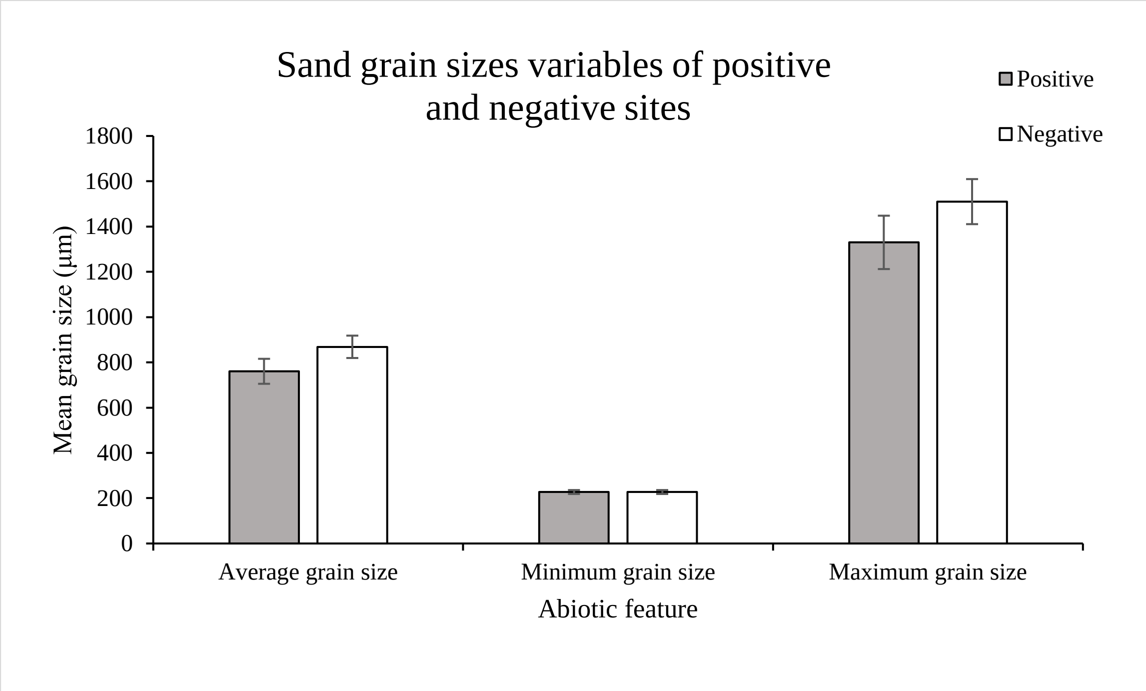


Figure 3.1.2. **Grain size variables (average grain size, minimum grain size and maximum grain size) based on samples from both positive and negative sites taken from semi-desert environment in Lanzarote with standard error (SE) bars.**

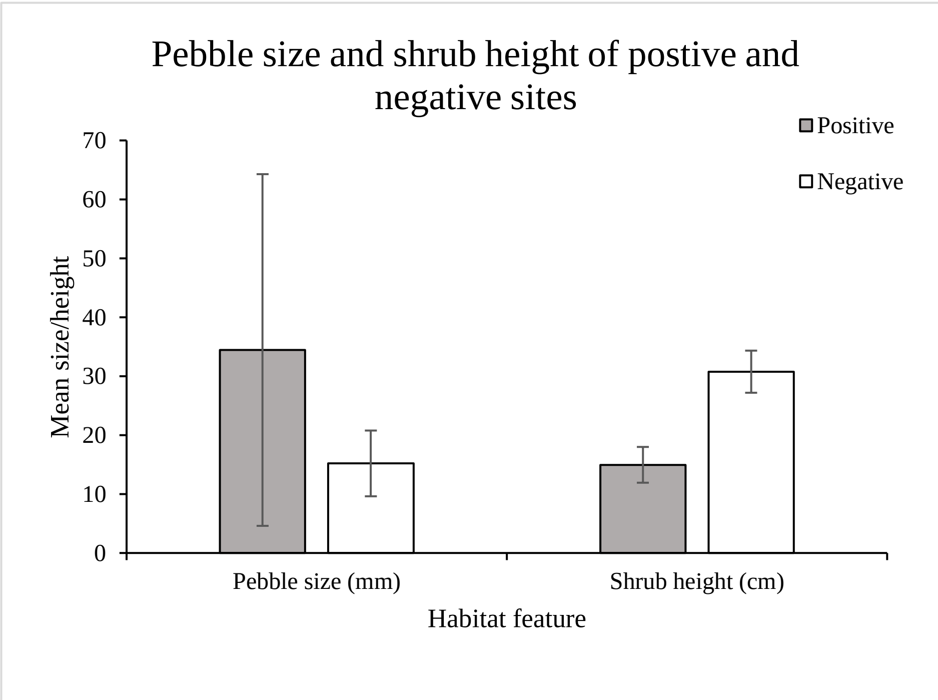


Figure 3.1.3. **Abiotic features (pebble size and shrub height) based on samples from both positive and negative sites taken from semi-desert environment in Lanzarote with standard error (SE) bars.**

This Mann-Whitney U test was conducted to determine any significant difference average grain size, minimum grain size, maximum grain size, pebble size and shrub height at the positive and negative sites (*Figure 3.1.2.*, *Figure 3.1.3.*). Of these factors, average grain size (MWU = 228, P = 0.097), minimum grain size (MWU = 312.5, P = 1.0), maximum grain size (MWU = 253, P = 0.228) and pebble size (MWU = 269.5, P = 0.386) were found to not be significantly different.

3.2. Biotic factors

Mann-Whitney U tests were conducted to compare biotic factors in 25 positive and negative sites to determine if there was any significant difference between factors over the two site types.

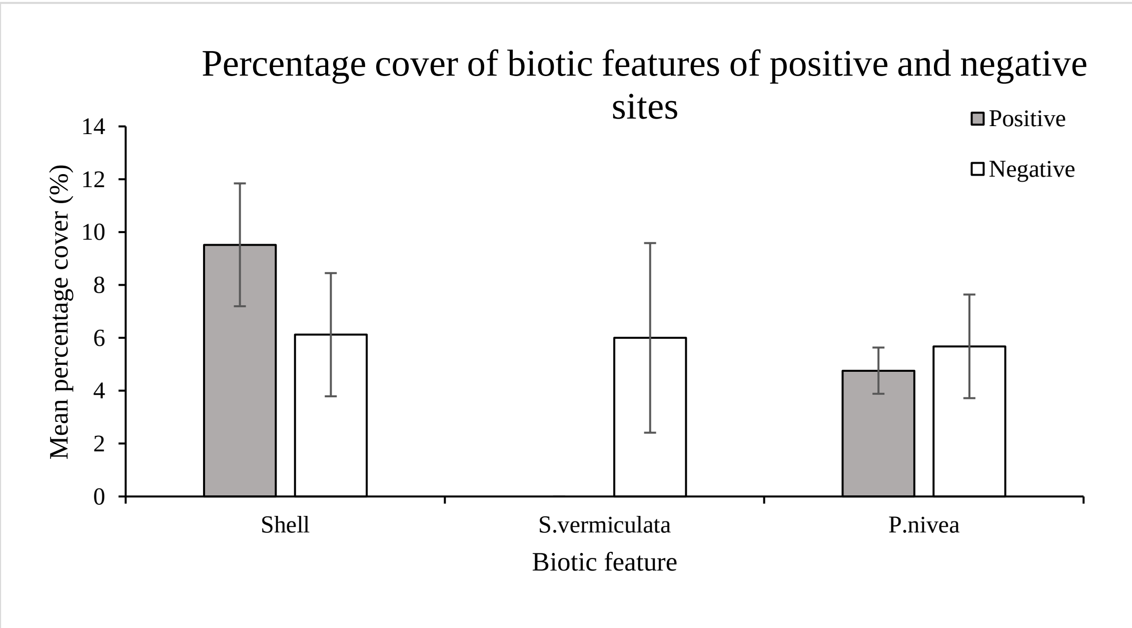


Figure 3.2.1. **Percentage cover of biotic features (shell, *S.vermiculata and P.nivea*) based on samples from both positive and negative sites taken from semi-desert environment in Lanzarote with standard error (SE) bars.**

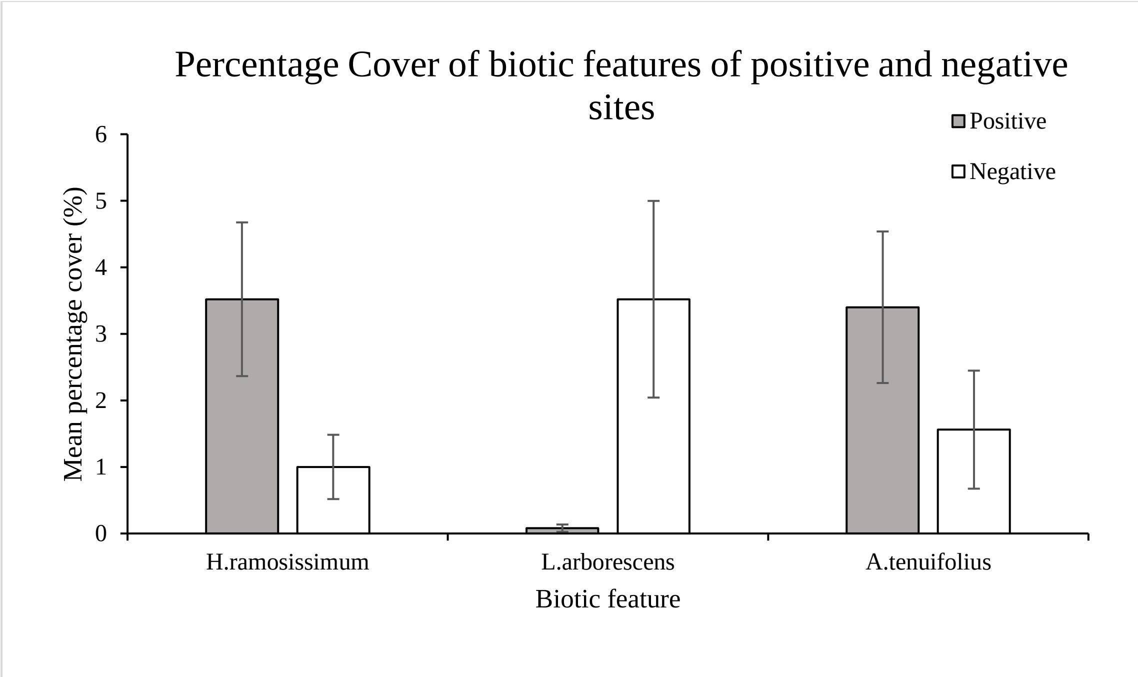


***Figure 3.2.2.* Percentage cover of biotic features (*H.ramosissimum, L.arborescens and A.tenuifolius*) based on samples from both positive and negative sites taken from semi-desert environment in Lanzarote with standard error (SE) bars.**

This Mann-Whitney U test was conducted to determine any significant difference between percentage covers of shell, *S.vermiculata*, *P.nivea*, *H.ramosissimum*, *L.arborescens*, *A.tenuifolius* (*Figure 3.2.1.*, *Figure 3.2.2.*) and shrub height (*Figure 3.1.3*). Of these factors, shell (MWU = 300, P = 0.807), *S.vermiculata* (MWU = 275, P = 0.077), *P.nivea* (MWU = 262.5, P = 0.321) and *H.ramosissimum* (MWU = 241, P = 0.087) were found to be not significantly different. While *L.arborescens* (MWU = 230.5, P = 0.023) and *A.tenuifolius* (MWU = 214.5, P = 0.027) were found to be significantly different with *L.arborescens* occurring significantly more in negative sites and *A.tenuifolius* occurring significantly more in positive sites. Shrub height (MWU = 142.5, P = 0.001) was also found to be significantly different with shrubs occurring significantly taller in negative sites. Although not significantly different, the percentage cover of shell was on average greater on positive sites than negative ones.

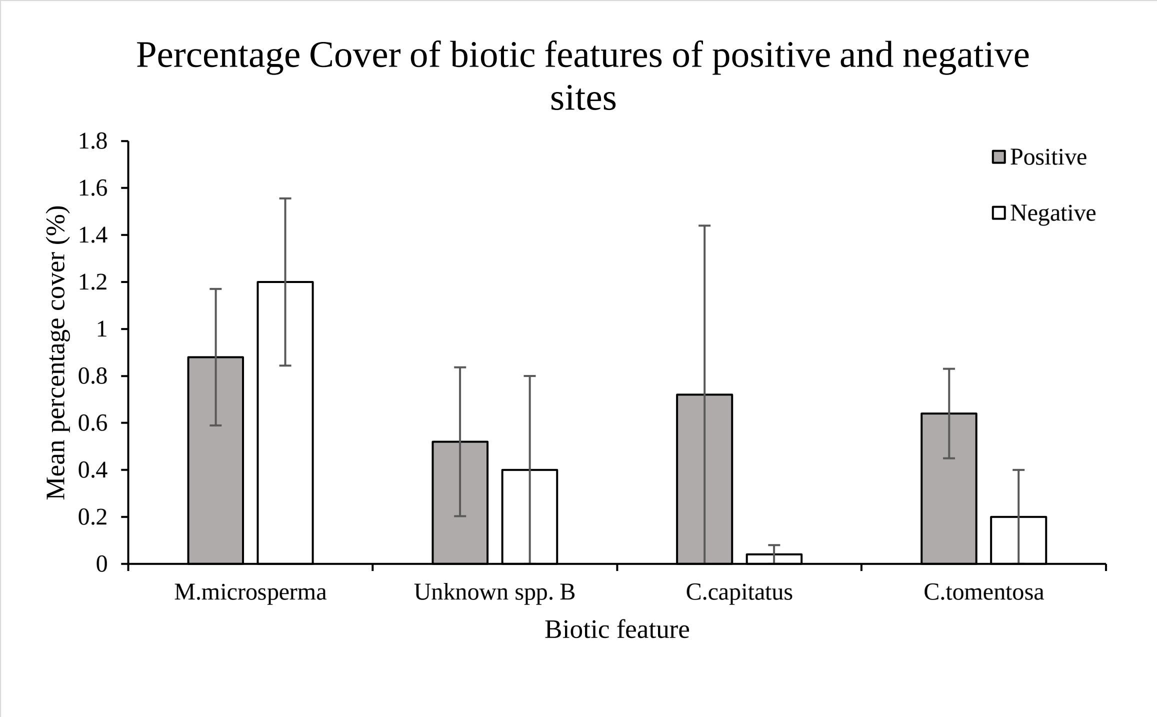


Figure 3.2.3. Percentage cover of biotic features (*M.microsperma*, Unknown *spp*. B, *C.capitatus* and *C.tomentosa*) based on samples from both positive and negative sites taken from semi-desert environment in Lanzarote with standard error (SE) bars.

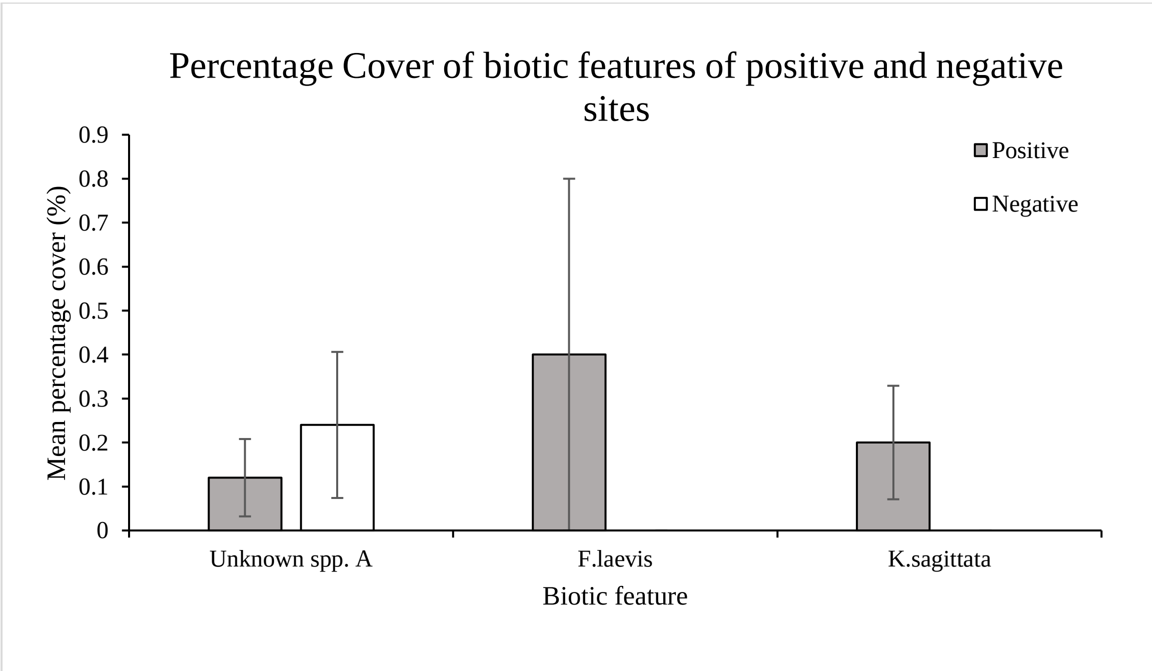
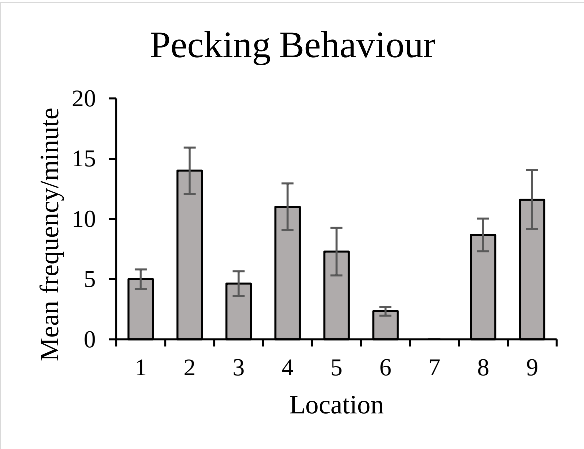


Figure 3.2.4. **Percentage cover of biotic features (Unknown *spp.* A, *F.laevis and K.sagittata*) based on samples from both positive and negative sites taken from semi-desert environment in Lanzarote with standard error (SE) bars.**

This Mann-Whitney U test was conducted to determine any significant difference between percentage covers of *M.microsperma*, Unknown *spp*. B, *C.capitatus*, *C.tomentosa*, *F.laevis*, Unknown *spp*. A, *K.sagittata* (*Figure 3.2.3., Figure 3.2.4.*). Of these factors, *M.microsperma* (MWU =284, P = 0.531), Unknown *spp*. B (MWU = 289, P = 0.322), *C.capitatus* (MWU = 312, P = 0.977), Unknown *spp*. A (MWU = 300, P = 0.641), *F.laevis* (MWU =300, P = 0.317) and *K.sagittata* (MWU = 275, P = 0.077) were found to be not significantly different. While *C.tomentosa* (MWU = 229, P = 0.015) was found to be significantly different occurring significantly more in positive sites.

3.3. Behavioural analysis

Mann-Whitney U tests were conducted to compare observed behaviours of 40 *Cursorius cursor* individuals over nine locations to determine whether there is any significance between the locations.



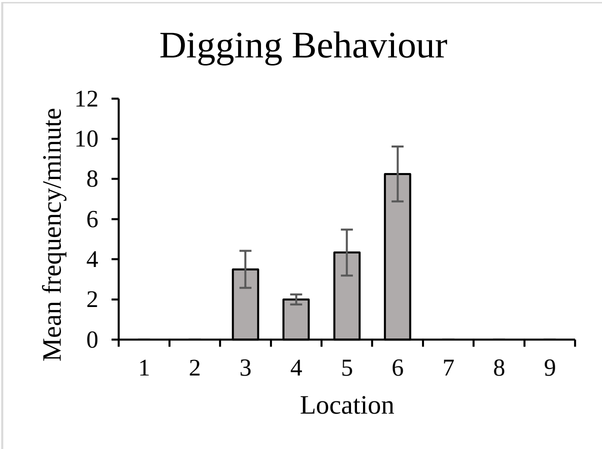


Figure 3.3.1. **Mean frequency/minute of pecking and digging behaviour based on behavioural samples taken from semi-desert environment in Lanzarote with standard error (SE) bars.**

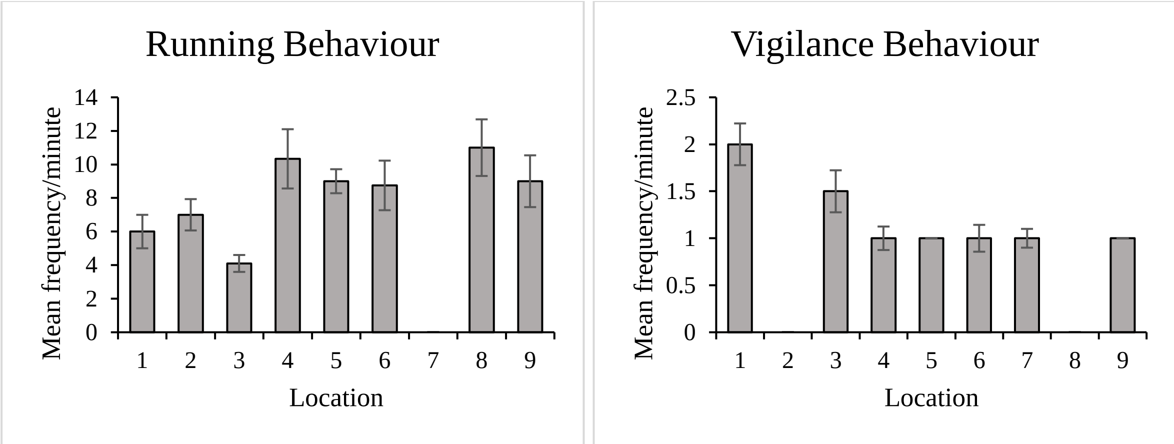


Figure 3.3.2. **Mean frequency/minute of running and vigilance behaviour based on behavioural samples taken from semi-desert environment in Lanzarote with standard error (SE) bars.**

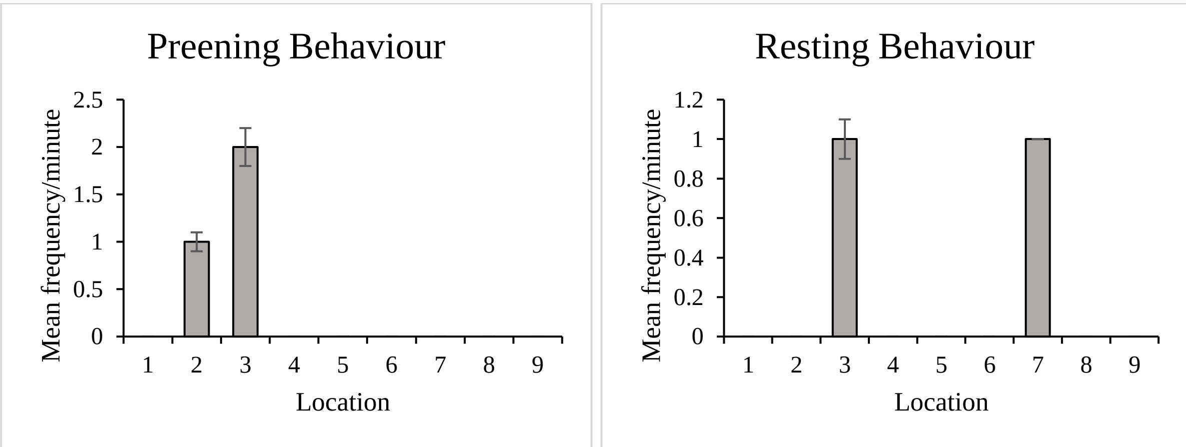


Figure 3.3.3. **Mean frequency/minute of preening and resting behaviour based on behavioural samples taken from semi-desert environment in Lanzarote with standard error (SE) bars.**

This Kruskal-Wallis test was conducted to determine any significant difference between the nine different locations when comparing frequency of pecking, digging, running, vigilance, preening and resting behaviours per minute (*Figure 1.3.1 - Figure 1.3.3*). Of these, location 1 ($\chi^2(2) = 0.750$, $P = 0.687$), location 2 ($\chi^2(2) = 3.789$, $P = 0.150$), location 3 ($\chi^2(5) = 10.811$, $P = 0.687$), location 4 ($\chi^2(3) = 3.857$, $P = 0.277$), location 7 ($\chi^2(1) = 0.00$, $P = 1.000$), location 8 ($\chi^2(1) = 1.765$, $P = 0.184$) and location 9 ($\chi^2(2) = 3.000$, $P = 0.223$) were found to be not significantly different. However, location 5 ($\chi^2(3) = 9.468$, $P = 0.024$) and location 6 ($\chi^2(3) = 7.852$, $P = 0.049$) were found to be significantly different when compared to the other locations.

Due to showing statistical significance, location 5 and location 6 were used to perform a Mann-Whitney U test to determine which behaviours were the most significantly different in location 5 and location 6 individually over all locations. At location 5 all four behaviours tested: pecking

(MWU = 68, *P* = 0.564), digging (MWU = 17.5, *P* = 0.628), running (MWU = 80.5, *P* = 0.105) and vigilance (MWU = 3.0, *P* = 0.727) all individually showed no significance due to the lack of data. Preening and resting behaviour was not tested as they did not occur during the observation period at location 5. At location 6, significantly less pecking behaviour (MWU = 13.5, *P* = 0.049) and significantly more digging behaviour (MWU = 4.5, *P* = 0.010) was observed while running (MWU = 55.5, *P* = 0.517) and vigilance (MWU = 3.5, *P* = 0.667) showed no statistical significance.

A Mann-Whitney U test was conducted to determine if there was a significance difference between sediment and plant samples at location 6 when compared to the other locations. Rock and 'other' were not found on positive samples so where included. Grain size averages, grain size minimums, grain size maximums, shrub heights and percentage covers of pebble, sand, shell, *M.microsperma*, Unknown *spp*. A, *S.vermiculata*, *P.nivea*, *F.laevis*, *K.sagittata*, *H.ramosissimum*, *L.arborescens*, *A.tenuifolius*, Unknown *spp*. B, *C.capitatus* and *C.tomentosa* were tested and showed no significant difference (*P*= 0.25 – 1.00) when compared to the other locations with. Unknown spp. A, S.vermiculata, P.nivea, F.laevis, K.sagittata, H.ramosissimum, L.arborescens, A.tenuifolius, Unknown spp. B and C.capitatus did not occur on the nine locations and so were removed for statistical analysis.

4. Discussion

4.1. Preference in abiotic factors

The study area solely encompassed a semi-desert environment which meant that abiotic factors made up the dominant features of the habitat surveyed with sand alone taking up on average 68% of all quadrats. Comparatively, biotic factors like vegetation are sparsely distributed (Palomino et al., 2008). Consequently, it was considered that abiotic factors would have a greater impact on the Courser's habitat preference (Palomino et al., 2008) though is not one of the research hypotheses of this study. Abiotic features found in the survey sites included sand from the Pleistocene epoch (0.8-0.1Ma), pebbles and exposed igneous rock from lava flows from the Miocene epoch (10-6.3Ma). Statistical analysis using non-parametric Mann-Whitney U tests showed that none of the abiotic features found in the positive and negative sites were significantly different. This supports the null hypothesis that Cream-coloured Coursers do not have a significant habitat preference based on abiotic habitat features alone. Despite this, rock cover was only found in negative samples and is not statistically different due to it only occurring in two of the samples. If the study was conducted over a longer period of time where more samples were taken, it is considered that this rock correlation, particularly solidified lava, at only negative sites would be maintained. Palomino et al. (2008) did a similar habitat preference study of Cream-coloured Coursers on Fuerteventura and Lanzarote. In this they found that the probability of occurrence was highest for Coursers in areas with less than 11% in maximum slope steepness and less than 23% rock cover which matches the trend found in this study. Traba et al. (2013) also found that Cream-coloured Coursers in Morocco follow the same trend of preferring areas with gentle slope and low rock cover. A preference in areas with higher bare ground cover and higher pebble cover has also been shown (Traba et al., 2013) though this is not supported by results found in this study which showed that percentage pebble cover is not significantly different between positive and negative sites. It is suggested that Cream-coloured Coursers prefer to avoid these conditions of steeper and rougher terrains as they are a cursorial species (well adapted to running (Abourachid, & Renous, 2000)). Steeper and rougher terrains lead to higher biomechanical and energetic costs towards ground locomotion which constrain the Coursers cursorial behaviours.

4.2. Preference in biotic factors

Statistical analysis using non-parametric Mann-Whitney U tests showed that three of the twelve plant species found in the sample sites were significantly different between positive and negative samples. This supports the alternative hypothesis that Cream-coloured Coursers do have a significant habitat preference based on biotic habitat features. Results showed that *A.tenuifolius* and *C.tomentosa* occurred significantly more at positive sites compared to negative sites while *L.arborescens* (*Figure 4.2.*) occurred significantly more at negative sites compared to positive sites. Although not statistically different, *F.laevis* and *K.sagittata* were only found to occur at positive sites with *S.vermiculata* only occurring at negative sites. No other research to date has been performed to determine the significance of different plant species on the habitat preference of the Cream-coloured Courser. Consequently, the reason for their significance is unclear as the vegetation does not directly contribute to the Coursers diet. Also, apart from *L.arborescens*, these species at the time of study were small, desiccated, and in a dormant or dead life stage (*Figure 4.2.B.*) which could mean that they have little in the way of biotic significance. They may, however, be a preference for insect prey of the Coursers or have a correlation with the Courser’s preferred abiotic features. Further research would have to be conducted to find the relation between the significant occurrence of these plant species and the Cream-coloured Coursers habitat preference.

***Figure 4.2. A and B. L.arborescens* flowering with healthy growth (A) (taken from www.floradecanarias.com) and desiccated condition of *L.arborescens* found at sample sites (B).**

Statistical analysis using non-parametric Mann-Whitney U tests also showed that shrub height (mostly comprised of *L.arborescens*) was significantly higher at negative sites compared to positive sites. This further supports the alternative hypothesis that Cream-coloured Coursers do have a significant habitat preference based on biotic habitat features. This result correlates with other studies that show a strong habitat avoidance of areas with tall vegetation (Palomino et al., 2008; Traba et al., 2013). It has been shown that this is due to short vegetation cover increasing ground-foraging efficiency and decreasing predation risks by facilitating vigilance (Whittingham, & Evans, 2004). Another reason for Cream-coloured Coursers to avoid habitats with a high density of *L.arborescens* is that it contributes to the diet of other Lanzarote semi-desert species such as the Houbara Bustard (*Chlamydotis undulata fuertaventurae*) and the Atlantic Lizard (*Gallotia atlantica*). Both species could potentially present intraspecies competition for food resources as they also include insect prey in their diet similar to that of the Cream-coloured Courser (Collins, 1993; Molina-Borja, & Barquin, 1986). Areas with high percentage cover of *L.arborescens* are also used by goat farmers that frequently herd the goats to these areas as they can graze on the *L.arborescens* (Martín, Marrero, & Nogales, 2003). Observations of the Cream-coloured Courser that included the presence of goats were discounted from being behavioural samples as the Coursers avoided the goats, presenting fleeing behaviour, by running or even flying away. Coursers avoiding interacting with the goats may be another reason why they avoid areas with high *L.arborescens* cover due to frequent goat activity. However, other studies have suggested that goat grazing seems to not have an important behavioural influence on the Cream-coloured Courser (Palomino et al., 2008).

4.3. Behavioural relationship with habitat preference

To determine if different abiotic and biotic habitat features affected the Cream-coloured Coursers behaviour, non-parametric Kruskal-Wallis and Mann-Whitney U tests were used to compare observed behaviours of 40 Courser individuals at nine locations to deduce any significant differences. Results showed that of the nine observation sites, only two were shown to have observed behaviours that were significantly different. This included a significantly increased frequency per minute of digging behaviour and significantly reduced frequency per minute of pecking behaviour showing that the Coursers spent more time digging for prey items than pecking at those on the surface at one of these locations. However, the difference in pecking and digging behaviours at this site cannot be justified to be as a result of different habitat features. This is because there is no significant difference in habitat features at these locations when compared to the other observation sites. This could be due to a lack of both behavioural and habitat feature data. It may also be because pecking and digging are both foraging behaviours which would not be directly affected by the habitat features sampled in this study as they are not included in the Coursers diet. The difference in feeding behaviours at this location is nevertheless suggestive of the Coursers feeding on different prey items. As prey species were not considered in this study, further research on prey species of the Cream-coloured Courser would have to be conducted to determine the amount of significance on habitat preference.

A more definitive rationale for the significant change in foraging behaviour of this group of Coursers observed is that it consisted of three adult birds, one juvenile and two chicks. This is unlike all other groups observed that only consisted of adults. Studies on other bird species have shown different diets of adults and chicks of the same species (Ydenberg et al., 1994; Saunders & Ydenberg, 1995) as well as adults changing foraging behaviour and prey selection when catching prey for self-feeding compared to chick provisioning (Davoren & Burger, 1999). Davoren & Burger (1999) suggest the reason for this is due to adults having greater energetic costs, for collecting as well as delivering the food, than benefits while provisioning chicks. Consequently, adults need to collect food that benefits long-term survival rather than short-term energy balance which is achieved though changing diet and foraging behaviour. Further study would have to be conducted in order to determine whether Cream-coloured

Coursers change their preference in habitats due to diet requirements when providing for chicks as well as for other life stage requirements.

4.4. Limitations and future research

Research on Cream-coloured Coursers is limited, particularly on the population inhabiting the island of Lanzarote. Because of this, beneficial information such as migration patterns, social networks and local distributions is unknown. This knowledge would allow for more efficient data collection and an understanding of variables which may affect results of other research. A possible rectification for this would be to ring Cream-coloured Coursers not only in Lanzarote but across their global distribution. This would allow research such as local distribution patterns; natal and breeding dispersal; colonisation and range expansion; metapopulation and source-sink dynamics; population genetic structure (Paradis, Baillie, Sutherland & Gregory, 1998) and monitoring of the timing, duration and direction of migration (Fiedler, 2003; Mouritsen, 1998). This would be beneficial to habitat preference studies as more accurate local distributions show distinct areas of used and available habitat to survey for differences in habitat features.

The distribution of Cream-coloured Coursers in its entirety is very large, spanning multiple continents, which is the cause of them being of least concern on the IUCN Red List (2016). However, it does cause difficulties when trying to perform in depth research on the species as a whole. It is limited on how much time, money and permission a researcher has to travel and study the Cream-coloured Courser in the different habitats across its global range. It is why this research project was only performed on a relatively small population on the island of Lanzarote and not at a larger scale. This is also why this study was limited to a short research time, as well as not over seasons, which limits the amount of data that can be collected and also the reliability of the results found. A study on Skylarks (*Alauda arvensis*) in southern England (Whittingham, Wilson, & Donald, 2003), found that, at least for Skylarks, there is a large generality in habitat preference across differently located populations. The study states that conservationists should have confidence in using management strategies based on habitat-association models of one population on other populations, however, also states that quantitative predictions should not be used. This means that small scale studies, although limited, can still prove to be of use for conservation of a species across its global distribution range. One other limitation of the Cream-coloured Courser's large global range is that not all studies conducted on the species will be written, or translated, into English. It previously has been stated that the research on Cream-coloured Coursers is limited but only in reference to English written or translated studies, due to the researchers involved only being able to read English, and as such may be incorrect. This highlights the importance of the Linneaus classification system of using a universal Latin genus and species name for every species. It allows researchers to search journal databases to find papers written in all languages which includes the particular species searched for.

The study was also restricted to certain times of day that the Coursers could be observed due to temporal changes in behaviour. During a short pilot study where bird species were observed to determine viability of study, it was clear that the Cream-coloured Courser could only be reliably seen between 9:00-16:30. As stated before the study was also restricted to one week in June, late August and September. Conducting the experiment throughout the year or at certain seasonal intervals would allow for a better understanding of the Cream-coloured Courser's habitat preference which in turn would be a greater use for species conservation and management. Another limiting factor for the study was that the behaviour of Cream-coloured Coursers includes traveling to different locations daily as well as being sparsely distributed throughout the semi-desert environment. This, along with their excellent camouflage, made them difficult to see which when combined with a limited study time lead to a limited number and frequency of Courser sightings. The addition of extensive heat haze caused a limitation in visibility of groups at long distances, the distance changing daily depending on temperature. This meant that though distant groups could be positively identified as Cream-coloured Coursers, observations of their behaviour had to be discounted due to a high chances of human error. Other discounted observations included those with the presence of goats as the Coursers avoided the goats and as such only presented fleeing behaviour. Another limitation due to the Courser's behaviour is that they reacted strongly to the sight of a human. This meant that no observations could be taken by walking or cycling through the semi-desert. Luckily they responded surprisingly little to off-road vehicles, which disguises the outline of a human body, and seemed almost completely habituated to them. This allowed for observational data to be collected in the vehicle but attempts to leave the vehicle would cause the Coursers to change from more natural undisturbed behaviours to fleeing or hiding. Consequently, this limited the length of time during the study period to be trying to locate groups of Coursers as the vehicle was only available on certain days at certain times. Another rectification for this would be the erection of strategically placed bird hides using the knowledge and management of the *Desert watch* conservation group. This would allow for the safe and non-intrusive observation of the

Cream-coloured Courser and other species without the need for an off-road vehicle. Birds hides could not only improve this study but also other research based in the semi-desert environments of Lanzarote. Focal improvements to this study would be to have a longer data gathering period spanning over seasonal changes with a greater amount of habitat feature and behavioural samples at particular locations. This would allow for a greater understanding of the true habitat preference of the Cream-coloured Courser as well as improving reliability of results.

4.5. Implications for conservation

Conserving the preferred habitat of a species is an important part of maintaining its conservation status. Habitat loss is one of the greatest threats to population health and species survival (Mills, 2007). The impact on conservation of knowing which habitats are used more frequently and which particular features cause the greater preference in these areas, both abiotic and biotic, is large. It helps determine the appropriate habitat features to conserve and allows for more informed and efficient conservation and management strategies (Cañadas et al., 2005). This study highlights the fact that Cream-coloured Coursers do have microhabitat preferences within seemingly similar areas. Although not shown in this study, the importance of showing consideration for abiotic features when studying habitat preference is apparent through other studies of Cream-coloured Coursers in in the eastern Canary Islands and North Africa (Palomino et al., 2008; Traba et al., 2013). Nichols, Killingbeck & August (1998) suggest that the conservation of geodiversity allows for the conservation of biological processes that generate and maintain biodiversity causing geodiversity to underpin biodiversity (Burek, 2001). The behavioural aspect of this study shows that it is important to also consider that the change of a species preference can additionally depend on changes of behavioural patterns. These can be according to time of year, food availability, amount of competition, predation risk and critical life stages (Doherty, Naugle, Walker, & Graham, 2008). Overall the implications of this study is that the results closely match those of the few similar studies on habitat preference of the Cream-coloured Courser (Palomino et al., 2008; Traba et al., 2013). This increases the reliability of the combined findings of research in this area allowing management strategies to be made with greater confidence and likely success. Conservation priorities to improve the quality of conservation include defining the critical areas for the Cream-coloured Courser and restricting the vehicle movement; controlling goat grazing and the prevention of habitat alteration in these areas (González, 1999). Additionally, increasing the awareness and education of the Cream-coloured Coursers to the general public and goat herders to get them to participate or cooperate in the conservation efforts towards their local bird species (Azman et al., 2010; Bickford et al., 2012).

5. Conclusions

Comparing habitat features in areas with frequent Courser occurrences to those where they have never been seen showed that Cream-coloured Coursers do have particular habitat preferences. The majority of habitat features sampled in this study were found not to contribute to the habitat preference of the Coursers though several biotic features were significantly different between positive and negative sites. Results showed that the Cream-coloured Coursers preferred areas with higher percentage covers of *A.tenuifolius* and *C.tomentosa* and avoided areas with higher percentage covers of *L.arborescens* and tall shrubs. Recording behaviours at particular sites and comparing differences in behaviours to those sites habitat features showed that significant behavioural changes were not affected by habitat features. These findings support the alternative hypothesis that Cream-coloured Coursers do have a significant habitat preference based on biotic habitat features. While they also support the null hypotheses that Cream-coloured Coursers do not have a significant habitat preference based on abiotic habitat features and do not show significant behavioural differences at locations with significantly different habitat features.

With the current amount of research in this field, it is not possible explain why the Coursers prefer greater amounts of *A.tenuifolius* and *C.tomentosa* in their habitats. However, other research does suggest that Cream-coloured Coursers do show spatial segregation with other species (Traba et al., 2013). *L.arborescens* is included in the diet of other omnivorous semi-desert species that also eat the Coursers invertebrate prey. Due to this it is suggested that the Coursers avoid the *L.arborescens* to avoid interspecies competition for food resources. Other studies also suggest that the Coursers avoid tall shrubs as shorter vegetation cover increases ground-foraging efficiency and decreases predation risks by facilitating vigilance (Whittingham, & Evans, 2004). Significant behavioural changes between sites were likely to be due to the presence of Courser chicks in the group observed. This highlights the importance of considering that the change of a species preference can be affected by other variables not included in this study such as time of year, food availability, amount of competition, predation risk and critical life stages (Doherty, Naugle, Walker, & Graham, 2008).

The overall implications of this study is that it is a relatively large proportion of the total amount of research done on the habitat preference of Cream-coloured Coursers as well as possibly the only one to research their relationship between habitat preference and behaviour. The increased amount of data in the research area causes the results of each study to be more reliable allowing them to be a dependable base for conservation and management strategies. The implications of the science communication leaflet created along with this project is that it is a tool to increase education and awareness of the Cream-coloured Courser to the public. The education and awareness of species in conservation is often underestimated and can be a valuable tool in generating societal change that is required for creating successful conservation strategies (Azman et al., 2010; Bickford et al., 2012).

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Appendix B – Science Communication Leaflet

Desert watch

DESERT WATCH is a project of a non-profit association "Viento del Noreste" which translates as Trade Winds. Its aim is to create awareness and is composed of volunteers that meet regularly to collect all types of biological data from the amazing habitat of El Jable; which is a vast desert found in the Canary island of Lanzarote. Besides bird counts, control of the phenology of plants and cleaning of the desert, the group also organises several types of scientific lectures detailing flora, fauna & geology found in the unique, protected reserve.

DESERT WATCH es un proyecto de la asociación sin ánimo de lucro "Viento del Noreste". Se trata de un grupo de voluntarios que se reúne periódicamente para recopilar información biológica sobre el espectacular hábitat del Jable de Lanzarote. Aparte del recuento de aves, control fenológico de las plantas y limpieza del desierto, Desert Watch organiza diversas charlas científicas sobre la flora, fauna y geología de la zona, así como colaboraciones con universidades europeas en el ámbito de la investigación y todo tipo de actuaciones de concienciación y conservación.

Conservation on Lanzarote

In October 1993 the United Nations Educational, Scientific and Cultural Organisation (UNESCO) declared Lanzarote a Global Biosphere Reserve. The aim is to conserve and create natural and cultural values through the use of careful management. Lanzarote and the Chinijo Islands were declared a UNESCO Global Geopark in 2015 which covers almost 2500km² of the islands and the surrounding ocean. The Geopark status was put in place to manage Lanzarote as a place of international geological significance to advance the protection, education and sustainable development of its environment.

Conservación en Lanzarote

En octubre de 1993, Lanzarote fue declarado Reserva Mundial de la Biosfera por la Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura (UNESCO). El objetivo es conservar y crear valores naturales y culturales mediante una gestión sostenible. Lanzarote y el Archipiélago Chinijo fueron declarados Geoparque Global de la UNESCO en 2015, el cual cubre una extensión alrededor de 2500km² de las islas y las aguas pertenecientes a la reserva marina. El estatus de Geoparque fue otorgado para la gestión de Lanzarote como un lugar de importancia geológica internacional para promover la protección, educación y desarrollo sostenible de su medioambiente.

Supported by
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United Nations Educational, Scientific and Cultural Organization · UNESCO Global Geoparks

University of Chester

DESERT WATCH

Cream-coloured Courser

(Cursorius cursor)

Identification and description

The Cream-coloured Courser (*Cursorius cursor*) is easily identified by its sandy-buff plumage and pale legs. They typically stand upright with a white lower belly and sharply contrasting black wing tips and black underwings, which are visible in flight. The head is strikingly marked with a black stripe from the eye to the back of the neck, bordered above by a white stripe, and has a bluish-grey crown.

Cream-coloured coursers like to live within warm desert environments in the Middle East, northern Africa and three of the Canary Islands: Fuerteventura, Gran Canaria and Lanzarote. In Lanzarote they can be seen within the desert north-west of Teguise in groups up to 14 strong running in short bursts to find small insects to eat. The breeding season is typically between February and May when they lay usually two eggs on shallow unlined scrapes in the desert sand.

Identificación y descripción

El corredor sahariano (*Cursorius cursor*) es fácilmente identificable por su plumaje de color beige-arena y sus patas claras. Su postura típica es erguida, tiene la parte inferior de la barriga blanca en contraste con las puntas y la parte inferior de las alas que son negras, lo que es claramente visible en vuelo. En la cabeza tiene una banda negra bien definida desde el ojo hasta la nuca, con un borde de color blanco en la parte superior y una coronilla azul-gris.

Los corredores saharianos suelen habitar en ambientes cálidos y desérticos en Oriente Medio, África del Norte y las Islas Canarias orientales: Fuerteventura, Gran Canaria y Lanzarote. En Lanzarote se pueden observar en el desierto de Soo al suroeste de Teguise en grupos de hasta 14 individuos, realizando trayectos cortos de forma veloz con paradas repentinas atrás de pequeños insectos para comer. La época de cría tiene lugar normalmente entre febrero y mayo y suelen poner 2 huevos sobre la propia arena del desierto, sin hacer ninguna alteración sobre la superficie.

Threats

Currently, the main threats facing a lot of species in the desert are the destruction of habitats through development of unsympathetic tourist resorts and the building of new roads. Livestock grazing and increased amounts off-road tourist vehicles also contribute to habitat destruction and disturbance of many species including the cream-coloured coursers. Climate change may also have as yet undetermined effects.

Amenazas

Actualmente las principales amenazas para muchas especies en el desierto, son la destrucción de los hábitats por el desarrollo no sostenible de complejos turísticos y mediante la construcción de nuevas carreteras. El incremento del número de vehículos turísticos todoterreno y el pastoreo también están contribuyendo a la destrucción del habitat y perturban muchas especies, incluyendo los corredores saharianos. El cambio climático también puede tener efectos aún sin determinar.

Appendix C – Behavioural Frequency Data Sheet

<u>Frequency data sheet</u>

Date, GPS, Time, Group size, Notes	Sample	Behaviour							
		Pecking	Digging	Running	Calling	Vigilance	Preening	Resting	Other
	1								
	2								
	3								
	4								
	5								
	6								
	7								
	8								
	9								
	10								

Appendix D – SPSS Outputs

Mann-Whitney U tests - Abiotic factors:

Pebble, Sand, Rock and Other.

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
Pebble	50	7.6200	10.84377	.00	40.00	.0000	2.0000	10.5000
Sand	50	64.4800	17.39955	29.00	96.00	52.0000	64.0000	79.2500
Rock	50	1.4000	7.00146	.00	40.00	.0000	.0000	.0000
Other	50	1.1200	5.37811	.00	30.00	.0000	.0000	.0000
sitetype	50	1.5000	.50508	1.00	2.00	1.0000	1.5000	2.0000

Ranks

	sitetype	N	Mean Rank	Sum of Ranks
Pebble	Positive	25	24.20	605.00
	Negative	25	26.80	670.00
	Total	50		
Sand	Positive	25	28.82	720.50
	Negative	25	22.18	554.50
	Total	50		
Rock	Positive	25	24.50	612.50
	Negative	25	26.50	662.50
	Total	50		
Other	Positive	25	24.00	600.00
	Negative	25	27.00	675.00
	Total	50		

Test Statistics[a]

	Pebble	Sand	Rock	Other
Mann-Whitney U	280.000	229.500	287.500	275.000
Wilcoxon W	605.000	554.500	612.500	600.000
Z	-.656	-1.612	-1.429	-1.768
Asymp. Sig. (2-tailed)	.512	.107	.153	.077

a. Grouping Variable: sitetype

Pebble size, Average grain size, Minimum grain size, Maximum grain size and Shrub height (biotic).

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
Averagegrainsize	50	814.5750	265.07194	343.50	1125.00	593.5000	875.0000	1093.5000
Minimumgrainsize	50	227.2800	43.50887	187.00	375.00	187.0000	250.0000	250.0000
Maximumgrainsize	50	1420.0000	547.34983	500.00	2000.00	1000.0000	1500.0000	2000.0000
Pebblesize	50	24.8200	106.64756	.00	750.00	.0000	5.5000	10.2500
Shrubheight	50	22.8600	18.24327	.00	60.00	.0000	24.5000	30.5000
sitetype	50	1.5000	.50508	1.00	2.00	1.0000	1.5000	2.0000

Ranks

	sitetype	N	Mean Rank	Sum of Ranks
Averagegrainsize	Positive	25	22.12	553.00
	Negative	25	28.88	722.00
	Total	50		
Minimumgrainsize	Positive	25	25.50	637.50
	Negative	25	25.50	637.50
	Total	50		
Maximumgrainsize	Positive	25	23.12	578.00
	Negative	25	27.88	697.00
	Total	50		
Pebblesize	Positive	25	23.78	594.50
	Negative	25	27.22	680.50
	Total	50		
Shrubheight	Positive	25	18.70	467.50
	Negative	25	32.30	807.50
	Total	50		

Test Statistics[a]

	Averagegrainsize	Minimumgrainsize	Maximumgrainsize	Pebblesize	Shrubheight
Mann-Whitney U	228.000	312.500	253.000	269.500	142.500
Wilcoxon W	553.000	637.500	578.000	594.500	467.500
Z	-1.658	.000	-1.205	-.868	-3.338
Asymp. Sig. (2-tailed)	.097	1.000	.228	.386	.001

a. Grouping Variable: sitetype

Mann-Whitney U tests - Biotic factors:

Shell, S.vermiculata, P.nivea, H.ramosissimum, L.arborescens and A.tenuifolius.

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
Shell	50	7.8400	9.05169	1.00	38.00	2.0000	4.0000	10.0000
S.vermiculata	50	3.0000	12.16385	.00	60.00	.0000	.0000	.0000
P.nivea	50	5.2200	6.78621	.00	30.00	.0000	2.5000	10.0000
H.ramosissimum	50	2.2600	4.56164	.00	20.00	.0000	.0000	2.2500
L.arborescens	50	1.8000	5.45856	.00	30.00	.0000	.0000	.0000
A.tenuifolius	50	2.4800	5.13587	.00	25.00	.0000	.0000	3.0000
sitetype	50	1.5000	.50508	1.00	2.00	1.0000	1.5000	2.0000

Ranks

	sitetype	N	Mean Rank	Sum of Ranks
Shell	Positive	25	26.00	650.00
	Negative	25	25.00	625.00
	Total	50		
S.vermiculata	Positive	25	24.00	600.00
	Negative	25	27.00	675.00
	Total	50		
P.nivea	Positive	25	27.50	687.50
	Negative	25	23.50	587.50
	Total	50		
H.ramosissimum	Positive	25	28.36	709.00
	Negative	25	22.64	566.00
	Total	50		
L.arborescens	Positive	25	22.22	555.50
	Negative	25	28.78	719.50
	Total	50		
A.tenuifolius	Positive	25	29.42	735.50
	Negative	25	21.58	539.50
	Total	50		

Test Statistics[a]

	Shell	S.vermiculata	P.nivea	H.ramosissimum	L.arborescens	A.tenuifolius
Mann-Whitney U	300.000	275.000	262.500	241.000	230.500	214.500
Wilcoxon W	625.000	600.000	587.500	566.000	555.500	539.500
Z	-.244	-1.768	-.992	-1.712	-2.278	-2.214
Asymp. Sig. (2-tailed)	.807	.077	.321	.087	.023	.027

a. Grouping Variable: sitetype

M.microsperma, Unknown1, F.laevis, K.sagittata, Unknown2, C.capitatus and C.tomentosa.

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
M.microsperma	50	1.0400	1.61574	.00	6.00	.0000	.0000	2.0000
Unknown1	50	.1800	.66055	.00	4.00	.0000	.0000	.0000
F.laevis	50	.2000	1.41421	.00	10.00	.0000	.0000	.0000
K.sagittata	50	.1000	.46291	.00	3.00	.0000	.0000	.0000
Unknown2	50	.4600	1.78669	.00	10.00	.0000	.0000	.0000
C.capitatus	50	.3800	2.54663	.00	18.00	.0000	.0000	.0000
C.tomentosa	50	.4200	.99160	.00	5.00	.0000	.0000	.0000
sitetype	50	1.5000	.50508	1.00	2.00	1.0000	1.5000	2.0000

Ranks

	sitetype	N	Mean Rank	Sum of Ranks
M.microsperma	Positive	25	24.36	609.00
	Negative	25	26.64	666.00
	Total	50		
Unknown1	Positive	25	25.00	625.00
	Negative	25	26.00	650.00
	Total	50		
F.laevis	Positive	25	26.00	650.00
	Negative	25	25.00	625.00
	Total	50		
K.sagittata	Positive	25	27.00	675.00
	Negative	25	24.00	600.00
	Total	50		
Unknown2	Positive	25	26.44	661.00
	Negative	25	24.56	614.00
	Total	50		
C.capitatus	Positive	25	25.52	638.00
	Negative	25	25.48	637.00
	Total	50		
C.tomentosa	Positive	25	28.84	721.00
	Negative	25	22.16	554.00
	Total	50		

Test Statistics[a]

	M.microsperma	Unknown1	F.laevis	K.sagittata	Unknown2	C.capitatus	C.tomentosa
Mann-Whitney U	284.000	300.000	300.000	275.000	289.000	312.000	229.000
Wilcoxon W	609.000	625.000	625.000	600.000	614.000	637.000	554.000
Z	-.626	-.466	-1.000	-1.768	-.969	-.029	-2.429
Asymp. Sig. (2-tailed)	.531	.641	.317	.077	.332	.977	.015

a. Grouping Variable: sitetype

Kruskal-Wallis Test - Behavioural Samples

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
Pecking	33	7.5758	5.60708	1.00	21.00	3.0000	7.0000	10.5000
Digging	17	4.8235	2.92052	1.00	10.00	2.0000	3.0000	8.0000
Running	39	7.7179	3.30031	1.00	17.00	5.0000	8.0000	10.0000
Vidulance	12	1.3333	.49237	1.00	2.00	1.0000	1.0000	2.0000
Preening	2	1.5000	.70711	1.00	2.00	.7500	1.5000	1.7500
Resting	2	1.0000	.00000	1.00	1.00	.7500	1.0000	1.0000
Sample	40	4.9500	2.30885	1.00	9.00	3.0000	5.0000	6.0000

Ranks

	Sample	N	Mean Rank
Pecking	1	2	12.75
	2	2	28.25
	3	8	12.19
	4	3	23.17
	5	7	16.14
	6	3	6.50
	8	3	21.33
	9	5	23.10
	Total	33	
Digging	3	6	7.33
	4	1	3.50
	5	6	8.00
	6	4	14.38
	Total	17	
Running	1	2	16.00
	2	2	17.50
	3	10	7.05
	4	3	24.67
	5	10	24.60
	6	4	23.63
	8	3	33.83
	9	5	25.30
	Total	39	
Vidulance	1	1	10.50
	3	6	7.50

	4	1	4.50
	5	1	4.50
	6	1	4.50
	9	1	4.50
	Total	12	
	7	1	4.50
Preening	2	1	1.00
	3	1	2.00
	Total	2	
Resting	3	1	1.50
	Total	2	
	7	1	1.50

Test Statistics[a,b]

	Pecking	Digging	Running	Vigulance	Preening	Resting
Chi-Square	12.581	6.868	21.579	4.813	1.000	.000
df	7	3	7	6	1	1
Asymp. Sig.	.083	.076	.003	.568	.317	1.000

a. Kruskal Wallis Test

b. Grouping Variable: Sample

Kruskal-Wallis Test – Locations

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
Location1	5	4.8000	3.89872	2.00	10.00	2.0000	2.0000	9.0000
Location2	5	8.6000	5.89915	1.00	17.00	4.0000	7.0000	14.0000
Location3	33	3.3636	2.28881	.00	10.00	2.0000	3.0000	5.0000
Location4	7	8.5714	6.80336	1.00	18.00	2.0000	7.0000	17.0000
Location5	24	7.0000	4.40356	1.00	20.00	3.0000	7.5000	9.0000
Location6	12	6.3333	3.47284	1.00	11.00	2.2500	7.5000	9.0000
Location7	2	1.0000	.00000	1.00	1.00	.7500	1.0000	1.2500
Location8	6	9.8333	1.94079	7.00	12.00	7.7500	10.5000	11.2500
Location9	11	9.4545	5.59220	1.00	21.00	6.0000	10.0000	12.0000
behaviour	41	2.6585	1.29634	1.00	6.00	1.5000	3.0000	4.0000

Ranks

	behaviour	N	Mean Rank
Location1	Pecking	2	3.00
	Running	2	3.50
	Vigilance	1	2.00
	Total	5	
Location2	Pecking	2	4.50
	Running	2	2.50
	Total	5	
	Preening	1	1.00
Location3	Pecking	9	19.28
	Running	10	21.75
	Vigilance	6	7.75
	Total	33	
	Preening	1	11.00
	Digging	6	18.00
	Resting	1	4.50
Location4	Pecking	3	5.00
	Running	2	5.00
	Vigilance	1	1.00
	Total	7	
	Digging	1	2.00
Location5	Pecking	7	11.57
	Running	10	17.10
	Vigilance	1	2.00

	Total	24	
	Digging	6	7.67
Location6	Pecking	3	3.00
	Running	4	9.00
	Vigilance	1	1.00
	Total	12	
	Digging	4	8.00
Location7	Vigilance	1	1.50
	Total	2	
	Resting	1	1.50
Location8	Pecking	3	2.50
	Running	3	4.50
	Total	6	
Location9	Pecking	5	7.20
	Running	5	5.80
	Vigilance	1	1.00
	Total	11	

Test Statistics[a,b]

	Location1	Location2	Location3	Location4	Location5	Location6	Location7	Location8	Location9
Chi-Square	.750	3.789	10.811	3.857	9.468	7.852	.000	1.765	3.000
df	2	2	5	3	3	3	1	1	2
Asymp. Sig.	.687	.150	.055	.277	.024	.049	1.000	.184	.223

a. Kruskal Wallis Test

b. Grouping Variable: behaviour

Mann-Whitney Test – Location 6 compared to other locations

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Pecking	33	7.5758	5.60708	1.00	21.00
Digging	17	4.8235	2.92052	1.00	10.00
Running	39	7.7179	3.30031	1.00	17.00
Vigilance	12	1.3333	.49237	1.00	2.00
Preening	2	1.5000	.70711	1.00	2.00
Resting	2	1.0000	.00000	1.00	1.00
Sample	40	1.9000	.30382	1.00	2.00

Ranks

	Sample	N	Mean Rank	Sum of Ranks
Pecking	5	3	6.50	19.50
	others	30	18.05	541.50
	Total	33		
Digging	5	4	14.38	57.50
	others	13	7.35	95.50
	Total	17		
Running	5	4	23.63	94.50
	others	35	19.59	685.50
	Total	39		
Vigilance	5	1	4.50	4.50
	others	11	6.68	73.50
	Total	12		
Preening	5	0[a]	.00	.00
	others	2	1.50	3.00
	Total	2		
Resting	5	0[a]	.00	.00
	others	2	1.50	3.00
	Total	2		

a. Mann-Whitney Test cannot be performed on empty groups.

Test Statistics[a]

	Pecking	Digging	Running	Vigilance
Mann-Whitney U	13.500	4.500	55.500	3.500
Wilcoxon W	19.500	95.500	685.500	4.500
Z	-1.981	-2.482	-.676	-.707
Asymp. Sig. (2-tailed)	.048	.013	.499	.480
Exact Sig. [2*(1-tailed Sig.)]	.045[b]	.010[b]	.517[b]	.667[b]

a. Grouping Variable: Sample

b. Not corrected for ties.