THE IMPACT OF CANS: A SURVEY ON INSECTS AND ARACHNIDS AS A POTENTIAL FOOD SOURCE FOR RAVENS (*CORVUS CORAX*)

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By

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This work is original and has not been previously submitted in support of a Degree, qualification or other course.

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ABSTRACT

1. Littering and fly-tipping has been noticed by a local volunteer group, Desert Watch, who have an interest in protecting the fragile region of El Jable in the north of Lanzarote, Canary Islands. Anecdotal evidence from Desert Watch states that unusual raven *Corvus corax* behaviour has been observed, namely pecking holes into and flying off with discarded drink cans. A survey was conducted into invertebrate occurrence in littered drink cans as a potential food source for ravens in El Jable, whilst also inspecting the frequency of peck holes.
2. Opportunistic sampling of littered drink cans was conducted along three roads using a 0.5x0.5m quadrat. Environmental factors, can variables, invertebrate counts and species were recorded for each sample.
3. The results of the study show that littering of drink cans occurs predominantly closer to roads. It is also evident that invertebrates interact directly with littered cans however, the primary reasoning for their presence is still uncertain. Research showed littered cans did not have a significant incidence of pecked holes.
4. It was found that invertebrates occupied a significant number of cans however, ravens do not appear to routinely target the cans. Environmental factors such as vegetation cover did not impact directly on the presences of peck holes or invertebrates, however pecked holes were significantly more likely to be found in alcohol cans. The majority of cans were also found between 5 and 26m of the road verges, which suggests road-side littering was an ongoing problem.

Key words: Lanzarote; Waste Management; Littering; Desert Conservation; Pollution; Ravens; *Corvus corax*; Invertebrates.

INTRODUCTION

Lanzarote (a UNESCO Biosphere site since 1993) is the most north-easterly island of the Canarian Archipelago, located 140km from the north-west coast of Africa (Santana-Jiménez and Hernández, 2011; Tejera et al, 2018; Cabrera, Alonso and Alcántara-Carrió, 2006b; Bloor and Brown, 2005; Genies, Mateo and Bons, 2000; Luis et al, 2017). It has an area of 862km² and an annual rainfall of less than 200mm (Cabrera, Alonso and Alcántara-Carrió, 2006b, Bloor and Brown, 2005). Concerns about fly-tipping, road-side littering and its impact on the environment of a semi-desert region called El Jable were expressed by a local volunteer team, Desert Watch, prompting research into the understudied location.

WASTE MANAGEMENT

Many environmental issues stem from ineffective municipal waste management, which is a global source of pollution caused by inappropriate waste disposal leading to rubbish contaminating land and bodies of water (Czarnecka et al, 2009; Desa, Ba'yah Abd Kadir and Yusooff, 2010). This may also encourage local residents to engage in activities such as fly tipping (Kolenda et al, 2020; Czarnecka et al, 2009). A critical element of effective waste management is public awareness and participation to ensure proper waste disposal (Hasan, 2004). Controlling waste is a daunting task which requires local authorities to closely manage all activities involved in collection and it has become a priority for many governments globally to provide effective and sustainable solutions (Huang, Pan and Kao, 2011; Rodrigues et al, 2018).

Small islands and locations with tourism such as Lanzarote are particularly complex (Willmott and Graci, 2012; Washburn, 2012). On small islands there is limited land on which to process solid waste (Willmott and Graci, 2012). Locals therefore often resort to open dumping on land and in water or open pit burning (Willmott and Graci, 2012). A report published in 2014 by the local Canarian authority (Cabildo de Lanzarote) states that due to limited land mass, there are scant resources available to manage waste, especially with tourism as a key economic driver. It is likely the rapid increase of tourism in the Canary Islands will cause wildlife reduction and habitat destruction (Luis et al, 2017).

WILDLIFE IMPACTS

The direct impact waste has on wildlife is vast, deeply concerning and ever increasing (Czarnecka et al, 2009). While in some respects human generated litter can provide a year-round food supply in urban environments through gardening, kitchen offal, landfill waste and artificial watering (drought proofing), it also has negative implications for wildlife (Lowry, Lill and Wong, 2012; Reshamwala et al, 2017). Changes in stress physiology in response to urbanisation have been observed in european blackbirds *Turdus merula*, demonstrating that human interference may cause adaptation even at a genetic level (Lowry, Lill and Wong, 2012). Evidence also indicates that solid litter products can cause significant changes in key behaviours such as disrupted roosting activity and increased risk-taking (Lowry, Lill and Wong, 2012). Both of these examples demonstrate a direct relationship between human litter and maladaptive behaviour in wildlife.

Combined with the increased availability of food waste comes solid waste products, which present a threat to wildlife through potential consumption of indigestible and harmful objects or entrapment of animals inside vesicles (Reshamwala et al, 2017; Moates, 2017). Studies by Moates (2017) and Hamed and Laughlin (2015) investigated the mortality rates of small mammals associated with discarded bottles and drink cans. Both papers cited roadside littering as an additional source of mortality for small mammals through entrapment.

Ravens C*orvus corax* will scavenge carcases and pilfer food from other animals as well as each other (Bugnyar, 2011; Bugnyar, Stöwe and Heinrich, 2007; Nogales and Hernández, 1997). They are intelligent opportunistic foragers who will take advantage of the nearest available food sources, whether it is from various human developments or more natural habitats (Kristan, Boarman and Crayon, 2004). Open dumping particularly attracts scavenging birds and in these times of extreme urbanization and interconnectivity, ravens are also attracted to road-kill (Dean and Milton, 2003; Lambertucci et al, 2009; Washburn, 2012).

Young ravens experience neophilia (the attraction shown towards novel objects) (Henrich, 1995; Brown and Jones, 2016; Greenberg, 2003). Neophilia is often directed towards objects that show the greatest contrasting stimulus with the background environment, such as shininess (Greenberg, 2003). It has been proposed that neophilia is a creative period in which the development of foraging repertoires can be improved (Greenberg, 2003). A study by Guerzou et al (2011) on ravens in nearby

Algeria showed that 80.8% of their diet was insects, which they concluded was due to the highly contrasted or shiny and colourful appearance of the insects. It is possible that their neophilia in adolescence may have contributed to this preference of diet. While this shows intelligence in ravens, it highlights a mechanism whereby they may mistake human litter for food. Guerzou et al (2011) also noted the ingestion of plastic and aluminium foil which have similar shiny properties to the insects.

An attraction to shiny objects may explain the unusual behaviour observed by Desert Watch in El Jable. It is therefore possible the ravens have learned there is a novel food supply within littered drink cans during their neophilic development. Ants in particular have been cited as targeting discarded drink cans for their nests, despite the fact that it led to high rates of entrapment (Kolenda et al, 2020). Other invertebrates were also susceptible to entrapment in littered cans (Kolenda et al, 2020). If such a phenomenon were to occur in El Jable, this may provoke interest from Ravens.

Wildlife naturally have to assess and adapt to their environment which can be affected by human alterations (Hawlena et al, 2010). Often ecological traps (low-quality habitats) caused by human interference are preferred over natural habitats, due to the animal's inability to reliably judge habitat quality and select habitats which improve their fitness (Hawlena et al, 2010). The rate of interference from humans in natural habitats exceeds animals' evolutionary ability to respond to change (Hawlena et al, 2010). Endemic species are particularly vulnerable, as they rely heavily on specific environmental parameters to survive and alterations may therefore lead to accelerated rates of extinction. As similar circumstances arise in El Jable, the risk to species' ability to survive appears set to increase.

EL JABLE

El Jable is a primary landmark in Lanzarote (Cabrera Vega and Bilbao, 2010). It is a geologically unique habitat found in the north west of the island. Marine sediments are deposited onto a lowland area of lava plain from Famara beach via prevailing trade winds (Cabrera, Alonso and Alcántara-Carrió, 2006b). These winds are seasonally variable with dominating winds blowing from north-north-east between May and September (Cabrera, Alonso and Alcántara-Carrió, 2006b). In the northwest of El Jable the sand has a high calcareous composition due to shells, bryzoa, algae and the remains of marine organisms from the ocean floor, giving it a particularly high nutrient content (Cabrera, Alonso

and Alcántara-Carrió, 2006a; Cabrera, Alonso and Alcántara-Carrió, 2006b). The nutritious sand allows the growth of plant life and supports endemic species, although the majority of species are not yet scientifically recorded.

El Jable's environment is similar to that of deserts, which are delicate ecosystems and among the most poorly understood biomes (Duncan et al, 2014). Excessive human traffic, vehicle pollution from roads and discarded waste products affect deserts and negatively impact biodiversity (Tourism and Deserts, 2006). A study by Walde et al (2007) highlighted the impacts of balloons on desert tortoises *Gopherus agassizii* in the Mojave Desert, recording the ingestion of balloons and entanglement by the string which lead to the loss of limbs. Lizards and snakes have received similar lacerations and reduced mobility as a result of contact with litter (Walde, 2007).

El Jable is known to be home to a number of native birds, such as cream coloured cursors *Burhinus oedicnemus* and Houbara bustards *Chlamydotis undulata*, and lizards, namely the canarian gecko *Tarentola angustimentalis* and atlantic lizard *Gallotia atlantia atlantia* (Wilkens, 2009). There are also a number of endemic plant species, making it an area of conservation concern (Wilkens, 2009). Local people often travel through El Jable to reach popular tourist destinations for selling wares or to access farming sites in the desert. Evidence of littering and fly-tipping has been noticed as a result. While Desert Watch is striving to raise the awareness of local people and tourists about the importance of both El Jable and proper waste management, the extent and impact of littering has yet to be analysed. Scientific evidence is needed to further support their endeavour.

THIS STUDY

Currently there is limited research into El Jable. It is understood that there is no consensus on the invertebrate life that lives there (A.Muchado, Personal communication, 11 May, 2020). The aim of this study is to investigate the impact of litter on wildlife in El Jable, prompted by Desert Watch who have reported ravens pecking holes into, and flying off with, littered drink cans. The objective is to investigate whether this unusual behaviour is related to the invertebrate contents and therefore constitutes a novel form of foraging, demonstrating that litter is impacting wildlife in El Jable.

MATERIALS AND METHODOLOGY

SUBJECT LOCATION

El Jable is an area of lowland confined to the northeast of Lanzarote and is comprised of windblown sand deposits from Famara beach by northerly winds, sediments eroded from Famara escarpments and sediments from eroding volcanic cones (Cabrera, Alonso and Alcántara-Carrió, 2006b; Bloor and Brown, 2005). The sand is deposited over lava plains (Cabrera, Alonso and Alcántara-Carrió, 2006b). The Desert is 21km long with a width ranging between 10km at the northern region and 4km in the southern region, with a total area of 90km² (Cabrera, Alonso and Alcántara-Carrió, 2006b). El Jable is hot, arid and seasonally varied (Cabrera, Alonso and Alcántara-Carrió, 2006b). Central regions are used for agricultural activity, goat grazing and aggregate extraction (Cabrera, Alonso and Alcántara-Carrió, 2006b).

ROADS AND MAPS

The data was collected within a 10.71km² area in the northern region. The road network across El Jable was central to the collection method as it is potentially the means of littering in the desert. The roads interconnect surrounding villages with Teguise, which is a popular tourist destination and market town.

Primary roads linking surrounding villages were considered through Google Maps for use in the study as they are the most likely candidates for littering. There is also some evidence from preliminary visits and Google Map images showing the presence of unofficial quad-biking and off-road motorbiking tracks near Munique, which was also considered when selecting roads. A less well beaten track was used in order to draw a comparison between busy and unfrequented roads. Sampling began 0.5km away from urban areas and 50m from main roads to ensure the areas used had no external disruption from villages and unstudied roads.

Areas of disturbed sand along tracks and near junctions were avoided as it was not truly representative of the desert sand, due to disturbance from traffic. All samples were taken a minimum of 5m from road verges. The distance at which samples should be taken from junctions was calculated using an average of the turning circles of 48 4x4 vehicles. For more detail see Appendix 1.

Based on the average turning circle of 11.46m, a minimum collection distance of 12m from junctions was put in place. Junctions within 24m of one another were avoided entirely. Eight roads were selected, however only three of these roads could be sampled (see Appendix 2). Data collection was disrupted and time constraints resulted from the Covid-19 pandemic which caused data collection to be terminated early.

PRIMARY METHOD

Systematic opportunistic sampling was carried out along 60m of terrain either side of the study roads. A 60m distance was selected to study distribution of cans across the desert and to assess the occurrence of roadside littering (cans evenly distributed across 60m would not imply road-side littering). Fields with evidence of activity such as crops or recent disturbance were avoided. Cans which were deemed appropriate for surveying were at a minimum 10m distance from other littered cans to prevent overlapping data. A data card was used for recording measurements throughout the collection process (See Appendix 3).

On the identification of a littered can, measurements were taken to ensure it was in line with parameters associated with the road edge, junctions and other can litter. A 0.5x0.5m quadrat was laid down with the can at the centre. The environmental data were taken. The GPS location was recorded using the Geo Tracker application. Air, surface and ground temperatures were recorded using a sensitive Comark 2007 probe thermometer. Using a x10 field magnifier the sand size, sorting and roundness were measured using a grain data card on which was the Phi scale, roundness index and sand sorting charts. The sand texture was judged to be either frosted or clear. The sand colour was graded against the Munsell Soil Colour Chart. Calcium carbonate levels of the sand were identified through the application of white vinegar to a sample of sand from within the quadrat. The reactivity of the sand (‘no reaction’ or ‘audible and visible fizzing’) identified the presence of calcium carbonate in the sand sample (Jones et al, 2000). Wind direction and speed were measured using the most up-to-date averages on the Met Office application.

The can measurements were then taken. Observations included the orientation (measured using a compass) and can type (‘soft drink’ or ‘alcohol’). Other measurements included the colour, can integrity, and presence of pecked holes characterized by the size (approximately 4-5cm diameter) and

folding back of metal (Appendix 4, fig. 1). In a habitat with an extremely limited number of species it was assumed that the only animal in El Jable with the cognitive and physical capabilities to open cans in this manner was the raven. The internal can temperature was taken before contact with the can to get a 'true' reading. Peck holes were recorded once the can was picked up for inspection.

Any non-flying insects or arachnids found while the quadrat was on the ground were recorded. Picking up the can was left until last to prevent disturbance of any life inside the cans. Using a sieve, the contents were collected in petri dishes to separate any specimens from the sand for identification. Images were taken of unknown insect and arachnid species found, with a scale and magnificiation where necessary. The internal surface of the can was checked for remaining specimens, before removing the can from the desert. Any inhabited cans with remaining specimens inside that could not be removed were left in the desert. Finally, the vegetation percentage was recorded through the use of a 0.5 x 0.5m quadrat, divided into 25 10x10cm squares. A systematic visual estimation of vegetation percentage for each square was recorded. An average of the overall percentage of the quadrats was calculated after data collection.

The control quadrat was placed 5m into the desert, in the direction away from the road. The location selection process for the initial quadrat ensured can-free sites for the subsequent control. The procedure for the control quadrat followed as described above, without can measurements.

Supplementary information was collected on the number of molluscs and measurements were taken of the largest mollusc and rock in each quadrat.

SUPPLEMENTARY STUDY

A supplementary experiment was carried out in order to assess occupation of non-flying insects and arachnids in cans over time. There were two phases to this experiment, which studied two separate locations in El Jable. The first, conducted in September 2019, was located 0.16km from a tarmac road (the LZ-402 from Famara to Teguise) along the outskirts of El Jable. Traffic on the road was regular and there was disruption from intermittent off-road quad-biking and motorcycling. The location was rocky with minimal vegetation and fairly flat terrain. The second phase, conducted in January 2020,

was located near the centre of El Jable with minimal rough-track access, sand dunes and a higher overall vegetation cover. The only known nearby anthropogenic activity was an active field.

In both locations uncleaned, empty soft drink and alcohol cans were oriented toward the four primary compass points (four for each can type). See Appendix 4, fig. 2. They were semi-submerged in sand with a rock on top to anchor them and prevent dispersal in the wind. The two can types were placed within 1m of each other. Readings of the cans were taken in the morning between 8 and 10am over a 7- and 8-day period (January and September respectively). All environmental measurements were taken at the time of the initial set up of study cans (refer to the collection process above). The external temperatures, wind direction, wind speed and internal can temperatures were recorded daily. The contents of the cans were also inspected daily and invertebrate identification was carried out in the same manner as the primary study.

CAN INTEGRITY GUIDE

Degree of can integrity was recorded for supplementary information (See Appendix 5). With a variety of invertebrates of different sizes, the degree of can integrity may be limiting to the size and number of invertebrates found within the can. Crushed cans also had a more convoluted surface, increasing the number of edges and wrinkles in which to hide. Cans with less than 25% integrity (above category 4) were not used in this study as the opportunities for investigation were limited.

SPECIES GUIDE

There is no comprehensive identification available for the insects or arachnids in Lanzarote, so a preliminary guide was created based on the observations of local people, Lanzarote guides and some reliable online resources (See Appendix 6) (Machado, personal correspondence, 11th May, 2020; Wilkens, 2009). Unknown species were recorded alongside the guide. To assist later identification, descriptions, sketches and photographs were taken (Appendix 7). With the information collected, educated predictions on the species were requested from entomologists and enthusiasts on social media, such as Twitter, Facebook and LinkedIn. This provided avenues for research into identification

of unknown species with guidance from Professor Adam Hart; an entomologist and professor of science communication at the University of Gloucestershire.

RESULTS

CAN USE

There was no statistically significant difference between the presence of holes and the number of invertebrates identified in cans (with a hole: median = 0, interquartile range = 1; without a hole: median = 0, interquartile range = 1. Mann Whitney U: U = 639.5, n^1 = 55, n^2 = 27, P = 0.216). It can therefore be stated that the presence of invertebrates was no more or less likely to be found in cans with pecked holes.

A significantly high number of invertebrates were found in quadrats containing cans, compared with can-free control quadrats (With can: median = 0, interquartile range = 1; without cans: median = 0, interquartile ranges = 0. Wilcoxon signed rank test: T =17, n=26, N= 82, P = <0.001). This appears to indicate an association between can presence and invertebrate activity (Fig. 3). In order to test this invertebrate presence in and on cans (can interaction) was compared with the number of invertebrates in the associated quadrat (no can interaction). There proved to be a significantly high number of invertebrates interacting with the can when compared to the number of invertebrates not interacting with the cans (interacting with cans: median = 1, interquartile range = 1.5; not interacting with cans: median = 0, interquartile range = 1. Wilcoxon signed rank test: T = 34.50, n=23, N=24, P = 0.001). Live and dead invertebrate counts were used to compare occupancy and entrapment amongst invertebrates interacting with cans, however there was no significant difference between the number of live and dead specimens (live: mean = 1.24 invertebrates, SD = 2.143, n = 21; dead: mean = 1.52 invertebrates, SD = 2.732, n = 21. Paired T-test (t = -0.384, df = 20, P = 0.705)

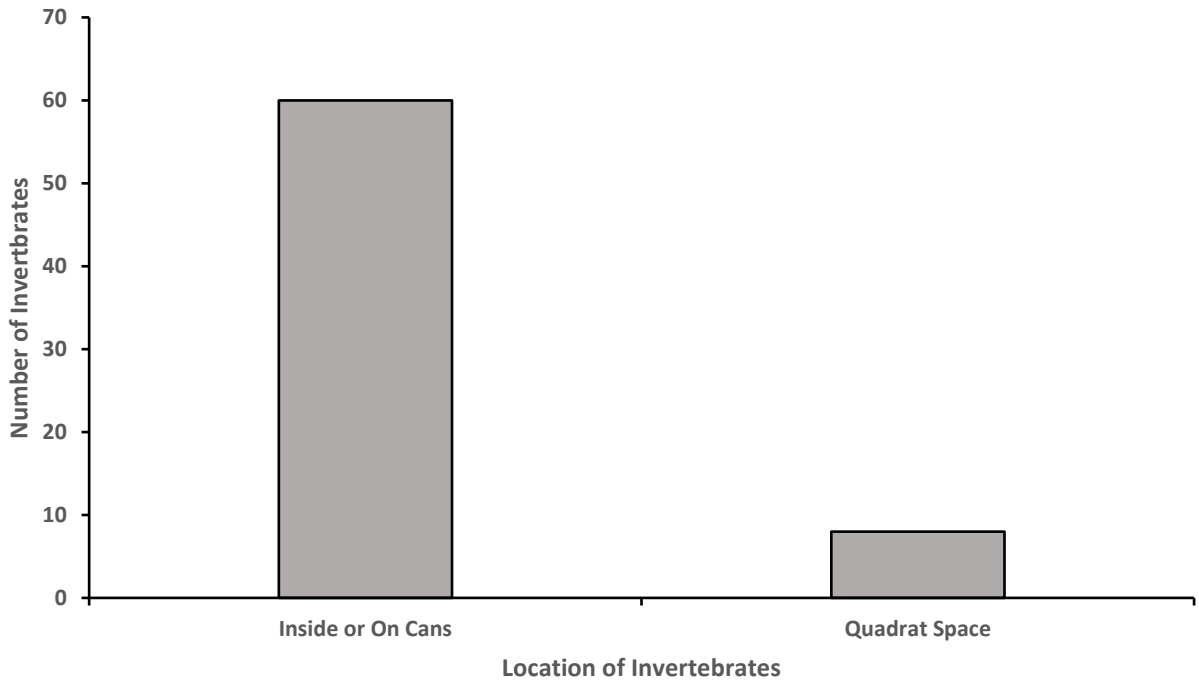

Figure 3*: The number of insects and arachnids found in different locations: Inside the can, on the outer surface of the can or within the 0.5x0.5m quadrat.*

DISTANCE FROM ROADS

A Poisson regression was conducted to analyse the relationship between the number of cans and the distance from the road. Cans were 23 (95% confidence interval 3.106 to 170.309) times more likely to be found in the shortest measured distance (between 5 and 11m) compared to further away from the road (up to 60m), a statistically significant result (P = <0.001). See fig. 4.

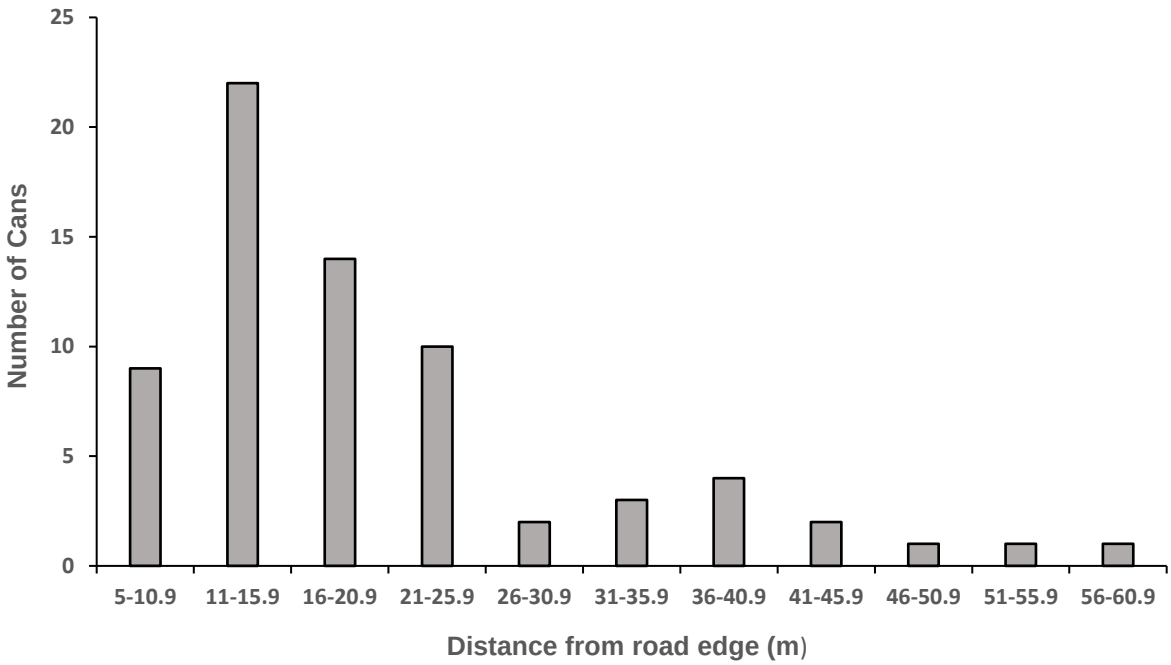

Figure 4: *The number of cans found at distances between 5 and 60m from the road edge.*

A linear regression was performed to assess the relationship between the number of invertebrates and distance from the road, however no significant result was found (Durbin-Watson: 1.823 Linear Regression: F = 1.233, P = 0.270). It can therefore be stated that there is no linear relationship between the number of invertebrates found in cans and their distance from the road.

VEGETATION COVER AND ANIMAL ACTIVITY

A linear regression was carried out to analyse the effect of vegetation cover percentage on the number of invertebrates present within quadrats. The amount of vegetation cover did not significantly affect the number of invertebrates identified in this study (Durbin-Watson: 1.756, Linear Regression: F= 0.972, P = 0.326). Invertebrates do not appear to show a preference for vegetated or unvegetated areas. Vegetation cover was also not a significant affecting factor for the number of cans with holes identified (Mann Whitney U: U=701.5, n^1 = 55, n^2 = 27, P = 0.686). These results indicate that ravens have no significant preference for targeting cans in vegetated or non-vegetated areas.

CAN TYPES AND ANIMAL ACTIVITY

To investigate the effect of can type (alcohol or soft drink containers) on the number of invertebrates found in cans a Kruskal Wallis test was conducted. The result was insignificant (Kruskal Wallis: X2 = 1.510, df=2, P = 0.470) confirming that invertebrates do not show particular preference for either can type. Conversely, can type did have a significant effect on the number of pecked holes identified in cans (Chi Square: X^2 (2) = 7.090, P = 0.029). This implies ravens preferentially peck holes in alcoholic cans (fig. 5).

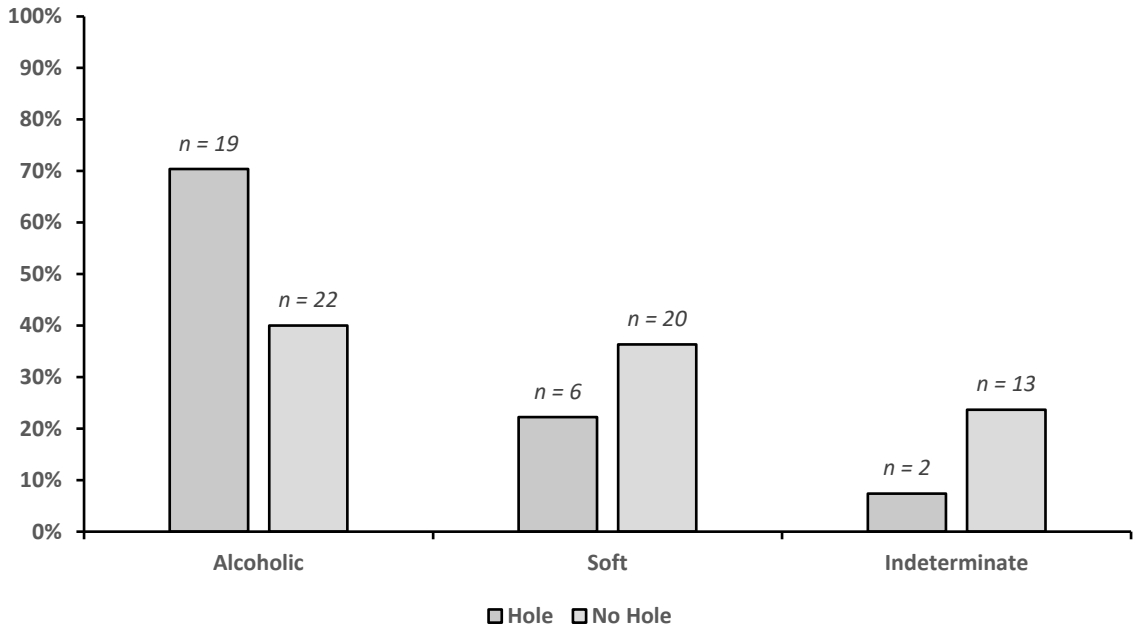

Figure 5: *The percentage of hole presence for alcoholic, soft drink and indeterminate cans collected during the study.*

A supplementary experiment was also conducted however, it did not provide enough data for statistical examination. The data can be found in Appendix 8.

DISCUSSION

INVERTEBRATE PRESENCE

Invertebrates were found to have a significant presence in quadrats associated with discarded cans however, the majority of invertebrates were not in the quadrat space but rather interacting with the cans directly. For this to occur the cans must provide advantages which invertebrates are attracted to, as it is statistically unlikely that they are there by chance alone. It is possible insects and spiders are drawn to the discarded drink cans for their protection from weather and predators. Crucial to this theory is the concept of 'adaptability'. Adaptability in invertebrates is well documented. There is evidence of aquatic invertebrates in estuaries and reservoirs creating habitats in substitute reefs made of waste materials, including metal (Chapman and Clynick, 2006; Czarnecka et al, 2009). Although promoting littering is not advocated, it shows that invertebrates are capable of utilising litter in novel environments created by waste. El Jable has become an increasingly polluted environment, and small spider webs have been observed on the internal and external surfaces of some discarded drink cans. It has been noted that in windier microhabitats spiders make smaller webs, which is consistent with webs found on discarded cans in El Jable (Blackledge, Kuntner and Agnarsson, 2011). Spiders avoid frequent relocation and prefer to find optimal habitats (Glover, 2013). They judge sites by physical support and prey availability among other preferences (Glover, 2013). These parameters have a profound effect on the habitat preference and prey capture rates in spiders (Glover, 2013). The statistical findings, combined with the small spider webs found in cans, suggests that discarded cans in El Jable probably provide shelter, food and a reliable surface on which to build such webs, compared to much of the surrounding desert.

Another occurrence which may encourage invertebrates to accumulate in and on discarded cans is the presence of condensation. It was observed in the mornings that the metal surface had condensation from the cooler night air, which for some species may be an essential source of water in the semi-desert where only 200mm of rain falls each year (Bloor and Brown, 2005). Further research and analysis on invertebrate species fluid requirements and their behaviours associated with this would be needed to confirm the validity of this theory.

Entrapment within cans is one possible reason for a significant number of invertebrates interacting with the cans rather than the surrounding quadrat space. Entrapment causes a build-up of dead

specimens within the cans, which could account for the number of in-can specimens recorded in the study. Invertebrate mortality and entrapment in discarded waste has already been documented. Ant species have been recorded creating nests in a variety of waste products including cans (Kolenda et al, 2020). The positive outcome of newly discovered niches were outweighed by the entrapment and mortality resulting from utilising litter (Kolenda et al, 2020). The degree of entrapment was assessed using live/dead counts of invertebrates interacting with cans in El Jable, resulting in an insignificant difference between the number of live and dead specimens. There was not a comparatively high build-up of dead invertebrates to live specimens which would be expected in the case of entrapment. It is likely therefore, that entrapment is not a primary cause of occupation in and on cans.

THE ROLE OF ENVIRONEMENTAL FACTORS

The majority of cans identified for analysis were found between 5 and 26m of the track verges suggesting roadside littering was occurring when people travelled through the desert. This was observed to be particularly prominent near villages and off-road biking tracks where there is more human interaction with the desert. Similarly, it was observed that less well beaten tracks in the desert showed fewer littered cans, specifically road two which was rough, sandy, less defined and had fewer cans until it came into close proximity to the main road, bordering the desert and connecting the villages. Road two was likely more often used by local farmers to utilise remote regions of the desert for agricultural use. Despite this, invertebrate numbers did not increase closer to road verges as may be expected with an increase in can presence. The distribution of invertebrates amongst cans therefore initially appears inconsistent. However, roads cause loss and fragmentation of habitats, discharge of toxic gases and substances as well as acoustic and light pollution (Tejera et al, 2018). These factors significantly reduce the habitability of roadside locations, and may therefore account for this finding (Tejera et al, 2018).

Vegetation cover was included as a factor as it was anticipated that more or less vegetated areas would exhibit differing numbers of invertebrates (Woodcock et al, 2010). The findings of this study did not reflect these expectations, but rather demonstrated a consistent invertebrate dispersal across all levels of vegetation. The root of this finding may lie in the sparse cover of plants in El Jable, which is typical to dry, desert-like environments (Li et al, 2009). Although in some regions vegetation cover

was as much as 100% (completely obscuring the ground), density of vegetation was not necessarily an analogue for increased vegetation species richness, which has been cited as a key factor in increasing invertebrate numbers (Woodcock et al, 2010). Areas of denser vegetation cover were heavily predominated by the thorned aulaga (*Luanaea arborescens*), demonstrating a lack of plant diversity which may be limiting to the number of invertebrates, even in more vegetated areas (Wilkens, 2009). It should be noted that such behaviours appear to be species specific. It is well documented that molluscs such as Dune snails (*theba geminata*), and others of the *Thebus* genus, rely heavily on regions densely populated with aulaga bushes (Wilkens, 2009). The lack of preference for vegetation cover in invertebrates was reflected in ravens, who also failed to show any bias towards vegetated or unvegetated areas.

Although it was initially suspected that sugary or alcoholic residues in littered cans might be attractive to invertebrates, specimens in this study showed no preference for either alcoholic or soft drink cans. However, ravens showed a marked preference for alcoholic drink cans, as demonstrated by a significantly high number of peck holes. Given that invertebrates did not display a preference, the finding is somewhat surprising. It cannot easily be accounted for by ravens' tendency for neophilia or their attraction to shiny objects, as both variables can be applied to either alcoholic or soft drink cans (Greenberg, 2003). Assessing the cause for this behaviour is likely to require a larger and more detailed study, focusing on raven relationships with littered cans.

Although more holes were identified in alcoholic cans, it is important to highlight that they constituted 50% of the cans collected in this study, skewing the data in their favour. In spite of this, a similar result was found in a study into the impact of littered cans and bottles on small mammals, where 53% of the cans were alcoholic (Moates, 2017). It is possible that alcoholic cans make up a higher percentage of can litter generally. If this is the case, similar biases could occur in future experiments.

RAVENS AND CANS

Ravens did not appear to use discarded drink cans frequently enough to suggest regular contact or feeding activity, in spite of evidence that invertebrates in cans provide a potential food source. The number of cans with pecked holes ($n = 27$) was outweighed by non-pecked cans ($n = 55$). While it was evident that ravens do not use the cans as a primary food source, it could be possible that they

used the cans as an opportunistic source of novel food as there are no documented species in Lanzarote with comparable cognitive abilities.

The frequency of pecked holes is low, bringing into question whether invertebrates are a substantial enough food source to merit the energy necessary to open cans. The trapped invertebrates are predated on by other life including lizards which may constitute a more rewarding food source for ravens. Three lizards were observed inside discarded cans during this study however, there was not enough data to explore this relationship. Desert lizards are agile and able to manoeuvre across sand quickly as a primary means of avoiding predators (Li et al, 2011). Due to the required energy expenditure, Ravens more commonly exploit carcasses rather than targeting live prey (Tome, Krofel and Mihelič, 2009). Roadkill is often a source of carrion and can include lizards (Kristan, Boarman and Crayon, 2004). It is possible that ravens target cans as a means of capturing higher energy prey while minimising energy output. This would create an energy efficient foraging strategy. However, as a limited number of lizards were observed, this phenomenon could not be explored and further research is needed for confirmation.

SUPPLEMENT

The supplementary study was carried out in order to observe the presence of invertebrates in cans between two sites over time. In both sites invertebrates were recorded within 24 hours of can placement. The total number of invertebrates was different across both sites (fig. 6). Site one showed less consistent occupation over time with two cans remaining entirely empty.

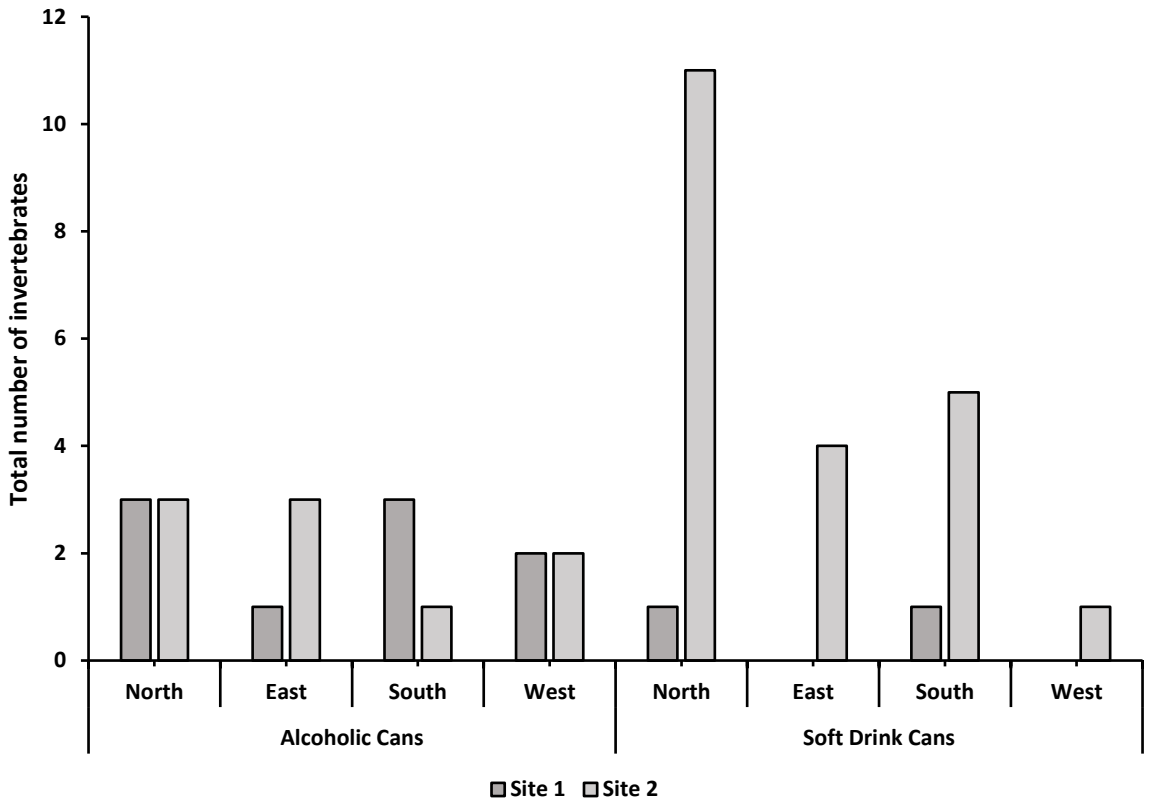

Figure 6 *– The total number of invertebrates found in each compass-point oriented can at two locations. Site one was located at the edge of El Jable by a road, while site two was in a secluded location near a farm in the centre of the study region.*

Site two however, displays a higher overall number of individuals with specimens in all cans. With site two being in a more secluded part of the desert, it is likely that the abundance is higher due to reduced impact from the roads and anthropogenic disturbances. This is further supported by the relatively few cans found on road two (*n = 9*) compared with road one (*n = 27*) and road three (*n =46*) in the primary study. The difference in invertebrate numbers between sites may also be due to the seasonal variation resulting from the 4-month gap between data collection. Data collection for site one was recorded in the summer, with high temperatures and dry weather. Rain and lower temperatures were recorded during data collection for site two, which simultaneously promoted new plant growth.

Invertebrates are likely to take advantage of young plants, affecting the data collected at site two. As statistical analysis could not be carried out on the supplement the results are limited, and further detailed investigation would be necessary to understand the relationship between invertebrates and cans over time in El Jable.

The results of this study highlight that roadside littering of drink cans is a problem. With a higher number of cans near roads, it is likely that roadside littering is the primary cause of littered drink cans. As they are sited near prominent roads, they are a likely result of local people travelling through the semi-desert. Invertebrate presence in cans is significant without evidence of physical entrapment, suggesting they are using the littered cans as a refuge from weather and predators. Litter may however, cause an ecological trap, leading to increased predation. Ravens likely utilise the cans as a novel food supply to access invertebrates or the insectivorous lizards which may be drawn to the cans. Although there is now evidence of wildlife being directly impacted by litter, the degree to which wildlife if affected is still uncertain, and further information is needed through future study.

It is evident that waste management is an ongoing issue in El Jable. Proper waste management requires active public participation and cannot rely entirely on legal enforcements, such as the UNESCO biosphere status (Hasan, 2004). For the prevention of further pollution in El Jable, increased awareness of the importance of proper waste management and the vulnerability of El Jable is essential in local communities and tourists alike (Appendix 9 for the educational leaflet). Desert Watch is already active in educating tourists and communities in Lanzarote about the impacts of littering amongst other activities. In spite of this, local protection or legal support would benefit El Jable and reinforce the efforts of the Desert Watch team. Further study into the effects of solid litter pollution on wildlife in El Jable is required to be able to conserve this unique habitat appropriately, and prevent future littering.

CONCLUSION

Ineffective waste management is a global source of pollution which contaminates both land and oceans (Czarnecka et al, 2009). The impact on wildlife is vast and continues to increase, causing behavioural and biological change to species, even on a genetic level (Czarnecka et al, 2009; Lowry, Lill and Wong, 2012). While wildlife can adapt naturally to a changing environment, they are challenged by the speed at which litter is polluting their habitats (Hawlena et al, 2010). El Jable in Lanzarote is home to endemic species which are likely to be suffering from similar human interference (Tejera et al, 2018).

Novel behaviour is demonstrated in the pecking of holes into littered drink cans by ravens. Although ravens do not appear to use discarded drinks cans as a primary food source, they may use them as an opportunistic foraging resource when food is scarce or unreliable in El Jable. Can numbers increase within 26m of the road verges, which is consistent with littering from passing traffic. This is noteworthy as human disturbance and littering appears to contribute to the reduction in habitability in roadside environments. This is evidenced by the fact that the number of invertebrates does not increase closer to roads, in spite of the increase in available cans.

Entrapment does not appear to be a likely cause for invertebrate presence in cans, therefore their primary function may be to act as a refuge from predators and prevalent winds. The study shows invertebrates display no preference for can type, vegetation cover or location, suggesting their presence in discarded cans is not based on environmental factors. The presence of invertebrates is important as it may also attract lizards which could be a more substantial, energy efficient food source for ravens, however the exact dynamic cannot be confirmed by this study.

In order to fully understand the impact of littered waste on this delicate habitat, further research is required into the relationship between invertebrates and their changing environment. Studying how invertebrates interact with the cans over time could lead to a more detailed understanding of how littering impacts invertebrates and predatory animals alike in El Jable. This will be fundamental to educating local communities on good litter management and enlightening them to the precarious position El Jable is in. Although the UNESCO biosphere reserve status provides some protection, it is evident it is not having a prominent enough effect on El Jable, and further protection is urgently needed.

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APPENDICIES

Appendix 1 – Turning circle calculations

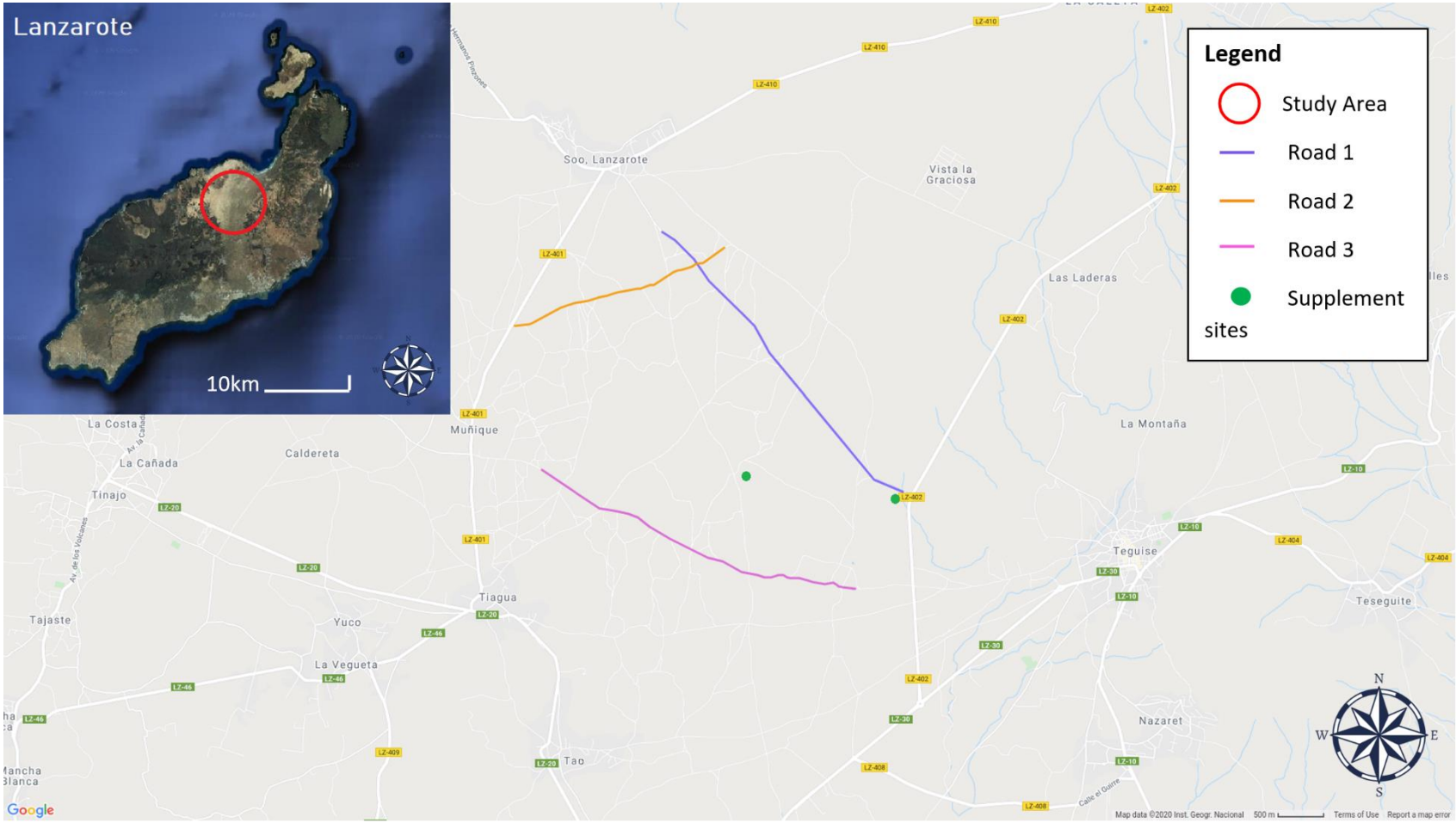
The turning circle in meters for 48 4x4 vehicle models collected from an online turning circle calculator (O'Grady, accessed July 2019). Additional information about the vehicle model, year of production, total length, total width, wheel base in millimetres and model series is included.

Model	Year	Length	Width	Wheel Base	Turning Circle (M)	Series
2.0 SD4 auto 4d	2016	4956mm	2220mm	2923mm	12	S
2.0 Si4 300 hp 4WD 5d	2016	4956mm	2220mm	2923mm	12	S
2.0 Sd4 auto 5d	2016	4956mm	2220mm	2923mm	12	S
SE 2.0 Si4 300hp 4WD 5d Petrol	2017	4956mm	2220mm	2923mm	12	SE
SE 2.0 Si4 300hp 4WD 5d Diesel	2017	4956mm	2220mm	2923mm	12	SE
SE 3.0 Sd6 306hp auto 5d	2018	4956mm	2220mm	2923mm	12	SE
SE 3.0 Si6 auto 5d	2017	4956mm	2220mm	2923mm	12	SE
SE 3.0 Td6 auto 5d	2017	4956mm	2220mm	2923mm	12	SE
Landmark 2.0 Sd4 240hp auto 5d	2017	4956mm	2220mm	2923mm	12	Special Edition
HSE 2.0 Sd4 auto 5d	2017	4956mm	2220mm	2923mm	12	HSE
HSE 2.0 Si4 300hp 4WD 5d	2017	4956mm	2220mm	2923mm	12	HSE
HSE 3.0 Sd6 306hp auto 5d	2017	4956mm	2220mm	2923mm	12	HSE
HSE 3.0 Si6 auto 5d	2017	4956mm	2220mm	2923mm	12	HSE
HSE 3.0 Td6 auto 5d	2017	4956mm	2220mm	2923mm	12	HSE
Anniversary Edition 3.0 Sd6 auto 5d	2017	4956mm	2220mm	2923mm	12	Special Edition
HSE Luxury 2.0 Sd4 auto 5d	2017	4956mm	2220mm	2923mm	12	HSE Luxury
HSE Luxury 2.0 Si4 300hp 4WD 5d	2017	4956mm	2220mm	2923mm	12	HSE Luxury
HSE Luxury 3.0 Sd6 306hp auto 5d	2017	4956mm	2220mm	2923mm	12	HSE Luxury
HSE Luxury 3.0 Si6 auto 5d	2017	4970mm	2220mm	2923mm	12	HSE Luxury
HSE Luxury 3.0 Td6 auto 5d	2017	4970mm	2220mm	2923mm	12	HSE Luxury
First Edition 3.0 Td6 auto 5d	2017	4970mm	2220mm	2923mm	12	First Edition
2.7 TdV6 5d	2004	4835mm	2190mm	2885mm	11	Standard Trim
2.7 TdV6 5d Auto	2004	4835mm	2190mm	2885mm	11	Standard Trim
2.7 TdV6 5d (7 Seat)	2004	4835mm	2190mm	2885mm	11	Standard Trim
2.7 TdV6 5d Auto (7 Seat)	2004	4835mm	2190mm	2885mm	11	Standard Trim
3.0 SDV6 (255bhp) GS 5d Auto	2004	4829mm	2176mm	2885mm	11.45	GS
2.7 TDV6 GS (09) 5d	2005	4829mm	2176mm	2885mm	11.45	GS
2.7 TDV6 GS (09) 5d Auto	2009	4829mm	2176mm	2885mm	11	GS
2.7 Td V6 GS 5d	2006	4835mm	2190mm	2885mm	11	GS
2.7 Td V6 GS 5d Auto	2006	4835mm	2190mm	2885mm	11	GS
3.0 SDV6 GS (11/13-) 5d Auto	2013	4835mm	2190mm	2885mm	11	GS
3.0 SDV6 GS 5d Auto	2010	4829mm	2176mm	2885mm	11	GS
3.0 TDV6 GS 5d Auto	2009	4829mm	2176mm	2885mm	11	GS
2.7 TdV6 S 5d	2004	4835mm	2190mm	2885mm	11	S
2.7 TdV6 S 5d Auto	2004	4835mm	2190mm	2885mm	11	S
4.4 V8 S 5d Auto	2004	4835mm	2190mm	2885mm	11	S
2.7 Td V6 XS 5d	2006	4835mm	2190mm	2885mm	11	XS
2.7 Td V6 XS 5d Auto	2006	4835mm	2190mm	2885mm	11	XS
2.7 Td V6 XS 5d (Leather)	2007	4835mm	2190mm	2885mm	11	XS
2.7 Td V6 XS 5d Auto (Leather)	2007	4835mm	2190mm	2885mm	11	XS
3.0 SDV6 (255bhp) XS 5d Auto	2011	4829mm	2176mm	2885mm	11	XS
3.0 SDV6 SE Tech 5d Auto	2004	4829mm	2200mm	2885mm	11	SE Tech
2.7 TdV6 SE 5d	2004	4835mm	2190mm	2885mm	11	SE
3.0 SDV6 Landmark LE 5d Auto	2004	4829mm	2176mm	2885mm	11	Lankmark
3.0 SDV6 Graphite 5d Auto	2004	4829mm	2200mm	2885mm	11	Graphite
3.0 SDV6 HSE Luxury 5d Auto	2004	4829mm	2176mm	2885mm	11	HSE Luxury
2.7 Td V6 Metropolis LE 5d Auto	2004	4835mm	2190mm	2885mm	11	Metropolis
3.0 SDV6 Landmark 5d Auto	2004	4829mm	2200mm	2885mm	11	Landmark
				Overall Average	**11.46**	

Appendix 2 – Study site map

A map of the roads selected for data collection. Purple and pink roads are the commonly used busy roads, while the orange highlights the sandy track.

The green dots are the locations of the supplement study sites.



Appendix 3 – Data Cards

A7 sized data cards with entries for all parameters was used for the collection of information. The upper most box to the right is used for writing the quadrate or control number. The weather was categorised into clear, patchy cloud, heavy cloud and rain. The ‘wind d/s’ is the direction and speed. Three readings were taken for the air, surface and ground temperatures to later calculate an average for each. The vegetation grid reflects the 50x50cm grid in the quadrat and is used for systematic estimation of the vegetation cover for each square. Details about the species found were written on the reverse of the card. As well as this, the number of rocks and snails were recorded and the largest rock and snail measurements.

ENVIRONMENT					
GPS					
WEATHER				DATE	
WINDD/S					
AIR TEMP.				TIME	
SURFACE				DISTANCE (M)	
GROUND					
SAND		**CAN**		**VEGETATION**	
CHEM.		TYPE			
COLOUR		STATE			
		TEMP			
SIZE		COLOUR			
SORTING		HOLE			
TEXTURE		ORIENT.			
ROUND		VEG%			

Appendix 4 - Photographic examples

Figure 1 – Top image*: Pecked hole approximately 5 cm across, showing evidence of clear and sharp edges, characteristic of tearing the can.* ***Bottom image:*** *Can showing holes caused by erosion. The edges are much blunter and generally unbent.*

Appendix 4 - Continued

Figure 2 *– Supplement experiment layout. Soft drink (pink) and alcohol (green) cans were placed half a meter apart facing at compass points. They were semi submerged to anchor the cans and marked for individual identification. Four separate sets of cans were placed across the two sites used.*

Appendix 5 - Can Integrity guide

- Measure the width, depth and length of cans to estimate their degree of can integrity
- 4 330ml drink cans were purchased for crushing.
- The cans were crushed to different amounts and took measurements.
- They were crushed to reflect the cans observed in the field.
- From this I created a categorical guide to assess the percentage of integrity
- Any measurements less than 5mm are disregarded as opportunity for investigation is unlikely.

DIMENSIONS (cm)

Length – the rim to the base

Width – middle point of the can.

Depth – smallest point of the can

Can number	**Length (cm)**	**Width(cm)**	**Depth(cm)**
1 (uncrushed)	**11.5**	**6.0**	**6.0**
2	**9.5**	**8.4**	**3.2**
3	**9.5**	**8.5**	**2.8**
4 (most crushed)	**11.4**	**8.0**	**1.2**

Category	Can integrity (%)	Example
1	100%	 
2	75%	 

3	50%	 Safeguarding NW England's geodiversity Safeguarding NW England's geodiversity
4	25%	 FANTA Safeguarding NW England's geodiversity Safeguarding NW England's geodiversity

Appendix 6 – Species Guide

Images and species descriptions from web resources and Wilkens, 2009.

Genus	Description	Image
Pachydema	• Red brown elytra. • Black pronotum, head and legs with thick light brown hairs growing from edges of body parts. • The entire body is stippled with indentations. • Clear separation between pronotum and elytra.	
Chrysolina (sanguiolenta)	• 6.5-8.4mm in length • Have dark brown or black elytra with bright reddish brown stripe along each flank. • Elytra is glossy with stippled indentations.	 
Sitona (lineatus)	• 3.4-5.3 mm in length. • They are characterised by a series of coloured scales arranged in alternating lines • Their bodies are long, thin and slightly flattened.	 

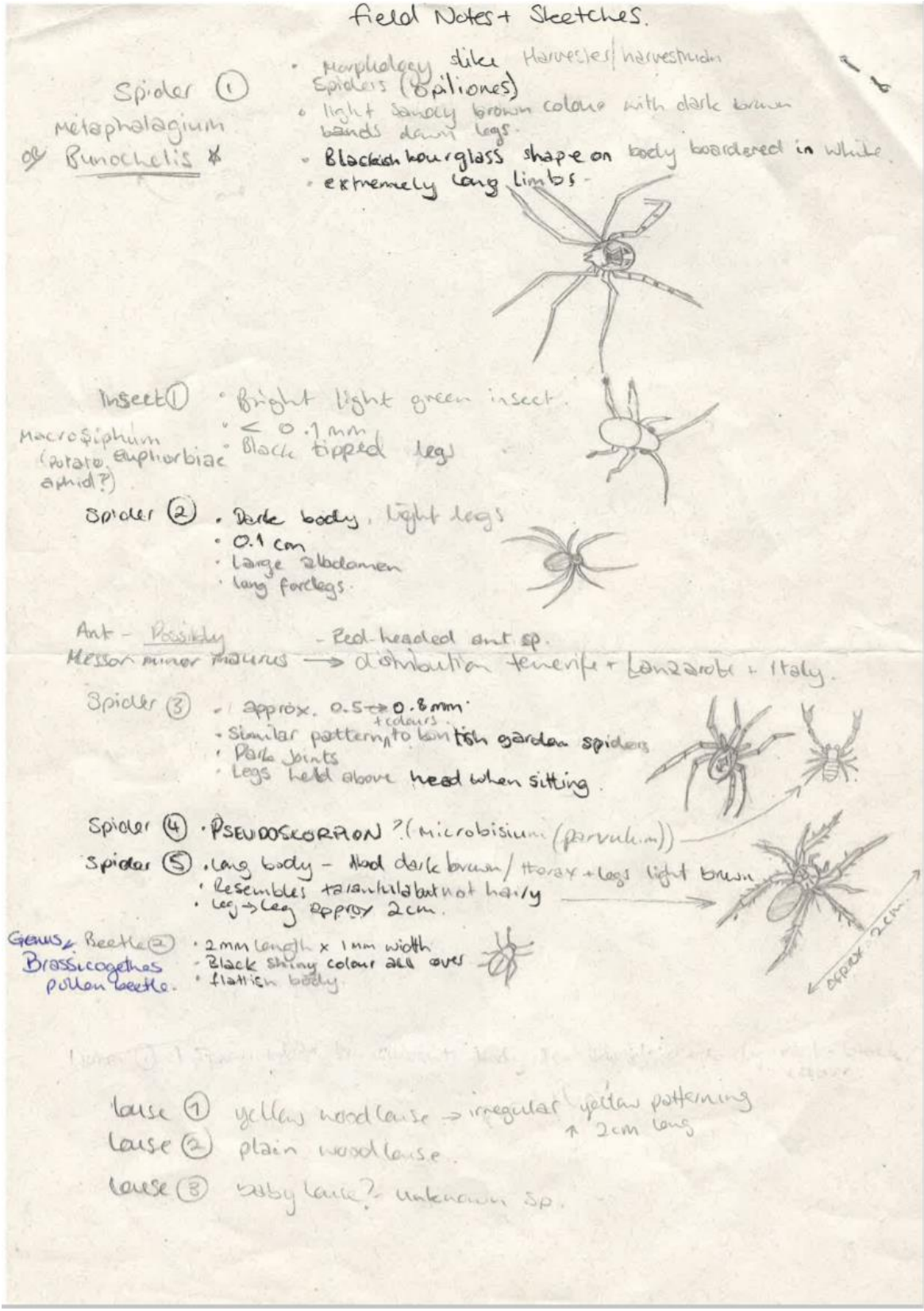
Zophosis	• Overall bluish black colour with vertical striae long elytra • matt body with very little shine.	
Arthrodeis	• 8mm in length. • Noticeably oval from a birds-eye view. Are slightly shiny and black. The Pronotum and elytra are fairly evenly sized covered in small stippled indentations.	
Myrmeleon hyalinus hyalinus **(Antlion Larvae)**	• Has a fusiform body, a very plump abdomen, and a thorax bearing three pairs of legs. • The prothorax forms a slender mobile "neck" for the large, square, flattened head, with a pair of large sickle-like jaws with several sharp, hollow projections.	 

Dericorys luteipes lobate	• Sexually dimorphic. • Males: • Multitude of colours. Head blue with cream eyes and antennae. Yellow legs and. • Roughly 4cm in length.	 
***Tarentola angustimentalis* (East Canary Gecko)**	• Males are larger than females • Approx. 8cm snout to vent with similar length tail • Dorsally flattened head and body • Sideways projecting legs • Body colour is variable	 

Gallotia atlantia atlantia **(Atlantic Lizard)**	• Sexually dimorphic. • Males – dark brown with blue/green spots on flanks • Female – brown/black with yellow stripe down flank • Pointed snout • Tail slightly spiny • Black throats	 

Appendix 7 – *Field sketches*

Field sketches of unidentified invertebrate species. Scientific drawings were made from live specimens. Descriptions were also provided to provide extra detail and scale.



Beetle (1)

Red-brown Beetle,
Blackish body,
0.8 cm
photo taken

Matt colour
stippled indentations

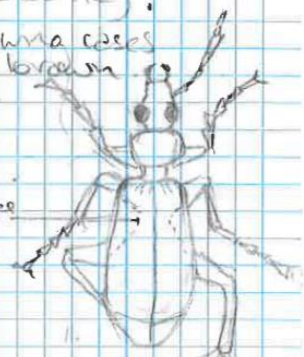
darkling beetle
zophosis punctata?

Oxycara?
rusty grabia

Beetle (3) ~~Dromius~~ (Ground beetle).

- Reddish-brown glossy body 3 mm cases
- Elytra translucent + light brown
- Defined thorax + abdomen
- Prominent beady eyes.
- flat elongated body.
- total length approx. 1 cm.

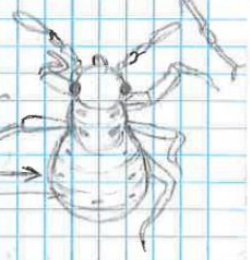
Ground beetle



Body shape underlying cases

Insect (2) → Aphid?

- Light Red bug
- 2 mm L x 1 mm W
- Black head + legs
- Overall drop shaped form
- no definitive separation between head, thorax + abdomen
- matt appearance
- visible horizontal creases
- faint dark spots down flanks



Spider (6)

- 0.5 cm approx.
- thick and longer forelimbs x4
- bilateral brown markings on lighter body
- semi translucent rear legs
- hairy front limbs.

Spider (7)

- Approx 0.5 cm body length
- 1 cm including legs.
- looks like garden spider
- thick legs with dark bands of brown.
- Diamond on abdomen.

Beetle (4)

Genus Geotrupes
Dor Beetle

Appendix 8 – Supplementary data

Results of a supplement experiment looking at the presences of invertebrates in cans over time as well as between two separate sites. Site one was located next to a main road at the edge of the desert, while site two was in the centre of the desert next to an area of secluded farmland.

	Alcoholic Cans				***Soft Drink Cans***			
	North	**East**	**South**	**West**	**North**	**East**	**South**	**West**
Site 1	3	1	3	2	1	0	1	0
Site 2	3	3	1	2	11	4	5	1

	Pachydema	***Sitona***	***Spilostethus***	***Zophosis 2***	***Cymindis***	***Louse 1***	***Louse 2***	***Louse 3***	***Spider 3***	**Total**
Site 1	0	0	1	0	0	7	3	0	0	11
Site 2	1	6	0	13	2	1	0	6	1	30
										41

Appendix 9 – Educational leaflet (next page)

A leaflet created for the education of local communities and tourists on the impact of litter and the importance of El Jable.

La Asociación Medioambiental Viento del Noreste, proyecto Desert Watch Lanzarote, ha venido observando en los últimos años con gran preocupación la cantidad de escombros y residuos que se esparcen a lo largo de las carreteras y que suponen un grave problema para la conservación del habitat de El Jable, ya que la basura afecta negativamente a la fauna salvaje (Imagen 2 - Un perenquén que perdió su cola atrapado en una lata).

Con el fin de profundizar en esta problemática se ha realizado un estudio a partir de la observación del comportamiento de algunos cuervos. En concreto, se han visto algunos cuervos que vuelan llevando latas en sus picos y a otros que las picotean hasta abrirlas, con lo que se puede deducir que han descubierto que dentro de estas latas pueden encontrar algún tipo de alimento, como insectos y arañas.

El estudio analizó la cantidad y tipos de insectos no voladores y arañas que estaban dentro de las latas arrojadas. Los huecos picoteados se han contabilizado también para ver cuántas las tenían (Imagen 3 - Una lata con hueco picoteado). Un experimento de fondo estudió la cantidad de invertebrados dentro de las latas en dos espacios diferentes; uno a lo largo de la pista y otro con muy poco acceso humano.

EL RESULTADO

A continuación se ofrecen los resultados del estudio:

- **Basura a lo largo de las carreteras o pistas es un problema** – los resultados apuntan a gran cantidad de residuos a lo largo de la carretera
- **Los cuervos suelen usar las latas de bebida tiradas** – probablemente como una fuente de alimento novedosa cuando no hay otra cosa, pero no como parte principal de su dieta. Ellas prefieren latas alcoholicas.
- **Los invertebrados habitan a lo largo de las pistas y en los lugares más remotos del El Jable** - muestran más diversidad y consistencia en números en lugares alejados de la intervención humana.
-

El estudio indica que los invertebrados e insectos se encuentran dentro de las latas pero continua una interrogante el porqué.

Los cuervos probablemente picotean huecos en las latas para buscar alimento pero no como la fuente principal. De ahí la necesidad de desarrollar más investigaciones de campo para entender bien el impacto de residuos sólidos en el hábitat de El Jable.

¿QUÉ PUEDES HACER PARA AYUDAR?

Afortunadamente hay muchas cosas que puedes hacer en Lanzarote para ayudar. Aquí te dejamos algunas de ellas para empezar:

- **Sé un buen turista en la Reserva de la Biosfera y el Geoparque Mundial de la UNESCO.**
- **Reduce reutilizando** – prevé la acumulación de residuos trayendo tus propios contenedores.
- **Trae tu basura de vuelta contigo** – no la dejes atrás cuando viajas por la isla
- Dispón de tu basura responsablemente – usa papeleras o puntos limpios disponibles
- **Sé considerado con los residentes** - ¡turista, recuerda que estás en su hogar, así que trátalo con respeto!
- **Respeta a los animales** – ¡también es su hogar!
- **Comunícalo** – recuerda a tus amigos que depositen sus residuos en las papeleras disponibles.

DESERT WATCH

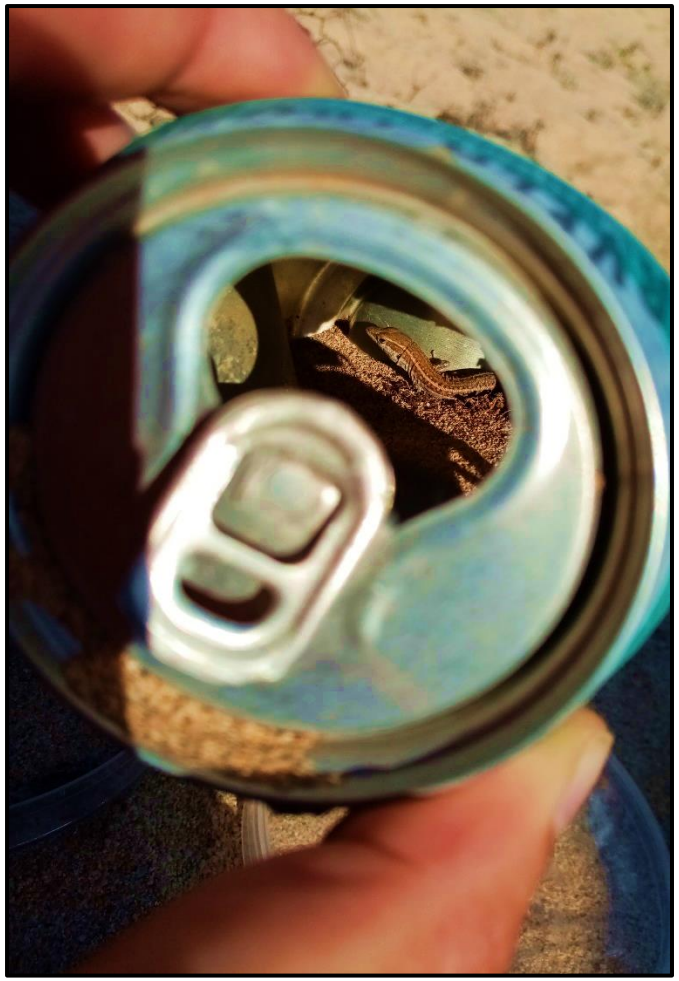
Desert Watch es un proyecto de la asociación sin ánimo de lucro "Viento del Noreste". Se trata de un grupo de voluntarios que se reúne periódicamente para recopilar información biológica sobre el espectacular hábitat del Jable de Lanzarote. Aparte del recuento de aves, observación y registro de las poblaciones de 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.

Written by Astrid Marsh.
Supported by C. Burek, M. Gea46
And C. Portella Ernest

United Nations Educational, Scientific and Cultural Organization

University of Chester

DESERTWATCH here to protect



Ravens and Litter in El Jable desert Lanzarote

Picture/imagen 1: Lanzarote with El Jable desert

LITTER, INVERTEBRATES AND RAVENS

Marine sand deposited by trade winds onto lava plains has created a semi-desert ecosystem called El Jable. Spanning across a north to south baring, El Jable has a total area of 90km^2.

El Jable is a precious habitat supporting some plants and wildlife found nowhere else in the world (Picture 1). The **UNESCO Biosphere status** for the island provides some legal protection for El Jable but more needs to be done. Unfortunately, little scientific research has been undertaken until very recently and wildlife is under stress from human impacts.

Desert Watch has seen that fly-tipping and road-side **littering is a big and worrying problem** in El Jable, and the litter is **negatively affecting wildlife** (Picture 2).

A study was conducted in El Jable to explore this concern. It had been noticed that **ravens were flying with cans in their bills and pecking holes in them**, suggesting there was something worthwhile feeding on inside, like insects and spiders.

The survey looked at the number and types of non-flying insects and spiders which were inside the littered drink cans. Pecked holes were also counted to see how many cans had them (Picture 3). A background test studied the number of invertebrates in cans at two different locations; one by a

Picture/Imagen 2: A gecko who has lost its tail trapped in a can

THE RESULT

The main results of the study were as follows:

- **Road-side littering is a problem** – results show that there is a lot of roadside litter
- **Ravens are likely to be using littered drink cans** – Probably as a novel food source when there is nothing else but not as part of its main diet. They prefer alcoholic cans.
- **Invertebrates are found around roads and in secluded parts of El Jable** – They show more diversity and consistency in numbers at sites away from human intervention.
- **Invertebrates interact directly with litter cans** - A significant number of invertebrates were found on or inside cans probably for protection from weather and predators.

The survey tells us that insects and spiders are in cans but it is still a mystery as to why. Ravens probably peck holes in cans for food, but not as a main food source. More research is needed to understand fully what the impact is of solid waste on the El Jable habitat.

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 sand and rocky desert found in the Canary island of Lanzarote. Besides bird counts, control of the plant populations and cleaning of the desert, the group also organises several types of scientific lectures detailing flora, fauna & geology found in the unique, protected reserve.

WHAT CAN YOU DO TO HELP?

Luckily, there is plenty you can do on Lanzarote to help! Here are a few things to get you started.

- **Be a good tourist in the UNESCO Global biosphere and global Geopark.**
- **Reduce by reusing** – prevent the build-up of litter by using your own containers.
- **Take your litter home** – don't leave it behind when you're travelling around.
- **Throw litter away responsibly** - use bins or recycling points provided.
- **Be considerate of local people** –Tourists, remember this is their home so treat it with care.
- **Respect the animals** – It's their home too!
- **Spread the word!** - Remind friends to dispose of litter in provided bins.

Picture/Imagen 3: A pecked hole in a can

BASURA, INVERTEBRADOS Y CUERVOS

Arena marina depositada por los vientos alisios en planicies de lava han creado un ecosistema semidesértico llamado El Jable. Atravesando la isla del norte al sur, El Jable cuenta con una superficie total de 90 km^2.

El Jable es un precioso hábitat que alberga una rica diversidad de algunas plantas y vida salvaje exclusiva a ese lugar (Imagen 1 - Lanzarote con la planicie del Jable marcada en rojo). El estatus de Reserva de la Biosfera de UNESCO otorgado a la isla de Lanzarote ha proporcionado al Jable algo de protección legal, pero se necesita hacer más. Lamentablemente, ha sido muy escasa la investigación científica realizada hasta la fecha y la naturaleza salvaje está bajo presión del imparable impacto humano.

Appendix 10 – People and Nature Author Guidelines

Length

We do not impose strict length restrictions on submissions to *People and Nature*; however, please ensure the length of your article is appropriate to your purpose. Editors will consider this when making their assessment. In general Research Articles will tend to be around 8000 words.

Article types

Research Article – empirical, conceptual and theoretical submissions are considered in this category. For empirical research qualitative, quantitative or mixed methodologies will be considered.

Review and Synthesis – these should identify evidence gaps or interpret evidence for stakeholders. Standard literature reviews will not be considered.

Perspective – Perspective articles are generally shorter than research or review articles. Perspectives should have a solid grounding in the published literature but might be more speculative and personal than a review article. Preference will be given to articles that provide novel links between fields, stimulate debate and/or suggest new research directions. Perspectives do not generally contain new data.

Debate and Conversation – commissioned pairs of articles giving two sides of a debate. These will not be available to submit without an invitation.

Correspondence – these are short comments on articles published in the journal, or the original authors' response to a correspondence piece. Correspondence articles should be submitted in a timely manner, ideally within 12 months of publication of the original article. Correspondence articles will be assessed by the journal Editorial Board and, if deemed to be of sufficiently broad interest to our readership, will usually be sent for external peer review. If accepted, correspondence articles will be held from publication while the authors of the original article are invited to respond. Authors of the original article are not required to write a correspondence response and are given a set time frame if they choose to do so. If accepted, both the Correspondence article and the Response will then be published together in an issue. If factual errors with the data or analyses presented in the original article

come to light, these will be investigated before publication of the Correspondence article(s) and a correction notice will be published either instead of or as well as the Correspondence article(s).

Manuscript specifications

For initial submission please refer to our **quick checklist**; however, for revisions and accepted articles we will ask you to adhere to the following:

Manuscripts should be formatted with double-spaced lines and continuous line numbers throughout the article, including pages for acknowledgements, references, tables and figures. Manuscripts must be written in English. Authors for whom English is not their first language may wish to consider using a professional editing service before submission, e.g. **Wiley's editing services**. The use of these services does not guarantee acceptance or preference for publication. It is also recommended that authors follow **search engine optimisations guidelines** to maximise the reach of their article.

All submissions should be written in English, However, we encourage authors to provide a second abstract in their native language or the language relevant to the country in which the research was conducted. The second abstract will be published with the online version of the article and will not be included in the PDF. Please note that second abstracts will not be copyedited and will be published as provided by the authors. Authors who wish to take advantage of this option should provide the second abstract in the main document below the English language version.

Submissions should be divided into the following sections:

Title Page

- A concise and informative title.
- A list of all authors' names with names and addresses of Institutions.
- The name, address and e-mail address of the correspondence author.

Abstract

The Abstract must not exceed 350 words and should list the main points you want authors to take away, using simple, factual, numbered statements.

Key-words

A list in alphabetical order of between three and ten words or short phrases. The most important key-words should appear in the title and the abstract as well as the key-word list. More **advice on selecting good keywords can be found here**.

Main text

Please divide the main text of your manuscript into clearly labelled sections that best suit the story of your article. We do not impose strict length restrictions on submissions to *People and Nature;* however, please ensure the length of your article is appropriate to your purpose. Editors will consider this when making their assessment. In general research articles will tend to be around 8000 words including title page, abstract, keywords and references. Please refer to our editorial policies when preparing your manuscript. In particular, where appropriate please ensure you include details of ethical approval and informed consent.

Acknowledgements (optional)

A brief statement acknowledging collaborators and research assistants who do not meet the criteria for authorship described above, or acknowledging funding sources, providing relevant permit numbers (including institutional animal use permits), or giving recognition to nature reserves or other organizations that made the work possible.

Conflict of Interest

People and Nature requires that all authors disclose any potential sources of conflict of interest. Any interest or relationship, financial or otherwise, that might be perceived as influencing an author's objectivity is considered a potential source of conflict of interest. These must be disclosed when directly relevant or indirectly related to the work that the authors describe in their manuscript. Potential sources of conflict of interest include but are not limited to patent or stock ownership, membership of a company board of directors, membership of an advisory board or committee for a company, and

consultancy for or receipt of speaker's fees from a company. The existence of a conflict of interest does not preclude publication in this journal.

Authors' Contributions

All submissions with more than one author must include an Authors' Contributions statement. All persons listed as authors on a paper are expected to meet ALL of the following criteria for authorship:

- substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data, or drafting the article or revising it critically for important intellectual content;
- final approval of the version to be published;
- agreement to be accountable for the aspects of the work that they conducted and ensuring that questions related to the accuracy or integrity of any part of their work are appropriately investigated and resolved.

Acquisition of funding, provision of facilities, or supervising the research group of authors without additional contribution are not usually sufficient justifications for authorship. The statement should include an explanation of the contribution of each author. We suggest the following format for the Authors' Contributions statement:

AB and CD conceived the ideas and designed methodology; CD and EF collected the data; EF and GH analysed the data; AB and CD led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

Data Availability Statement

To enable readers to locate archived data from papers, we require that authors list the database and the respective accession numbers or DOIs for all data from the manuscript that has been made publicly available. For example, "Data available from the Dryad Digital Repository http://dx.doi.org/10.5061/dryad.41qh7 (Kiere & Drummond 2016)." When a DOI is available for the data, the full data citation should also be given in the reference list. See below. Please see our editorial policies page for further information.

Figures and Tables

Figures, including photographs, should be referred to in the article text as Fig. 1, Figs 2–4. References to tables should not be abbreviated, i.e. Table 1. All lettering and symbols must be clear and easy to read. Legends should provide enough details for the figure or table to be understood without reference to the main text. Information (e.g. keys) that appear in the figure should not be duplicated in the legend.

Figures and Tables should be presented in the manuscript file with their legends and may be either embedded in a relevant position in the main text or placed at the end of the document. Full instructions on preparing your figures are available **here**.

References – USE APA REFERENCING

In text citations should follow the author-date method whereby the author's last name and the year of publication for the source should appear in the text, for example, (Jones, 1998). The complete reference list should appear alphabetically by name at the end of the paper. Please note that a DOI should be provided for all references where available.

You will not be asked to reformat references during submission or peer review – this will be handled during typesetting however, a sample of the most common entries in our reference lists appears under the general style points at the end of this page for reference**.**

Data Sources (optional)

Authors of submissions that use data from multiple published sources (e.g. if the paper describes a meta-analysis) are encouraged to cite these data sources in the main text of the manuscript. This ensures that these references are fully indexed and their authors are given proper citation credit.

Data sources can be cited in the “Materials and Methods” or in the “Data Availability Statement” sections. If a large number of data sources are used, instead of citing the sources individually, a separate list should be provided after the literature reference list under the heading “Data Sources”. The Material and Methods section should then refer to this section, i.e. “A list of data sources used in the study are provided in the Data Sources section.”

Data from articles published in journals or data with a DOI should follow the normal journal citation format. Citation of datasets without a DOI is permitted, provided the data repository meets the standards set out in our Data Archiving Policy. They should be formatted as above but should provide the permanent repository link and accession number for the data.

Supporting Information (optional)

Essential supporting information can be published in the online version of the article. Instructions for the preparation of Supporting Information are given **here**. **Note, however, that the BES does not allow data sets to be uploaded as Supporting Information.** All relevant data must be archived in accordance with the **BES Data Archiving Policy** .

Plain Language Summary

To raise the profile of your work and make it accessible to the widest possible audience, you are required to upload a plain language summary at the revision stage, explaining the importance of your work in a way that is accessible to the widest possible audience, not limited to scientists and fellow practitioners. Guidelines for this summary can be found **here**.

Manuscript submission

During submission, authors will be asked to confirm that:

- The work as submitted has not been published or accepted for publication, nor is being considered for publication elsewhere, either in whole or substantial part.
- All authors and relevant institutions have read the submitted version of the manuscript and approve its submission.
- All persons entitled to authorship have been so included.
- The work is original and all necessary acknowledgements have been made.
- The work conforms to the legal requirements of the country in which it was carried out, including those relating to conservation and welfare, and to the journal's policy on these matters

General style points for after acceptance

You will be asked to adhere to the below style points should your manuscript be accepted for publication. They are included below for reference:

Give Latin names in full at first mention in the main text. Subsequently, the genus name may be abbreviated, except at the beginning of a sentence. If there are many species, cite a Flora or check-list which may be consulted for authorities instead of listing them in the text. Latin names following common names should not be separated by a comma or brackets.

Authors should use the International System of Units (S.I., Système International d'Unités; see Quantities, Units and Symbols, 2nd edn (1975) The Royal Society, London). If the paper contains many symbols, they should be defined as early in the text as possible, or within the Materials and methods section. Journal style for time units are: s, min, h, days, weeks, months, years. Use 'L' for litre not 'l' to avoid confusion with 'one'. Use the negative index for units, e.g. number of insects g-1dry wt (also note there is no period for wt). Probability values should be denoted as *P*.

Mathematical expressions should be carefully represented. Wherever possible, mathematical equations and symbols should be typed in-line by keyboard entry (using Symbol font for Greek characters, and superscript options where applicable). Make sure that there is no confusion between similar characters like l ('ell') and 1 ('one'). Ensure that expressions are spaced as they should appear. If there are several equations they should be identified by an equation number (i.e. 'eqn 1' after the equation, and cited in the text as 'equation 1').

Numbers from one to nine should be spelled out except when used with units, e.g. two eyes but 10 stomata; 5 °C, 3 years and 5 kg. Do not use excessive numbers of digits when writing a decimal number to represent the mean of a set of measurements. The level of significance implied by numbers based on experimental measurements should reflect, and not exceed, their precision; only rarely can more than 3 figures be justified.