PhD-Dissertation Reviews in Ornithology (2018-2019 Academic Year)

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PHD-DISSERTATION REVIEWS IN ORNITHOLOGY (2018-2019 academic year)

Edited by Francisco VALERA

This section includes the abstracts of some of the PhD-Dissertations submitted in Spain during the 2018-2019 academic year as well as some others not published in earlier volumes of *Ardeola*. They are in alphabetical order by University where they were presented and, then, by year and alphabetical order of the author's surname. This section also includes a link to access the full version of the reviewed thesis when available.

Esta sección incluye los resúmenes de algunas de las Tesis Doctorales en Ornitología defendidas en España en el curso 2018-2019 junto con otras no recogidas en reseñas anteriores. Se ha seguido una ordenación alfabética por Universidades y, dentro de ellas, por año y autor. También se incluye un vínculo que permite acceder a la versión completa de la tesis reseñada en caso de que esté disponible.

Informative note:
In its section PhD-Dissertations Reviews in Ornithology, *Ardeola* reports any studies on ornithological issues presented in our country. The section is intended as an updated overview of the latest ornithological research performed mainly in Spain. In spite of the efforts of the editor to compile all the theses, we are aware that the collaboration of researchers (supervisors and doctorates) is needed to give a full view of ornithological research in Spain. We therefore invite the scientific community to report on their results (address: ardeola@seo.org). The Scientific Committee of SEO/BirdLife grants a biannual prize to the best Ph Dissertation included in this section. The prize is awarded in the corresponding Spanish Ornithological Conference. We are looking forward to hearing from you, also as proof of the relevance and quality of ornithological research in Spain.

Nota informativa:
Ardeola *recoge en su sección Reseña de Tesis Doctorales en Ornitología aquellas tesis leídas en nuestro país que estudien temas ornitológicos con el fin de informar sobre las más recientes investigaciones desarrolladas, fundamentalmente en España, en este campo científico. A pesar de los esfuerzos que realizamos para reseñar todas las tesis concluidas, somos conscientes de que un registro completo y actual de las mismas requiere de la colaboración de los investigadores (directores y doctorandos). Por ello, invitamos a todos aquellos implicados en la realización de tesis en ornitología a que nos informen de sus resultados (dirección: ardeola@seo.org). El Comité Científico de SEO/BirdLife otorga con carácter bianual un premio a la mejor tesis doctoral reseñada en esta sección, que es entregado en el Congreso Español de Ornitología correspondiente. Esperamos vuestras noticias como buena señal de la pujanza de la investigación ornitológica en nuestro país.*

Universidad de Alicante

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Ecological characterization and use of the Mourning Dove (*Zenaida macroura*) in a tropical agrosystem (Cienfuegos, Cuba).

*[Caracterización ecológica y aprovechamiento de la paloma rabiche (*Zenaida macroura*) en un agrosistema tropical (Cienfuegos, Cuba).]*

Key words: breeding success, food spectrum, index of dietary importance, reproductive cycle, *Zenaida macroura*.

Palabras clave: ciclo reproductivo, espectro alimentario, éxito reproductivo, índice de importancia alimentaria, Zenaida macroura.

Abstract:

The ecological knowledge of the Mourning Dove (*Zenaida macroura* L.) in Cuba turns out to be insufficient, fragmented and dispersed. This, together with the different forms of exploitation to which the species is currently subjected and the lack of regulation, raise important doubts about the effects that exploitation may have on their populations. The objective of the research was to characterize the essential aspects of the ecology and human exploitation of the Mourning Dove that may be useful for its sustainable management in a tropical agrosystem. The study was carried out in the "Damují" hunting area of the municipality of Rodas, province of Cienfuegos, Cuba, covering 645.8ha. I found that the agricultural biotope with coverage presented a better quality for the studied species, given the predominance of herbaceous species, which constitute the main food source, and the presence of boundaries and isolated trees that offer shade, shelter and substrates for nesting. In contrast to the typical forest biotope, the Mourning Dove presented an aggregated distribution in the agricultural biotope with coverage, determined by the composition and structure of the vegetation and therefore by the availability of food. The reproductive period extended from March to August, but a part of the population also bred all the year round. Thirty-one nests were detected. They were found in five nesting habitats and over 10 different species of plants, although there was a greater preference for spiny trees and shrubs. Total reproductive success was 55%. The analysis of the age ratio showed an imbalance in favor of the males. The age ratio also evidenced that the population is not completely replaced which must be taken into account for its management. Concerning the food spectrum, 33 items were identified, of which 88% are of plant origin, 9% are foods of mineral origin and 3% of animal origin. The seeds of *Euphorbia heterophylla* and *Panicum maximum* were the most important food elements. The bulk of the diet (79%) was made up of seeds of herbaceous plants, preferring small seeds, of which only 10% were agricultural crops. The Mourning Dove fed preferentially in areas with herbaceous species and some degree of bare soil. Agricultural lands were the best feeding sites, over livestock areas or natural forests and forest plantations. The morphometric characterization of the species differs statistically from that described in other studies conducted in the country and in the U.S. Two types of ectoparasites were found in the population, the Gavilán Fly *Lynchia americana* and an unknown mite. *Lynchia americana* is housed in the plumage of the bird and showed a high temporality, its incidence peaking during the rainy season. The mite is the most frequent parasite. It is found on the legs of the dove during most of the year. The Mourning Dove is the most important hunting species in the country, above the Anatidae and other species of Columbiformes. Illegal hunting (69%), mainly of nestlings and juveniles (73%), is the most common form of exploitation of this dove. Pneumatic rifles and slings are the

hunting techniques causing highest mortality. The knowledge provided by this research offers the necessary elements for the protection and management of the species in the study area and, in general, in the country, and contributes to the sustainable management of this bird species.

Academic year: 2016-2017.

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Reproductive biology and conservation of the White-collared Swift (*Streptoprocne zonaris*) in south centre Cuba.

*[Biología reproductiva y conservación del vencejo de collar (*Streptoprocne zonaris*) en el centro sur de Cuba.]*

Key words: Apodidae, Cuba, habitat selection, reproductive success, Topes de Collantes.

Palabras clave: Apodidae, Cuba, éxito reproductivo, selección de hábitat, Topes de Collantes.

Abstract:

The White-collared Swift *Streptoprocne zonaris* is a species with a wide distribution in the Americas, from Mexico, Central America and the West Indies to South America. In Cuba, it has a restricted distribution in the southern mountains from Guamuhaya, Sierra Maestra and Sierra Cristal. Information on the biology and ecology of this species is generally limited, especially in Cuba. Until now, there are only a few reports on its activity in this island. Information on behaviour and reproductive biology of birds is essential to identify appropriate conservation actions for declining and threatened species. Birds can be excellent indicators for the environmental quality of territories. Therefore, they are frequently used as a reference to assess the situation of a territory that should receive legal protection. Several species of birds use caves and cliffs for nesting, the White-collared Swift among them. It has been suggested that this behaviour could be an anti-predator strategy or an ecological adaptation to the karst environment. Swifts nesting places are associated with rivers and waterfalls, which could be related to the thermoregulation of the altricial chicks, favouring more constant temperatures and higher minimum values during the night. In this context, given the lack of information about the species in Cuba, and since some of its resting and nesting places are in areas of particular environmental interest but lacking appropriate management measures, we developed this study about the ecology and the conservation of the White-collared Swift in Cuba. The fieldwork was performed in the natural area of Topes de Collantes (south centre of Cuba). Results show that the reproductive season of the White-collared Swift in this area spans approximately 77 days, from the end of April until mid-July. The beginning of the reproductive season coincides with the arrival of the rainy season. This will probably guarantee the availability of materials for nest construction, and a greater availability of trophic resources. The materials for the nest are collected inside the nesting sites, with participation of both adults in transport and conditioning of the nest. The most used location for nests in caves was on ledges in the walls, and the most frequent height was 3-4m. Most nests were concentrated in roofed chambers in the caves, which could be related to a greater microclimatic stability that would favour reproduction and protection against predators. The clutch size was two eggs, with some cases of three eggs, a clutch size first recorded for Central America and the Caribbean area. The volume of the eggs was related to the incubation success and the reuse of the nesting place, the latter being related to the height at which nests are found: nests used for the first time are built higher than those used more than once. This could be because young couples or couples who have lost their usual posi-

tions occupy the places that are available at a greater height. Most of the reused posts were found in the roofed chambers, indicating a strategy to avoid predators. The reproductive success during the two seasons evaluated was 63.64%; with 0.87 chicks/nest. The behavioural spectrum observed during the reproductive season is wide and complex. The different behaviours displayed during this period are influenced by the content of the nests (egg or chick) and the phases of reproduction (nest building, incubation, and chick feeding). The presence of tourists close to nesting sites does not influence directly the swift's reproductive success, but evidence of an indirect influence makes it necessary to implement management measures in order to minimize such impacts. This work on the reproductive biology of *S. zonaris* contributes to filling important knowledge gaps and provides methodological tools for the evaluation of the status of the species in the Cuban context, whose monitoring will favour the conservation of the natural values of the areas associated with its reproduction.

Academic year: 2018-2019.

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A life in flight; new inputs from movement ecology of Lesser Kestrel (*Falco naumanni*). *[Una vida en vuelo; nuevas aportaciones a la ecología del movimiento del cernícalo primilla (*Falco naumanni*).]*

Key words: Booted Eagle, infrastructures impact, migration, Montagu's Harrier, wintering areas.

Palabras clave: águila calzada, aguilucho cenizo, áreas de invernada, impacto de infraestructuras, migración.

Abstract:

Animal movement is an important component of the ecological and evolutionary process, and includes topics such as habitat fragmentation or global change. Animal movement has aroused interest for humans for years and, recently, both scientists and naturalist have promoted new techniques to unravel some unknown aspects of an emerging paradigm, the "movement ecology". Recent improvement on remote tracking technologies enables us to monitoring many species throughout space and time, getting a lot of new information. The Lesser Kestrel *Falco naumanni* is a small migratory falcon that was seriously threatened at the end of the last century, becoming extinct in many locations throughout its range. It was listed as "endangered" and, during decades, it has been the focus of intensive conservation and research efforts. Nevertheless, several aspects of its biology still remain unknown. This thesis has three main objectives: (i) study the migration phenology (improving the few previous geolocators studies that underestimated migration times, especially during the equinoxes), the exact routes and the possible effects of climatic conditions (e.g. wind) over migration; (ii) study of the wintering areas using a multi-specific approach that also considers the transaharian migratory raptors Montagu's Harrier *Circus pygargus* and Booted Eagles *Hieraaetus pennatus;* and (iii) evaluate the impact of habitat loss due to new infrastructures in priority habitats for the species. We got data from 26 Lesser Kestrels (captured and marked with satellite telemetry or with dataloggers between 2010-2017 in Villena, southeastern Spain) and from 23 Montagu's Harriers and 14 Booted Eagles (captured and tagged with different tag models in Spain between 2006-2014 by the Vertebrates Zoology Research Group of the University of Alicante and by the Migra Project ran by SEO/BirdLife). Our main results include some unknown topics of the ecology of the Lesser Kestrel: (i) the long scales performed in North Africa, (ii) their time-budget pat-

terns, with nocturnal migration and with some parameters (distance/day or flight speed) more similar to larger soaring raptors than to other hawks, (iii) the location and fidelity to wintering areas, and (iv) their loop migration pattern, that implies different routes and, possibly, different risks and energy consumption rates along different stopovers or flyover areas, which may affect bird survival. Also, we have been able to check how different species (soaring harriers vs flapping kestrels) respond differently and complexly to main winds. General environmental conditions, and therefore wind patterns, are expected to change because of global change. This can have, in the long term, effects on the bird's behavior and on their populations. This thesis shows that high densities of wintering Lesser Kestrels can also be found out of Senegal (one of the most important areas for this species), namely in Mali and Mauritania. Besides, habitat preference of Lesser Kestrels in the wintering areas suggests that they may be exposed to similar risks than the ones they face during the breeding season. For example, agricultural intensification and pest-control with massive use of pesticides raise serious threats to insectivorous species, because they decrease prey availability and may have direct lethal effects on birds. This is especially serious in the Sahel where farmland is normally outside protected areas and the foraging strategies of insectivorous raptors depend on irregular pulses of food induced by rainfall, showing home-ranges too extensive to be protected. According to this, the multi-species analysis allowed us to identify and characterize smaller common priority areas that safeguard winter habitats of different migratory raptors. We show that forest areas close to farmlands (the most selected foraging zones), seem necessary to determine the key areas. Finally, this study also shows that the infrastructure's impact on the kestrel's breeding habitat can be minimized if close suitable habitats are preserved (i.e., high prey availability). In many cases, the possible impact of infrastructures is evaluated in a restricted area around them, while the surrounding territory, where the possible negative effects could be alleviated, is neglected. Also, the criteria used to delimit the boundaries of Special Protection Area (SPA) are sometimes inappropriate since they only use, for example, the distribution of nests to delimit these areas. Yet, their foraging habitats should also be considered. Future studies that include a larger data set will allow the analysis of the consistency of our results over the years (e.g., the scales or the time-budget), to check how birds behave under different conditions (e.g., different ages and/or populations with different migratory distances – e.g., Asian Lesser Kestrel populations) and how respond to changing winds. The new improvements on monitoring techniques will allow us a better understanding of how global changes will affect species and how we can counteract their possible negative effects.

Academic year: 2018-2019.

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Movement ecology of migratory raptors.
[Ecología del movimiento de aves rapaces migradoras.]

Key words: GPS/satellite telemetry, migration, movement patterns, soaring raptors, wind effects.

Palabras clave: efectos del viento, migración, patrones de movimiento, rapaces planeadoras, telemetría satelital/GPS.

Abstract:

The movement ecology of birds is a subject that has undergone a breakthrough in recent years, largely due to the development of satellite telemetry and its implementation to

ornithological research. This knowledge contributes to a better understanding of the behavior of the species and the factors that affect them, which in turn is also essential for the design of appropriate conservation plans. In this context, this thesis focuses on the study of the movement ecology of four species of migratory raptors: the Egyptian Vulture *Neophron percnopterus*, the Booted Eagle *Aquila pennata*, the Short-toed Snake Eagle *Circaetus gallicus* and the Red Kite *Milvus milvus*. The main goals the thesis are: (i) to study the movement ecology of the mentioned species; to analyze the effect of environmental conditions, especially wind patterns, on the migration of raptors; (ii) to analyze interspecific differences in movement strategies according to the trophic ecology and environmental characteristics; and (iii) to assess the ability of raptors to adapt and respond to global change, and their usefulness as indicator species. To address these objectives, we tagged individuals with GPS/satellite telemetry (by the Vertebrates Zoology Research Group of the University of Alicante or by the Migra Project ran by SEO/BirdLife). All the birds were captured in Spain, except two Snake-toed Eagles that were tagged in Italy. Regarding the wind effects on the migration routes, we studied the geographical, seasonal and interspecific variation with the Egyptian Vulture, the Booted Eagle and the Short-toed Snake Eagle, being the three species trans-Saharan soaring raptors. The analysis showed that daily movements of Egyptian Vultures and Booted Eagles were significantly affected by tailwinds during both autumn and spring migrations, and the effect of crosswinds was significant in all cases. Interestingly, Egyptian Vultures and Booted Eagles showed latitudinal differences in their behavior, compensating more frequently at the onset of autumn migration and with a higher proportion of drift segments at the end of the season when they reach their wintering areas. In contrast, there was a higher drift at the onset of spring migration and a higher compensation at the end. These results suggest that changes in weather conditions due to global change may affect the geometry of the migratory routes of soaring raptors and their behaviour. The movement patterns during the breeding/summering and wintering period were also analyzed to evaluate interspecific and seasonal differences. For this, we checked the fit to two strategies of random search: the Lévy and Brownian movement. The results suggest that in species with a specialized diet (i.e., Short-toed Eagle) the Lévy pattern would maximize the encounters with scarce and unpredictable resources, whereas for species with a broad trophic niche (i.e., Booted Eagle and Red Kite), movements could be adapted to exploit different food resources according to their abundance. Scavengers like the Egyptian Vulture shift between both search strategies according to the distribution of carrion. Therefore, the analysis of food search patterns can be used as an indirect indicator to track changes in food availability across a broad range of environmental conditions. This thesis also provides new information about some aspects of the spatial ecology of the Red Kite, evidencing a great variation in its movements. We studied the autumn and spring migrations between the wintering quarters in Spain and the breeding/summering areas in Central Europe, determining parameters such as the duration of migration, the speed or the number of stopover days, or intraspecific differences. We found that, in spring, juvenile individuals, that showed a wider phenological range, began to migrate significantly later than adult birds. During the breeding season in Spain, adult Red Kites (particularly the females) concentrated mainly their movements in the nest area. These breeding adults preferred lands occupied by scrub, herbaceous vegetation, non-irrigated

crops and heterogeneous agricultural areas, which highlights the importance of conserving the agroforestry landscape and its heterogeneity. Red Kites showed different behaviour throughout their juvenile dispersal: individuals from Baleares remained close (ca. some tens of kilometers) to the nest, but peninsular birds moved further, overall above 100km from the nest, travelling through the center, north and west of the Iberian Peninsula. Some of these individuals had temporary settlements close to the nest, but others settled more distantly, up to 651km from the nest. In conclusion, this thesis provides new information on the behavior and ecology of migratory raptors, both about the effect that environmental conditions may have on their movements and on their spatial ecology at different stages of the annual cycle.

Academic year: 2018-2019.

Universidad Autónoma de Barcelona

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Causes and consequences of brain size evolution: A global analysis on birds.

[Causas y consecuencias de la evolución del tamaño del cerebro: Un análisis global en aves.]

Key words: behavioural flexibility, cognition, diversification, environmental changes, macroevolution.

Palabras clave: cambios ambientales, cognición, diversificación, flexibilidad de comportamiento, macroevolución.

Abstract:

Why some species of vertebrates, including humans, evolved large brains despite the associated energetic and developmental costs is one of the main puzzles in evolutionary biology. Of the many hypotheses that have been launched to try to resolve this puzzle, environmental variability stands out as a major cause of relative brain size variation. More formally, the cognitive buffer hypothesis (CBH) postulates that relatively larger brains evolved to facilitate behavioural adjustments to enhance survival under changing conditions. The rationale of the CBH is that advanced cognition can increase fitness in varying environments by enhancing information gathering and learning, facilitating for instance shifts between different feeding sites or food types to alleviate periods of food scarcity. Increased survival would, in turn, facilitate a longer reproductive life, thereby compensating for the developmental and energetic costs of growing a large brain. While the CBH has received ample empirical support in recent years, some authors have questioned its relevance to account for the evolution of enlarged brains. This PhD thesis explores the causes and consequences of brain size evolution, using birds as a study model. The thesis has three specific objectives: (i) to explore the validity of relative brain size as a standard measure for comparing changes in brain structure among species, an assumption of the CBH; (ii) to test the link between brain size and environmental variation, a major prediction of the CBH; and (iii) to explore the consequences of relative brain size for the evolutionary diversification of the species. It takes advantage of a large database on brain size comprising more than 1,900 extant bird species in combination with recently developed phylogenetic comparative methods to elucidate the origins of brain size variation in the most diverse vertebrate class. As a first objective, the thesis validates the extent to which relative brain size is a good proxy of the brain structures involved in the capacity to construct behavioural responses to new challenges. Although there is ample evidence that large-brained species are better problem-solvers

and have higher capacity for behavioural innovation, the debate still exists on whether the whole brain is biologically meaningful or instead one should focus the attention to particular brain structures responsible for these cognitive abilities. In chapter one, detailed measurements of several brain regions are compared, to show that associative areas of the brain –classically related with general intelligence– are disproportionally larger in large brained species and accurately predict variation in the whole brain, therefore validating its use in the later analyses. According to the CBH, species living in regions with higher environmental variation should be selected for larger brains, unless they have adaptive specialisations to avoid drops in resource availability. In chapter two, this hypothesis is validated, showing that birds living in highly seasonal and unpredictable environments (i.e. high-latitude regions) possess relatively large brains than residents from other regions. Further reconstructions of evolutionary trajectories are also consistent with the hypothesis that larger brains (relative to body size) evolved when the species invaded more seasonal regions. However, the alternative –that the species already possessed larger brains when they invaded more seasonal regions– cannot be ruled out. In chapter three, additional support for the CBH is found. Based on sister-taxa comparisons, species living on oceanic islands appear to have relatively larger brains than their mainland relatives. Phylogenetic ancestral trait estimations further confirmed this trend and show that these differences mainly reflect in situ brain evolution rather than varying colonisation success. Besides, a phylogenetic path analysis shows that the best-supported scenario to explain the evolution of enlarged brains in islands is that selection arises from the need to confront increased uncertainty in resource availability that characterizes islands, an evolutionary change that is also facilitated by a slower pace of life. Finally, chapter four explores the possibility that the evolution of larger brains has also consequences for species diversification. As predicted by the behavioural drive hypothesis, frequent behavioural changes as a response to environmental challenges should expose individuals to new sets of selective pressures, thereby favouring evolutionary divergence from the ancestors, finally leading to speciation events. Diversification rates are estimated using two conceptually different approaches and consistent evidence is found in favour of the hypothesis, as lineages with larger brains (relative to body size) have diversified faster than lineages with relatively smaller brains. The best-supported trait-dependent model suggests that brain size primarily affects diversification rates by increasing speciation rather than decreasing extinction rates. In addition, the effect of relative brain size on species-level diversification rate was additive to the effect of other intrinsic and extrinsic factors. Altogether, our results highlight the importance of brain size as an important factor in evolution and reinforce the view that intrinsic features of species have the potential to influence the pace of evolution. Overall, the findings of this thesis provide evidence that relatively large brains function, and hence may have evolved, to cope with environmental changes, and that the evolution of enlarged brains may subsequently influence the evolutionary diversification of the lineage. These results help understand why different animal groups have independently evolved large brains, which can also shed light on the mystery of how our ancestors evolved and also give clues on how animals might respond to the rapid human-induced environmental changes that characterize the Anthropocene era.

Academic year: 2017-2018.

Universidad Autónoma de Madrid

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Trophic niche in *Falconidae*: heterogeneity of habitat, nutrition and reproduction.
[Nicho trófico en Falconidae: *heterogeneidad de hábitat, nutrición y reproducción.]*

Keywords: *Falco tinnunculus*, *Falconidae,* generalism, nutritional composition, trophic niche.
Palabras clave: composición nutricional, Falco tinnunculus, Falconidae, *generalismo, nicho trófico*.

Abstract:

This thesis examines the trophic ecology in the falconids as a group of predatory raptor species with a cosmopolitan distribution. In a first approach within the scheme of trophic niche (specialist-generalist strategies), this thesis investigated whether diet diversity of falconid species is able to predict both size of the range and landscape heterogeneity measured as the biomic specialization index (BSI; number of biomes inhabited) at a global scale. It is postulated that if a generalist trophic strategy allows species to expand and colonize new areas and habitats, both diversity and diet richness should be positively correlated with the number of biomes occupied and the size of the range. In a second step, the thesis focuses on a species, the Common Kestrel *Falco tinnunculus*. Trophic niche and foraging strategy in relation to fitness, breeding territory, habitat and nutritional composition of its main prey-species in a Mediterranean montane population are investigated. Offspring viability (physical and immunological condition) is used as a component of fitness, nest-box occupation during 8 years is used as kestrel preference for habitat/territory. It is postulated that if generalism is a beneficious strategy and more diverse landscapes offer more diverse prey types (Landscape Heterogeneity Hypothesis; LHH), then the best individuals should show a more diverse diet and occupy more diverse territory habitats. In relation to the foraging behaviour, it is analysed whether the kestrels follow the classical scheme of the Optimal Foraging Theory (Central Place) based on the relationship between the time spent foraging and the energy obtained from the food or, on the contrary, the nutritional components of the prey species also play a relevant role in a predator species. Furthermore, potential access to prey species was calculated by assigning values to those ecological features that impede (or facilitate) prey capture by kestrels. Results revealed that trophic breadth was not a good predictor for range size but for landscape heterogeneity: more diet generalist species inhabited more biomes, that is, more heterogeneous landscapes. In addition, both trophic breadth indexes (richness and diversity) at both taxonomic ranks (class and order) showed clear differences in the distribution of generalist-specialist species within the clade, therefore in the description made of trophic niche of species. It is concluded that diet breadth is an important ecological trait explaining global patterns of biome occupation for individuals, populations and particularly species. Concerning the Common Kestrel, its diet changed significantly among years and individuals of better quality fed their offspring with a higher diversity of prey species and a higher amount of food. Moreover, nestlings receiving a more diverse diet from parents, but not a higher amount of food, showed better body condition and immune response than nestlings fed with a less diverse diet. It is concluded that by broadening the trophic niche in unpredictable environments, individuals can increase fitness. The results for kestrel's territories quality in the population studied showed that the territory quality was quadratically correlated with

habitat diversity, with the best territories being the least and most diverse. Moreover, diet diversity was not correlated with territory quality, but it was negatively correlated with landscape heterogeneity. We conclude that generalist foraging strategies in Common Kestrels are based on an active search for different prey species within or between habitats rather than on the selection of territories with high habitat diversity. Regarding foraging behaviour, this thesis revealed that capturability index and load-size explain the time spent by kestrels to provision a prey item, although the explanatory power of load-size is low for large prey. Kestrel prey preference is mainly based on specific nutritional components, such as fat, protein and amino acid contents. Finally, the results show a particularly strong preference of kestrels for Common Voles *Microtus arvalis*. It is concluded that nutritional composition of food plays an important role also for the foraging strategies followed by predators. In addition, it is highlighted the importance of considering capturability indexes of prey species in optimal foraging models.

Academic year: 2016-2017.

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Evolutionary history and diversification mechanisms in the avian genus *Junco*: a multidisciplinary approach using phenotypic, ecological, phylogeographic and phylogenomic data.

[Historia evolutiva y mecanismos de diversificación en el género de aves Junco*: un enfoque multidisciplinar utilizando datos fenotípicos, ecológicos, filogeográficos y genómicos.]*

Key words: avian radiation, neutral divergence, recent diversification, selection, speciation.

Palabras clave: divergencia neutra, diversificación reciente, especiación, radiación en aves, selección.

Abstract:

Recently diversified systems are optimal research subjects to study the relative roles of genetic drift, gene flow and selection in shaping patterns of diversity and promoting the formation of new evolutionary lineages. In the early stages of the speciation process, causal correlations between selective factors and patterns of phenotypic and adaptive genetic divergence are still recent and detectable. In turn, reconstructing the evolutionary relationships of closely related lineages is a challenging task because of potential gene flow and/or incomplete lineage sorting. In this thesis, I develop an experimental design that combines phylogenetic and phylogeographic analyses with phenotypic, ecological and genomic data in order to infer the evolutionary relationships and the mechanisms of early lineage divergence involved in the radiation of the songbird genus *Junco* (Aves: Emberizidae) from Central and North America. Previous analyses based on mtDNA markers revealed a lack of genetic diversity and strong signatures of recent population expansion in the phenotypically differentiated and geographically structured boreal forms of Dark-eyed Junco (*Junco hyemalis*). These patterns suggested a process of rapid diversification during a northward recolonization of the North American continent from Mexico after the last glacial maximum (LGM) ca. 18,000 years ago. New phylogenetic molecular dating confirms the postglacial origin of the northern *Juncos*, and phylogenomic analyses based on genotyping-by-sequencing (GBS) single nucleotide polymorphisms (SNPs) recover a pattern of reciprocal monophyly among the rapidly diversified young lineages. This contrasts with at least four isolated lineages showing relative phenotypic stasis in the south of the distribution. Whole-genome analyses also support the recent origin of the boreal forms of *Junco*, and recover signals of demographic expansions and limited gene

flow during lineage diversification, suggesting a scenario of rapid divergence in allopatry. Using linear regression and multivariate analyses, I also find signs of an association between adaptive genomic variability and variation in both ecological and sexually selected traits, evidencing the roles of natural and sexual selection in jointly driving rapid phenotypic divergence and lineage diversification in the Dark-eyed Junco complex. In addition, genome surveys based on SNPs reveal genomic landscapes of divergence with no obvious regions of high differentiation, with significant outliers found to be scattered across the entire genome. These patterns are consistent with a diversification process driven by multiple selective factors acting on many independent genome-wide loci. Overall, the analyses and results reported in this dissertation reveal the *Junco* system as one of the fastest radiations known in vertebrates, driven by the combined effects of historical processes such as demographic expansions and drift in isolation, and also selective factors including natural and sexual selection.

Academic year: 2017-2018.

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Development of new tools for the diagnosis and control of West Nile virus infection.
[Desarrollo de nuevas herramientas para el diagnóstico y control de la infección por el virus West Nile (Nilo Occidental).]

Key words: diagnostic, immune response, surveillance, vaccine, West Nile virus.
Palabras clave: diagnóstico, respuesta inmune, vacuna, vigilancia, virus West Nile.

Abstract:

West Nile virus (WNV) is a bird-hosted, mosquito-borne virus that is currently considered one of the most remarkable emerging pathogens due to its recent geographical expansion and its epizootic, zoonotic and epornitic capacities. This thesis deals with the development of useful tools in the diagnosis, surveillance and control of the infection produced by this virus. As a starting point for the different works carried out, the necessary reagents were obtained to undertake these developments, the WNV non-structural recombinant protein NS1 and the complete WNV structural region expressed in the form of an empty capsid, or "virus-like particle" (VLP). Several methodologies potentially useful in the diagnosis and control of the disease produced by WNV were established and tested with these reagents. First, the immunogenicity and immunoprophylactic capacity of NS1 was tested in a natural host model, the Red-legged Partridge *Alectoris rufa*. For this purpose, groups of partridges were inoculated with recombinant NS1 or an unrelated (mock) recombinant protein, and challenged with infectious WNV. A third group received no inoculation prior to challenge. The NS1 group failed to elicit detectable antibodies to NS1 while in the mock group a specific antibody response was observed. Moreover, no protection against WNV disease was observed in the NS1 group, but rather, it showed significantly higher viral RNA load and delayed neutralizing antibody response, and suffered a more severe clinical disease, which resulted in higher mortality. This adverse effect did not happen in analogous experiments carried out in mice. The mechanism behind this adverse reaction observed in partridges is unknown and merits further investigations. Secondly, the immune response to the NS1 protein in horses was compared with the response to structural proteins in VLP form by means of ELISA techniques in order to explore methods for differentiating vaccinated from infected animals through serological analysis. The results showed that differentiation using the system under study is possible between vaccinated

and infected animals under controlled conditions, but it is not as effective in the conditions prevailing in the field. Third, the antigenicity of the VLP obtained was evaluated in order to verify if they could represent viable alternatives to the antigens used in the diagnostic tests, being suitable for this purpose in the tests carried out. Finally, the monoclonal antibody 1D11, generated in the laboratory in previous studies, was assessed as a reagent for the immunodetection of a wide range of WNV variants, using immunochromatographic techniques. The results revealed that the mAb 1D11 can detect all tested WNV lineages, and differentiate this virus from other related flaviviruses, which points to 1D11 as an effective immune reagent for the universal detection of WNV.

Academic year: 2018-2019.

Universidad de Barcelona

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Assessing and mitigating the seabird bycatch in the artisanal longline fisheries of the Mediterranean.

[Evaluación y mitigación de las capturas accidentales de aves marinas en la pesca artesanal de palangre del Mediterráneo.]

[Avaluació i mitigació de les captures accidentals d'ocells marins en la pesca artesanal de palangre del Mediterrani.]

Key words: demersal longline, differential mortality, factors affecting interactions, mitigation measures, Shearwaters.

Palabras clave: factores que afectan las interacciones, medidas de mitigación, mortalidad diferencial, palangre demersal, pardelas.

Abstract:

Seabirds are amongst the most threatened group of birds in the world, especially due to the pressures caused by human activities. In particular, bycatch mortality by commercial fisheries represents one of the major threats to many seabirds worldwide. Seabirds are highly sensitive to non-natural mortality due to the characteristics of their life cycle. For this reason, incidental catches by fisheries are putting many seabird species at risk. In the Mediterranean, the longline fishery is the main cause of seabird mortality and possibly the most important factor contributing to the decline of endemic Shearwater (Procellariidae) populations. However, the information available on the level and extent of its impact is scarce and fragmented. Moreover, no mitigation strategy to prevent this bycatch mortality has been implemented yet in the fleet. This thesis aims to assess and contribute to the knowledge about seabird bycatch by longline fisheries of the western Mediterranean, as well as to identify the most appropriate mitigation strategy for the fleet. In particular, the study has focused on demersal longliners since they use the most dangerous gear for seabirds and because there is little information available. Observations on board demersal longliners in the western Mediterranean have revealed a high mortality of seabirds, in particular of the three endemic and threatened species of Shearwaters: Scopoli's *Calonectris diomedea*, Balearic *Puffinus mauretanicus* and Mediterranean *P. yelkouan*, calling for urgent and effective action to reduce their bycatch rates. This greater susceptibility of Shearwaters is due to their highly aggregative behaviour and deep diving capability, which together lead to occasional massive catches of dozens and even hundreds of individuals, and also significant economic losses for fishermen. There are several temporal, operational, spatial and meteorological factors influencing the bycatch risk, but the most dominant ones are the season and the setting time. Other influential factors are the bait type, wind conditions, longline configuration (distance

between the weights), proximity to the breeding colonies and the number of hooks set. The use of different approaches (concurrent analysis of GPS data from seabirds and Vessel Monitoring System) from vessels, seabird counts from onboard observations and the mortality reported by fishermen) has allowed more detailed exploration of the effects of trawl fishing on the bycatch risk by longliners. In Scopoli's shearwater, the reduction of discards by trawlers led to increased interaction between these seabirds and longliners, thus increasing the bycatch risk. Consequently, the incoming legislation adopted by the European Union, which intends to ban discards through landing obligation, will likely aggravate the bycatch problem, at least in the short-term. Examination of the carcasses collected from the longline fisheries operating in the study area has demonstrated unequal bycatch mortality at population level, which may exacerbate bycatch impacts on population dynamics. Adults are the age class most affected, being particularly vulnerable in the vicinity of breeding colonies for the case of Scopoli's shearwater, which also show a male-biased mortality at the beginning of the breeding season. However, in *Puffinus* shearwaters, mortality is female-biased during the chick-rearing period. Furthermore, the mortality on longlines in the study area is more pronounced but not limited to Spanish breeding colonies, as birds from other Western Mediterranean colonies are bycaught while using the area as a stopover site during the migration period. This shows that the impacts of the Spanish longliners are spread well beyond Spanish colonies. The trials of different mitigation methods adapted to demersal longliners has helped to identify the most appropriate strategies to reduce the seabird bycatch by the fleet studied. It appears that night setting would be the most effective method to prevent seabird mortality without compromising target catches or other non-commercial species. However, these results should be confirmed for longliners targeting species other than European Hake *Merluccius merluccius*. Likewise, a temporal closure of the fishery during the most conflictive months is also a promising strategy to reduce the impact of bycatch. Nevertheless, this limitation should be implemented together with other measures and its potential effects on fishing activity should be carefully evaluated. Other methods that may reduce seabird bycatch include increasing the sink rate of the longlines and avoiding the use of baits attractive to seabirds. However, the high diversity of fishing strategies and gears used in the area hampers the identification of suitable solutions applicable to the whole fleet. Consequently, to deal with this complexity it would be necessary to establish a set of different mitigation measures that can be adapted to the majority of fishing methods.

Academic year: 2017-2018.

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Demographic viability and effect of anthropogenic environmental changes in the distribution, diet and body condition of an expanding population of Egyptian Vulture *Neophron percnopterus*.

[Viabilidad demográfica y efecto de los cambios ambientales antropogénicos en la distribución, dieta y condición física de una población de alimoche Neophron percnopterus *en expansión.]*

Key words: landfill, predictable anthropogenic food subsidies, scavenger, threatened species, vulture.

Palabras clave: buitre, carroñero, especie amenazada, fuentes de alimentación predecible, vertedero.

Abstract:

The Egyptian Vulture *Neophron percnopterus* is a threatened species worldwide. The

Iberian Peninsula holds 50% of its global population, which has declined by 25% over the last 20 years. Despite this negative global trend, an increase from one to 22 pairs over the last 25 years has been observed in eastern Catalonia, where the species has colonised areas in which it was previously unknown. According to our population models, this population growth can be explained by a higher survival of adult individuals than the one observed in other Iberian populations. Such high survival rate can probably be related to the uncommon use of poison in Catalonia in comparison to other areas of the Iberian Peninsula, where poisoning is the main cause of non-natural mortality in Egyptian Vulture. Moreover, arrival of new individuals (immigrants) is necessary to explain population growth. Since this is a philopatric species, the most likely origin of these new individuals is the adjacent population of western Catalonia. In order to assess the environmental characteristics of new colonized areas, we studied the population expansion pattern of the species. Specifically, we evaluated the influence of food resources of anthropogenic origin (landfills and vulture restaurants), hereafter Predictable Anthropogenic Food Subsidies (PAFS). Results suggested that PAFS play an important role in the territorial selection of adult pairs, as breeding territories are closer to landfills than expected by chance. However, other environmental factors such as south facing rocky areas, urbanization and proximity to conspecifics are also important for territorial selection. Then, we studied the diet of breeding pairs to evaluate to what extent individuals rely on landfills. We compared results obtained with two different methods: (i) stable isotopes analysis, and (ii) analysis of diet remains found in nests (mainly bones, feathers and hair). Both methods evidenced that the proportion of food from landfills in some pairs could be more than 50% of the overall diet. Moreover, our results show that diet based on waste is the main factor affecting the physiological indicators of fledglings. Specifically, a higher proportion of waste in the diet was related with lower levels of some vitamins and carotenes, which have important functions such as antioxidant defences, immunostimulating properties and ornamental purposes. Finally, we analysed the concentration of different families of pollutants; metals, organochlorine compounds (Ocs), polybrominated diphenyl ethers (PBDEs) and perfluorinated substances (PFAS) in individuals as well as the influence of these compounds on their physiology. Most analysed pollutants were below the detection limit or were, in general, low. In spite of these low levels, individuals from more humanized areas had higher levels of PFAS. This thesis provides relevant information in two ways: (i) it describes the demographic increase of the worldwide-threatened Egyptian Vulture. Highlighting the causes that have led to the positive trend in our study area could be very useful for the conservation of the species in other areas; (ii) it evaluates the implications of feeding in landfills in a scavenger bird. In an anthropic world where resource distribution is constantly changing, providing knowledge about the influence of landfill sites can be key to designing future management measures for threatened or pest species using these resources.

Academic year: 2017-2018.

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From behavioral ecology to demography: lessons for the Little Bustard (*Tetrax tetrax*) conservation.

*[De la ecología del comportamiento a la demografía: lecciones para la conservación del sisón común (*Tetrax tetrax*).]*

Key words: anthropogenic mortality, diet composition, incubation behaviour, inter-

individual habitat selection, ranging behaviour.

Palabras clave: comportamiento de campeo, comportamiento de incubación, composición de dieta, mortalidad antropogénica, selección interindividual del hábitat.

Abstract:

The conservation of endangered species requires understanding what factors determine habitat selection, survival and breeding success of their populations. Under the current agricultural intensification context, species inhabiting agrarian environments must adapt, *sensu lato*, to the rapid changes and constraints of these systems. Nevertheless, not all species can do this easily and, as a result, dramatic population declines and even biodiversity loss take place. The Little Bustard *Tetrax tetrax* is a Palearctic steppe bird with important populations in the Iberian Peninsula. In the last decades, the species has experienced a rapid population decline, mainly due to agricultural intensification, but illegal shooting and power line collisions are also threatening factors. Currently, the Little Bustard is ranked as "Vulnerable" in Europe and "Near Threatened" at global scale. The specific processes linking agricultural intensification and population decline in the Little Bustard are surely complex and multifactorial. This thesis aims to improve the knowledge necessary for a proper and effective management for the conservation of this species. For this reason, some biological topics relevant for the understanding of the demography of the species, such as adult mortality, hatching success and incubation behaviour, have been investigated, as well as habitat selection and diet during the non-breeding season. Animals usually show non-random spatial distributions resulting from the cumulative effects of many factors that are often difficult to separate. By using spatial eigenvector mapping in combination with habitat models, we showed that ranging behaviour of female Little Bustards in the non-breeding season was affected by the independent effect of habitat variables and spatial constraints, as well as by their joint effect. Approximately one third of the spatial aggregation observed in female Little Bustards distribution was related to responses to the spatially aggregated environment. Moreover, the fact that different females presented, not only spatial aggregations at the same scales, but also aggregation to the same areas of the Lleida Plains, suggests that observed patterns could be related with landscape configuration heterogeneity. Spatial predictors representing aggregation patterns at ~18km and 3-5km respectively had a high importance in female occurrence. However, pure habitat effects were also identified. Terrain slope, Alfalfa *Medicago sativa* and corn stubble availability were the variables that most contributed to environmental models. Overall, models revealed a non-linear negative effect of slope and positive effects of intermediate values of alfalfa and corn stubble availability. High levels of cereal stubble in irrigated land and roads also showed a positive effect on occurrence at the population level. Our results provide evidence that female Little Bustard ranging behaviour was spatially constrained beyond environmental variables during the non-breeding season. This pattern may result from different, not mutually exclusive processes, such as cost-benefit balances of animal movement, configurational heterogeneity of environment or from high site fidelity and conspecific attraction. Measures aimed at keeping alfalfa availability and habitat heterogeneity in open landscapes and flat terrains could contribute to protect Little Bustard populations during the non-breeding season. Up to 62 plant species were identified among the diet of the Little Bustard in the non-breeding season in Spain. The most consumed species were cultivated legumes (46.7%) and dicotyledon weeds (45.6%), while monocotyledons were

scarcely consumed (7.7%). Diet composition differed significantly between dry and irrigated farmland areas. In irrigated areas, diet was mainly composed of legumes, in particular alfalfa. In contrast, in dry farmland areas diet was more diverse, composed mainly of weeds (Compositae, Papaveraceae, and Cruciferae) and also cultivated legumes, particularly Vetch *Vicia sativa*. These results suggest that legume crops could improve habitat quality in areas with scarce food resources. However, in the case of irrigated areas, the strong reliance on alfalfa could make the Little Bustard more vulnerable to changes in land use. Concerning adult Little Bustard mortality in Iberia, we found that annual anthropogenic mortality is likely to have a critical impact on the species, with values almost as high as those attributed to natural causes. Collision with power lines was the main anthropogenic threat to the adult population (3.4-3.8%/year), followed by illegal killing (2.4-3%/year), which had a higher impact than initially foreseen. We found that replacement clutches are more common than previously reported. The replacement rate was 67% for first clutches that failed during incubation and 57% for failed second clutches. Overall, nest failure accounted for 67.9% of clutches, influenced by the low hatchability of replacement clutches (16.7%). Farming practices accounted for 36.8% of nest failures. The main cause of failure was nest desertion/predation (58%). Laying date had a negative effect on the hatching probability of clutches and on the risk to fail among first clutches. The size of nesting field (negative effect) was the most important predictor for the hatching probability. Measures aimed at improving food provision by increasing field edge density and fallow availability may facilitate hens to keep body-condition prior and during incubation, as well as providing suitable habitat for replacement clutches. Adaptive irrigation and mowing patterns in alfalfa fields during the nesting season would also contribute to increase the hatchability of replacement clutches.

Academic year: 2018-2019.

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Evolutionary patterns and processes of migratory behaviour in Palearctic-Paleotropical birds.

[Patrones y procesos evolutivos del comportamiento migratorio en aves del Paleártico-Paleotrópico.]

Key words: bird migration, Euro-Africa flyway, evolution, niche, Pleistocene.

Palabras clave: evolución, migración de aves, nicho, Pleistoceno, ruta euro-africana.

Abstract:

One of the most fascinating aspects of birds is their capability to migrate from one area to another throughout the year. Unravelling the patterns and processes involved in the evolution of migration is paramount to understand the current biogeography, ecology and evolution of migratory birds. On this basis, the main aim of the present thesis was to extend the knowledge on the mechanisms involved in the evolution of bird migration. To achieve this, the thesis comprised two main sections. In the first one, the aims were to disentangle the patterns of evolution of migratory behaviour and identifying the main factors that play an important role in it. In this context, we used the *Sylvia* warblers as a case of study, due to their well-known distributions and wide range of migratory behaviours. In the second section, we explored the climatic niche and the potential distribution of breeding and wintering ranges in the last glacial maximum (LGM) of trans-Saharan long migratory species, in order to unravel the potential changes in migratory behaviour under different environmental

conditions. We explored the evolution of migration in *Sylvia* warblers as both a discrete and continuous character using ancestral state reconstruction (ASR) methods. We recovered the basal node as migratory in most analyses, suggesting five independent losses of migratory behaviour in *Sylvia* warblers, including some cases in island subspecies. Both analyses performed with migration as discrete or continuous character recovered different probabilities of sedentariness or migratoriness in some conflicting nodes depending on ASR elements used. This forced us to consider controversial hypotheses of the evolution of migration in some clades that could evolve from migratory to sedentary in a very short period of time or going through a partial migratory status instead. Furthermore, we used phylogenetic comparative methods to assess whether the evolutionary patterns of migratory distances are correlated with several biometric, climatic and productivity variables in a phylogenetic context, using *Sylvia* warblers as a case study. Our results recover net primary productivity (NPP) in the breeding range and during the breeding season as the variable with a stronger positive correlation with migratory distances. Several climatic variables show a correlation with the evolution of migration, and among morphological variables, migratory lineages tend to have longer wings than sedentary ones. It is not possible to disentangle if NPP was the main driver in the evolution of bird migratory behaviour or a consequence of it, yet migration and NPP seem to be tightly related today and along their evolutionary history. In the second part of this PhD thesis, we explored the evolution of migration in a macroecological perspective; including the study of climatic niche of migratory species and the changes in their distributions through climatic change scenarios as glaciations. Migratory birds occupy different geographic areas during breeding and wintering periods and are exposed to different factors. One of those factors is the climatic component of the niche. We tested if migratory birds display similar climatic conditions in both breeding and wintering areas, using 355 migratory bird species from Eurasia to Africa flyways. Our results show that there is not climatic niche overlap between both ranges. This suggests that the climatic niche of most Euro-African migratory species is larger than expected. Given these results, we propose that both breeding and wintering climatic data need to be considered when analysing the niche of a species (e.g. performing species distribution models), in order to incorporate the total width of the climatic niche. During the Plio-Pleistocene, glacial cycles have shaped Northern Hemisphere birds' distributions that could result in changes in their migratory behaviour. In this context, it has been suggested that long-distance North American migratory species could have lost their migratory condition during cold periods, regaining it later in warmer periods. We tested this hypothesis in Eurasian-African extant migratory bird species. We modelled the present and LGM distribution of 80 trans-Saharan bird migratory species, and we revised the available fossil record. Our results show a southwards reduction of the breeding distributions during the LGM compared to the present and similar wintering areas in the present and Pleistocene, with the Saharan belt gap always present through time. These results, combined with evidence from the Pleistocene fossils from Africa, do not support the hypothesis of a loss of migratory condition in these species. In conclusion, the results of this thesis suggest that migratory behaviour would be a more conserved character than previously thought, at least during the Pleistocene, and that changes in the character probably happened before in the evolutionary history of birds, and only recent island colonisation has shifted the behaviour to sedentary status.

Academic year: 2018-2019.

Universidad de Extremadura

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Temporary qualitative study of the sectorial biodiversity of the years of maximum and minimum reception of birds in the Arrocampo reservoir of the Almaraz Nuclear Power Plant (Cáceres).

[Estudio cualitativo temporal de las biodiversidades sectoriales de los años de máxima y mínima acogida de aves en el embalse de Arrocampo de la Central Nuclear de Almaraz (Cáceres).]

Key words: characterization of communities, population dynamics, relationships with environmental physical factors, systematic evaluation of populations.

Palabras clave: caracterización de comunidades, dinámica de poblaciones, evaluación sistemática de poblaciones, relaciones con factores físicos ambientales.

Abstract:

This thesis studies the avian community of the Arrocampo reservoir (Cáceres). The study focuses on the years 2009-2010, when the maximum and minimum number of species for a series of more than 30 years was recorded. Determining the possible causes of these situations, as well as evaluating a possible analytical strategy are the main challenges addressed. The importance of water has been particularly recognized since man discovered agriculture. Consequently, the construction of reservoirs for livestock, human populations and agriculture was developed. These reservoirs are the home of numerous species of waterbirds, so that they find food and shelter, as well as suitable places for nesting, maintenance and care of the offspring. Birds, together with other organisms, are part of an ecosystem characterized by a certain stability and with a relevant temporal dynamic. The Arrocampo reservoir, built for the cooling of the Almaraz nuclear power plant, is one of the most original reservoirs in the world since: (i) its water level is constant, (ii) it has a spatial thermal gradient at the horizontal level, (iii) water circulates around a wall in the center of the reservoir and from the bottom of the vessel, which forces the water to move in a double direction. Since its commissioning (1976), this reservoir has housed numerous waterfowl, which has been periodically censused since 1983, thus enabling knowledge of its successional variations, rhythms and fluctuations. In this scenario, the spatio-temporal distribution of bird populations that occupy the reservoir in extreme situations has been studied. The analysis of more than 30 years of monitoring allowed to identify 2009 and 2010 as the years with higher and lower presence of bird species (biodiversity or specific richness). Data on occurrence of the different species and on climate (by AEMET and the nuclear power plant) were subjected to various analyses (ordination and classification) to study the relationship between the composition of the community, the spatial component (derived from the reservoir sectorization) and climate. The results and conclusions obtained can be compared with the ones from other reservoirs and establish generalizations of interest both in the world of nature assessment, conservation and environmental impact assessment. There is no universal strategy for the assessment of each reservoir. The use of birds as an indicator, prioritizing the frequencies of occurrence, allows the use of other indices, such as diversity, determination of trophic structures, diversification or valuation of specific persistence, etc. Therefore, the ornithological characterization of each system can be used as a measure of quality. In parallel, carrying out the simultaneous monitoring of the populations facilitates the knowledge of the structures and dynamics of the populations,

especially of the most faithful ones due to their permanence, and even to particularize their relations with the most characteristic habitats fitting the preferences of each species in the reservoir. Finally, we suggest that the fluctuation of biodiversity between 2009 and 2010 may be due to the strong interannual contrast in rainfall. The number of species that used the reservoir in 2009 was higher because this year was drier, and therefore the conditions of the areas around the reservoir were worse for the birds while the conditions of the Arrocampo reservoir were constant and offered an optimum water level and temperature for birds. In contrast, 2010 was a particularly rainy year, and the conditions of the reservoirs and ponds around Arrocampo were much more favorable for birds, which were not limited to using Arrocampo as a breeding or wintering place.

Academic year: 2016-2017.

Universidad de Granada

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Behavioral and physiological responses to brood parasitism and nest predation in two passerine species.

[Respuestas comportamentales y fisiológicas frente al parasitismo de cría y a la depredación de nido en dos paseriformes.]

Key words: brood parasitism, co-evolution, egg-rejection process, immune response, nest predation risk.

Palabras clave: coevolución, parasitismo de cría, reconocimiento y expulsión de huevos, respuesta inmune, riesgo de depredación de nido.

Abstract:

Brood parasitism and nest predation are two of the most important selective pressures in birds. Avian brood parasitism is one of the best examples of a coevolutionary process, where hosts evolve a series of adaptations to counteract the fitness costs imposed by brood parasites. Among these defensive adaptations, recognition and rejection of the parasitic egg are decisive. Nest predation, on the other hand, is a classic example of agonistic interaction, being the most important force shaping nestlings' life-history traits. The main aim of this thesis is to expand our knowledge on how these two selective pressures shape some behavioural and physiological responses in birds. In the first part of the thesis, we provide new information on the breeding biology of a poorly known bird, the Western Bonelli's Warbler *Phylloscopus bonelli*, which is also a potential host for the Common Cuckoo *Cuculus canorus* in Southern Europe. This novel and detailed information is essential to draw attention to the potential risks that it might face in the near future, considering the reduction of this species in the study area. The second part focuses on brood parasitism. Using the Bonelli's Warbler, we first investigated whether different characteristics of the parasitic egg (size and material) used in egg-rejection experiments could affect the egg-rejection behaviour. This kind of methodological studies are critical to determine the validity of experiments in the field. We found that plasticine may misrepresent the responses to experimental parasitism because this material facilitates egg ejection, provoking a decrease in nest desertion rate. Further, small parasitic eggs could be easily ejected and warbler nests parasitized with large eggs were more often deserted, thus indicating that nest desertion occurs because of the constrains imposed by the size of parasitic eggs. Within the framework of this second part, and linking with the next one, we also studied the interaction between brood parasitism and nest predation. In this case, we used the Common Blackbird *Turdus merula*, which suffers high nest pre-

dation levels. Despite several studies on parasite-host systems, only recently researchers have understood that the recognition and rejection of parasitic eggs are part of a complex process, where the decision of rejecting mainly depends on the costs associated to that action, the external stimuli perceived by the host or its internal status of motivation. Predation could be one of the environmental pressures that may promote evolutionary changes in the phenotypic traits of egg-rejection process, affecting the cost-benefit trade-off. Nevertheless, studies on these mechanisms are limited. We found that blackbird females exposed to risk of adult predation showed a significant lower ejection rate, whereas the risk of offspring (egg) predation did not modify females' anti-parasitic behaviours. Interestingly, this effect increased towards the end of the breeding season. These findings open a new research line in the study of brood parasitism and provide new knowledge in our understanding of egg-rejection process mechanisms. The third part of this thesis investigates physiological anti-predator strategies against nest predation, which have been frequently neglected. Predation risk is known to modify the hormonal responses of prey. However, very little is known about its effect on immunity, which is a crucial physiological component. In the first chapter of this part, we explored whether a short-term nest predation risk, typical of a predator encounter, can provoke changes in nestlings' immunity. Using blackbirds, we experimentally tested several levels of nest predation risk and measured a complete set of immunological variables. We found that nest predation risk induced an increase in ovotransferrin, immunoglobulins and the number of lymphocytes and eosinophils, suggesting a general activation of the immune response, which will prepare nestlings to cope with the possible inflammation or infection following a predator attack. Interestingly, only high and extreme levels of risk caused the changes, indicating that nestlings would be able to modulate their immune responses according to the perceived level of threat. In the second chapter, we tested the effects of a long-term increase in nest predation risk, which is more related to the ecology of fear concept. Changes in the immune system can impose important costs in organisms, thus, we hypothesize that the responses to short- or long-term predation risk are different. In addition, nestling have to invest many resources during their developmental period, a condition that may interfere with the immunological response. By increasing predation risk during the whole blackbird nestling period, we found a reduction of immunoglobulins but an increase of lymphocytes, which confirms the above-mentioned hypothesis. Indeed, health status and body condition conditioned their immunological defences. For instance, only those nestlings without endoparasites or in good body condition could increase their immune response. This thesis confirms that brood parasitism and nest predation, through the behavioural and physiological mechanisms that induce, strongly shape the evolution of the adaptations in birds. We demonstrated the interplay between these two decisive selective pressures offers a new perspective of the forces that may shape the evolution of the anti-parasite defences in host. Further, we discovered that immunological responses triggered by predation risk might have important consequences in developing organisms, as they can alter the trade-offs between immunity and the physiological processes of development.

Academic year: 2016-2017.

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Behavioral, physiological and reproductive effects of predation and avian brood para-

sitism risk on the reproduction of birds: Does fear matter?

[Efectos comportamentales, fisiológicos y reproductivos del riesgo de depredación y del parasitismo de cría en la reproducción de las aves: ¿importa el miedo?]

Key words: birds, ecology of fear, parasitism risk, predation risk, sub-lethal effects.

Palabras clave: aves, ecología del miedo, efectos subletales, riesgo de depredación, riesgo de parasitismo.

Abstract:

Predation and inter-specific avian brood parasitism are two fundamental selective forces that have contributed to modulate the reproductive behavior and life-history strategies of birds. Recently, it has been suggested that, in addition to the direct effects of predation, the risk of suffering predation (fear) could have sub-lethal effects on prey affecting behavioral and reproductive traits in ecological and evolutionary time. In addition, it has not been studied yet whether the fear of suffering brood parasitism could also affect reproductive traits of the hosts or behaviors other than those involved in the defense against parasites. The main objective of this thesis is to identify the indirect or sub-lethal effects of fear of predation and inter-specific brood parasitism in several bird species. To address this objective, we studied possible changes in behaviors, life-history traits and physiology in response to a series of experimental manipulations of predation and inter-specific brood parasitism risk before and during reproduction. Experimental procedures were designed at different spatial scales in a community of non-excavating birds breeding in nest-boxes, and in a population of Magpie *Pica pica* parasitized by the Great Spotted Cuckoo *Clamator glandarius*. We evaluated the response to perceived risk through different cues that can be noticed by different communication channels (i.e. olfactory, acoustic and visual cues). This thesis first provides new evidence of the sub-lethal effects of predation and inter-specific brood parasitism on decisions prior to the reproduction of birds in natural environments. These effects have been shown through changes in nest-site choice in host and prey species and have indirect effects on community structure, composition and level of interaction between guilds. We also found effects of the risk of nest predation perceived during reproduction through changes in parental care. However, we did not find clear evidence of the effects of the risk of parasitism on reproductive and physiological traits in a host of an obligate brood parasite, once reproduction had begun. The results also suggest that human activity can be perceived as a risk factor modulating the physiological state of species under population decline, because of the alteration and disturbances in their habitats. Therefore, this thesis offers new advances in the study of the risk of predation and the risk of cuckoo parasitism in ecological time of great interest both in the field of Evolutionary Ecology and Behavior with application in Animal Conservation and Management. In addition, I suggest that the study of multiple cues is necessary to fully understand the effects of risk, given that birds may evaluate threats perceived by cues through different communication channels.

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Defences against brood parasitism in the Common Blackbird (*Turdus merula*): plasticity, physiology and evolution.

*[Defensas frente al parasitismo de cría en el mirlo común (*Turdus merula*): plasticidad, fisiología y evolución.]*

Key words: avian brood parasitism, co-evolution, Common Blackbird, eco-physiology, egg ejection.

Palabras clave: coevolución, ecofisiología, expulsión de huevos, mirlo común, parasitismo de cría.

Abstract:

The severe fitness costs imposed by avian brood parasitism select for the evolution of anti-parasitic defences in hosts, setting the stage for a co-evolutionary arms race where brood parasites evolve adaptive counter-defences, which select for improved host defences, further parasitic adaptations, and so on. Though these adaptations can be found in all stages of the breeding cycle, the main defence against brood parasitism is the rejection of the parasitic egg. Egg rejection is a complex process where several stages can be differentiated: egg recognition, decision-making and egg-rejection itself. Throughout this thesis, the study of egg rejection is approached by focusing on those factors that govern each of these stages. Egg ejection can be carried out by deserting the parasitized nest, ejecting the foreign egg, or burying it in the nest. The potential costs associated with each of these egg-rejection mechanisms are very different, so that the host's choice is modulated by a balance between costs and benefits of the anti-parasitic response. Chapter one explores whether nest desertion can be considered an egg-rejection mechanism in medium or large-sized hosts, who would be able to eject the parasitic egg. Results prove that nest desertion cannot be considered a response unequivocally directed to brood parasitism in the Common Blackbird *Turdus merula*, a medium-sized potential host of the Common Cuckoo *Cuculus canorus*. Therefore, future studies on egg rejection using similar species should cautiously consider nest desertion as a response to brood parasitism. Different traits of parasitic eggs (mass, colour and size) affect specific stages of the egg-rejection process including the host decision-making, which may result in the acceptance of previously recognized eggs. Chapter two shows that hosts are not willing to assume the potential costs associated to the ejection of a slightly heavier egg. This low motivation turns out in acceptance decisions, confirming that egg recognition is not necessarily followed by egg rejection. Chapter three goes one step further showing how the different stages of the egg-rejection process are independently impacted by different characteristics of parasitic eggs. This chapter evidences that colour mimicry hampers egg recognition (the first stage of the process) and leads to egg acceptance. Though egg size does not seem to affect recognition, it does delay the decision to eject (the second stage of the process) and imposes mechanical restrictions on the action stage (the third stage). The existence of such acceptance decisions implies that the egg-rejection rate does not necessarily reflect the egg-recognition abilities of hosts. Given its importance in regulating animal behaviour, endocrine pathways are excellent candidates to continue unravelling the proximate mechanisms underlying egg rejection. Thus, chapter four investigates how hosts adjust their hormonal state to deal with parasitic eggs, as well as the potential effects of these adjustments on the physical state of hosts. Results show that parasitic eggs can be a hormonal stressor for hosts. Parasitized individuals showed higher corticosterone levels and lower body condition than non-parasitized ones. Furthermore, prolactin levels indicated that blackbirds tend to maintain the parental effort even when parasitized, which might explain the absence of nest desertion in response to experimental parasitism. The key role that host decision-making play in anti-parasitic defences suggests that plastic responses are common among hosts. Chapter five reviews the evidence of plastic defences against parasitic eggs, showing that phenotypic plasticity in egg rejection is less widespread than might be expected. This chapter examines the factors that favour the evolution of phenotypic

plasticity, as well as the importance of plastic defences in the co-evolutionary relationship between brood parasites and their hosts. On the other hand, chapter six provides experimental evidence on the evolutionary origin of the egg-rejection abilities exhibited by potential host species not currently impacted by interspecific brood parasitism, as is the case of blackbirds. According to the results, the most probable origin of the egg-rejection abilities in blackbirds is a past exploitation by interspecific brood parasites. Current absence of interspecific brood parasitism in some potential host species might be due to their successful anti-parasitic defences, which can persist even after speciation events. In chapter seven, we investigated whether there are sex differences in egg rejection, which is particularly relevant in species in which incubation relies exclusively on females. Contrary to conventional theory, we found that male blackbirds are able to recognize and eject parasitic eggs. However, recognition abilities of males are less developed than those of females, probably because they do not participate in egg incubation. According to the new theoretical framework in the field of animal decision-making, the results of this thesis highlight the need to update some terms frequently used in egg-rejection studies, as well as the inclusion of new concepts to future studies. In chapter eight, we propose an updated terminology advocating for the consistent use of terms in future studies on egg-rejection. Overall, this thesis provides significant advances in our understanding of the co-evolutionary interactions between brood parasites and hosts, particularly in relation to the main anti-parasitic defences: egg rejection. All these results show egg-rejection is a complex and potentially plastic process that is modulated by the cognitive abilities of hosts, the environmental context, host's physiology and the characteristics of the parasitic egg.

Academic year: 2017-2018.

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Study of the causes of morbidity and mortality in wild birds admitted to the Wildlife Rehabilitation Center of Tafira, Gran Canaria (2003-2013).

[Estudio de las causas de morbilidad y mortalidad en las aves silvestres ingresadas en el Centro de Recuperación de Fauna Silvestre de Tafira, Gran Canaria (2003-2013).]

Key words: causes of morbidity, final disposition, raptor, seabird, wildlife rehabilitation center.

Palabras clave: ave marina, ave rapaz, causas de morbilidad, centro de rehabilitación de fauna silvestre, disposición final.

Abstract:

This study analyzes the causes of admission and the outcomes of the rehabilitation of 6,804 wild birds [raptors (2,458), seabirds (1,956) and other avian orders (2,390)] admitted to the Tafira Wildlife Rehabilitation Center (TWRC) in Gran Canaria Island, Spain, from 2003 to 2013, assessing a quality auditing system based in the crude and stratified (by causes of admission) rates of several final disposition categories, the time until death, and the length of stay as quality indicators. Primary causes of admission were: trauma, infectious/parasitic disease, metabolic/nutritional disorder, orphan young birds, poisoning/intoxication, crude oil, light pollution/fallout, fishing gear interaction, glue trap, captivity, other causes, and unknown/undetermined. Final dispositions rates were: euthanasia (E_r), unassisted mortality (M_r) during hospitalization, release (R_r), and permanent captivity (C_r). The time until death (T_d) for euthanized birds and for birds that died during the hospitalization, and the length of the stay in the center for released

birds (T_r) were also evaluated in each case. In the survey of raptors, the most frequently admitted species were: Eurasian Kestrel (*Falco tinnunculus*; 53%), Eurasian Long-eared Owl (*Asio otus canariensis*; 28.1%), Canary Islands Common Buzzard (*Buteo buteo insularum*; 8.0%), and Eurasian Barn Owl (*Tyto alba*; 4.4%). The most frequent causes of admission were trauma (33.8%), orphan young birds (21.7%), unknown (18.4%), and metabolic/nutritional disease (11.1%). Morbidity caused by glue trapping and entanglement in Burr Bristlegrass *Setaria adhaerens* had a prevalence of 5.0% and 1.8%, respectively. The highest number of admissions during the breeding and non-breeding seasons was observed for the Eurasian Barn Owl and the Barbary Falcon *Falco pelegrinoides*, respectively, mainly due to trauma of unknown origin. The final disposition rates of the 2,194 raptors admitted alive were: E_r = 19.8%, M_r = 22.2%, R_r = 57.6%, and C_r = 0.5%. E_r was higher in the trauma category (37.3%), while M_r was higher in infectious/parasitic disease (60%). R_r was notably higher in glue trap (85.9%), entanglement in *S. adhaerens* (85%), and orphan young (78.7%). Within the group of euthanized raptors, the longest median T_d was observed for the metabolic/nutritional disease category (T_d = 20.5 days), whereas the majority of causes of admission had median T_d values < 3 days. The median T_d for raptors that died during the hospitalization period ranged from 0 days (predation) to 5.5 days (other causes). Within the group of released raptors, the median time of stay in the TWRC ranged from one day (orphan young) to 153 days (infectious/parasitic disease). In the survey of seabirds, Yellow-legged Gull *Larus michahellis* was the species most frequently admitted (46.5%), followed by Cory's Shearwater *Calonectris diomedea borealis* (20.1%). The most frequent causes of morbidity were light pollution/fallout (25.8%), poisoning/intoxication (24.7%), and other traumas (18.1%). The final disposition rates of the 1,823 seabirds admitted alive were: E_r = 15.3%, M_r = 16.3%, and R_r = 68.3%. The highest E_r was observed in the 'other traumas' category (58.1%). Seabirds admitted due to metabolic/nutritional disorder had the highest M_r (50%). The highest R_r was observed in the light pollution/fallout category (99.2%). Within the group of euthanized seabirds all categories had median T_d values ≤ 2 days. The median T_d in the seabirds that died during the hospitalization period was ≤ 3 days for all categories. Within the group of released seabirds, the median time of stay in the TWRC ranged from 0 days (light pollution, other traumas, and orphan young) to 15 days (crude oil). Concerning other avian orders, the most frequently admitted ones were: Order Passeriformes (n = 724, 30 species), Order Charadriiformes (n = 592, 14 species), Order Columbiformes (n = 310, six species), and Order Apodiformes (n = 244, four species). The Eurasian Thick-knee *Burhinus oedicnemus* was the species most frequently admitted (20.3%), followed by the Eurasian Blackbird *Turdus merula cabrerae* (13.5%), and the African Collared-Dove *Streptopelia roseogrisea* (10.9%). The most frequent causes of morbidity were trauma (27.8%), orphan young (27.2%), unknown/undetermined (19.4%), and captivity (10.2%). The final disposition rates of the 2,276 birds admitted alive were: E_r = 16.7%, M_r = 26.5%, R_r = 54%, and C_r = 2.8%. The highest E_r was observed in the trauma category (39.4%). Birds admitted due to metabolic/nutritional disorder and poisoning/intoxication had the highest M_r, 48.5% and 43.5%, respectively. R_r values > 70% were achieved in the following causes of admission: captivity (80.3%), crude oil (80%), glue trapping (73.3%), and orphan young (70.5%). Within the group of euthanized birds the longest median T_d was observed for the infectious/parasitic disease category (T_d = 24 days), whereas the majority of causes of admission had median T_d values

< 2 days. The median T_d in the birds that died during the hospitalization period ranged from 0 days (fishing gear) to 16.5 days (captivity). Within the group of released birds the median time of stay in the TWRC ranged from 0 days (captivity) to 47.5 days (infectious/parasitic disease). This survey provides useful information for the conservation and welfare of these bird species. We suggest that at least the stratified analysis by causes of admission of the three final disposition rates, the time until death and the length of stay at the center should be included in the outcome research of the rehabilitation of wild birds. The high release rate for raptors (57.6%), seabirds (68.3%), and other avian orders (54%) achieved at the TWRC emphasizes the importance of wildlife rehabilitation centers for the medical management of injured birds and their release into the wild.

Academic year: 2016-2017.

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Species distribution models for birds: How useful are their outcomes for conservation applications?

[Modelos de distribución para aves: ¿Cómo de útiles son sus resultados para aplicaciones de conservación?]

Key words: birds, conservation, species distribution models, validation.

Palabras clave: aves, conservación, modelos de distribución de especies, validación.

Abstract:

Species distribution models are increasingly used to guide biodiversity conservation actions. These models predict the probability of species occurrence in locations where the species presence is unknown based on the link between species presence and environmental conditions. Probability of species occurrence is often considered as indicator of habitat quality. Correct interpretation of the outcomes of this modelling technique is of paramount importance before using the models for conservation purposes. The main objective of this thesis is to contribute to providing evidence of the usefulness and applicability of species distribution models for some conservation and management applications. Despite the growing research interest about species distribution models, many conservation practitioners remain sceptical about their usefulness in biodiversity conservation projects. We show that model outcomes are as able as local bird experts to identify unknown presence areas for a nearly threatened bird species. We also present an innovative analytical framework using data from breeding bird atlases to help in the initial design of monitoring projects. The data generated through these monitoring projects would be appropriate to produce accurate species distribution models and maps. We evaluated the reliability of species distribution models using measures of reproductive performance with data obtained from constant effort bird ringing sites. We showed that models may help to predict habitat quality but not for all species at any spatial scale. We also showed that the outcomes of species distribution models might provide misleading information to guide the spatial prioritization of management or conservation options when species switch or expand to a novel habitat. With our results, we encourage the use of species distribution models among practitioners as an accepted tool to support biodiversity conservation and management. However, caution is needed when interpreting model outcomes, especially in the areas where a species occupies several habitat types and when novel conditions are emerging because of human-induced rapid environmental changes.

Academic year: 2018-2019.

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Ecosystem services and scavengers: ecological and socio-cultural assessment.

[Servicios ecosistémicos y carroñeros: valoración ecológica y sociocultural.]

Key words: carrion removal, EU sanitary policies, extensive livestock farming systems, traditional ecological knowledge, vultures.

Palabras clave: buitre, conocimiento ecológico tradicional, eliminación de carroña, políticas sanitarias de la UE, sistemas extensivos de ganadería.

Abstract:

This thesis focuses on the ecosystem services provided by vertebrate scavengers in Spain from a social-ecological perspective. Chapter one revealed that research on carrion, scavenging and associated ecosystem function and services provided by scavengers have been scarce until recently. Moreover, research on social perceptions and attitudes towards scavengers, as well as indigenous and local knowledge (ILK) on carrion and scavenging, remains virtually unexplored. In chapter two, we assessed the novel source of greenhouse gases (GHG) emissions emerged following the implementation of a controversial European sanitary regulation (EC 1774/2002). This regulation required the collection of livestock carcasses from farms and their transformation or destruction in authorized plants. This situation had negative impacts on the conservation of scavengers and generated an unprecedented source of GHG emissions. Quantification of such emissions showed that supplanting the natural removal of dead extensive livestock by scavengers with carcass collection and transport to processing plants meant the emission of 77,344 metric tons of CO_2 equivalent to the atmosphere per year, in addition to annual payments of ca. $50 million to insurance companies. Paradoxically, the areas with the highest levels of GHG emissions coincided with areas holding the highest densities of vultures. Our findings support the return to a traditional and natural scenario in which scavengers freely remove livestock carcasses. In chapter three, the conservation and environmental consequences of the network of protection areas for the feeding of necrophagous species of European interest (PAFs) was evaluated. In an attempt to mitigate the negative impacts of the restrictive sanitary regulation (EC 1774/2002), a new regulation was approved (EC 142/2011) to allow farmers to leave the carcasses of extensive livestock within PAFs. Evaluation of the Spanish PAFs network reveals that the majority of the autonomous communities established PAFs in their territories, although the design criteria were variable. The extensive livestock carrion biomass potentially available for scavengers within PAFs was 33,474 tons per year, which represented 35% of the annual extensive livestock biomass generated in peninsular Spain. The breeding distribution of the targeted species was better represented within PAFs than that of the non-targeted species. Similarly, breeding distribution of threatened species was better represented than the one of non-threatened species. The overlap between PAFs and the home range of GPS-tracked vulture populations ranged 63%-100%, whereas at the individual level, it ranged 21%-100%. The home area of these and other populations of GPS-marked vultures covered 3-14 autonomous communities and 1-4 countries. At the individual level, vultures used an average of 3.4 autonomous communities and 1.5 countries. The implementation of the PAF network implied a potential reduction of ca. 56% of GHG emissions compared to the previous scenario, therefore being an important improvement

compared to the previous scenario. However, the new regulation could be improved by considering the overall distribution of additional scavenger species and by supra-regional and supra-national coordination and management. In chapter four, farmers perceptions about the ecosystem services provided by vertebrate scavenger in Spain were assessed. The findings indicated that carrion consumption was perceived by farmers as the most important service provided by scavengers. Interestingly, the same species and species within the same guild can be dually perceived as beneficial or harmful depending on their consideration as scavengers or predators, respectively. Vultures were perceived by farmers as the most beneficial taxonomic group. Farmers recognized the importance of scavengers as providers of ecosystem services when the species had a more restricted distribution and their populations were perceived as declining. Farmers also noticed that the provision of scavenging services increased with broader scavenger distributions and recognized a higher capacity of the scavenger guild to provide ecosystem services in those scavenger communities with higher functional diversity. Farmers performing traditional livestock practices (e.g. transhumance and the abandonment of livestock carcasses in the field) had higher knowledge on scavengers and positive perception of them. In contrast, farmers having a higher livestock numbers, having suffered attacks on livestock by scavengers, and having had a carcass removal insurance in the past, showed more negative perceptions of scavengers. Results support the implementation of conservation policies in Europe that favor traditional extensive farming systems and strengthen the link between farmers and scavengers. In chapter five, we examined the similarities and contradictions between shepherds' ILK and scientific knowledge (SK) on the scavenging service provided by the vertebrate scavengers in extensive livestock farming systems in Spain. Overall, a high consistency between ILK and SK was found, particularly at the species level, which was also consistent over the range of shepherd ages and experience. At the species level, the scavengers' occurrence at carcasses observed by shepherds was highly correlated with the occurrence calculated from camera traps. Likewise, the shepherds' consideration of each species as provider of the scavenging service and the carrion biomass consumed by the species calculated from camera traps were also highly related. At the community level, no differences were found between ILK and SK regarding the mean detection time of carcasses by scavengers, whereas there were differences in the mean consumption time of carcasses, being lower for ILK than the calculated with camera traps. Results support the integration of ILK and SK into the management strategies of vertebrate scavengers. Overall, this thesis emphasizes the need to (i) link sanitary and environmental policies, (ii) support the implementation of policies that favor traditional extensive farming systems, and (iii) integrate ILK and SK into the conservation strategies of vertebrate scavengers.

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Ecological and genetic analysis of plant-animal interactions in Mediterranean enviroments.

[Análisis ecológico y genético de interacciones planta-animal en ambientes mediterráneos.]

Key words: extreme fragmentation, frugivorous birds, long-distance seed dispersal, molecular markers, old fields restoration.

Palabras clave: aves frugívoras, dispersión de semillas a larga distancia, fragmentación extrema, marcadores moleculares, restauración de campos abandonados.

Abstract:

Plant-animal mutualistic interactions such as seed dispersal and pollination are fundamental in the reproductive biology of many plants that rely on animals either for the pollination of their flowers and/or the dispersal of their seeds. The study of such processes can be difficult to address only by classical ecological techniques (e.g. bird census) since results could be skewed, for instance, by different detectability rate of species. Furthermore, some ecological processes occur at a vast spatial and/or temporal scale (e.g. long-distance seed dispersal) and thus cannot be detected through traditional approaches. In that sense, the application of indirect techniques such as genetic tools can help to efficiently monitor these ecological interactions. This thesis is composed by four chapters in which plant-animal mutualisms are studied from different approaches combining ecological and genetic tools and at different geographical scales. Three of them use birds as focal species models. In the first chapter, we analyse the spatial genetic structure patterns of a bird-dispersed fleshy-fruited shrub (*Pistacia lentiscus* L.), as well as the role of long-distance seed dispersal in such patterns. Frugivorous vertebrates typically provide dispersal services within the range of a few metres up to some kilometres from the seed source. But a few studies have also shown that migrant frugivorous birds provide long-distance seed dispersal services across sea barriers connecting populations hundreds of kilometres apart with important implications for the gene flow among plant populations. We sampled 74 populations across all the range of *P. lentiscus* spanning from the Canary Islands to Israel (1,057 individuals). We used microsatellites combined with landscape genetic tools to test the influence of long-distance dispersal events mediated by migrant frugivorous birds on spatial genetic patterns of *P. lentiscus* populations located on opposite shores of the Mediterranean Sea. Our results showed a high genetic connectivity among populations distributed at North and South side of the Mediterranean Sea. All clustering analyses detected two genetic clusters, one from the Canary Islands to the Sicily strait and one in the Eastern of the Mediterranean Basin including populations of Libya, Cyprus and Israel. Populations from the Balkans and Aegean islands seemed to act as links between both clusters as inferred from their levels of admixture and the highest betweenness centrality in the genetic network. Our findings are congruent with the foraging movements of frugivorous birds whose migratory routes traverse the Mediterranean Basin from North to South. Thus, every driver affecting bird migratory patterns (e.g. climatic change, fragmentation and poaching) would potentially change the genetic structure pattern of animal-dispersed plant populations. In the second chapter, we study the effects of extreme fragmentation on the genetic diversity of remnant populations of *P. lentiscus*. We combined microsatellites analyses, mist-netting and bird censuses to address our goals. Birds showed a poor contribution to *P. lentiscus* seed dispersal. Our results showed a high genetic diversity and absence of differentiation between shrub patches, probably due to a strong but recent fragmentation. Nonetheless, we detected some signs of inbreeding, and hence, the occurrence of latent impacts cannot be disregarded. In the third chapter, we develop and test a methodological framework based on the combination of ecological (bird census and camera trapping) and genetic tools (DNA barcoding) to assess the contribution of seed dispersers to old fields restoration. Land abandonment is increasing across Europe but with higher intensity in Medi-

terranean semiarid areas. These old fields represent an opportunity for the recovery of natural vegetation. However, the ecological succession can be slow or even voided under semiarid conditions, which usually entails severe erosion processes. Animal vectors can accelerate old fields recovery by mobilizing seeds from wild remnants of vegetation. Therefore, it is important to design restoration frameworks that take advantage of such vectors. We deployed restoration structures as artificial perches and water troughs (a limiting factor in semiarid areas) to attract birds to old fields, and we also provided microenvironments and prevented herbivory to increase seedling survival opportunities. The restoration structures proved to be effective for increasing seed arrival to the study areas while no seeds were found in control plots. We identified bird seed dispersers from remaining avian DNA in seed surfaces found in bird droppings or regurgitations. Despite seed arrival was enhanced, a subsequent plant establishment has not been observed so far. The study pointed out to the importance of implementing different techniques, including molecular studies, to characterize and assess avian seed disperser performance. In the last chapter, we investigate the impact of managed bees (honey bee) on pollination networks under a variable degree of land use and beekeeping intensity. Results revealed a poor impact of land use on pollination networks and corroborated the impact of honey bees on wild bees also in semiarid ecosystems by promoting the spread of pathogens in the landscape. Overall, the part of this thesis dedicated to birds, represents an important advance to unravel the role of frugivorous birds to seed dispersal from the intercontinental to the local scale, and in the evaluation of the specific service of seed dispersal towards areas under restoration. Furthermore, it also provides outstanding insights about the impact of human disturbances on pollination networks.

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Pathogen dynamics in wild bird species: circulation of avian influenza viruses in natural vs. anthropic ecosystems and concurrent infections with other agents in waterbirds.

[Dinámica de patógenos en aves silvestres: circulación de los virus influenza aviar en ecosistemas naturales vs. *antrópicos e infecciones concurrentes con otros agentes en aves acuáticas.]*

Key words: avian influenza, concurrent infections, epidemiology, phenology, wild birds.

Palabras clave: aves silvestres, epidemiología, fenología, infecciones concurrentes, influenza aviar.

Abstract:

Avian influenza viruses (AIV) are well maintained in water ecosystems where they are known to persist for long periods. However, AIV may also infect poultry and mammals, humans included. AIV infections in wild aquatic birds occur via the digestive or respiratory route generally in absence of apparent signs of disease, but they are highly contagious. Some AIV variants however, can cause disease or even the death of the bird, being poultry like chicken, quails or turkeys especially susceptible. In this regard, according to the ability of AIV to cause disease or mortality in chickens, AIV are classified in two pathotypes; low pathogenic avian influenza viruses (LPAIV) or highly pathogenic avian influenza viruses (HPAIV). This PhD thesis is composed of four chapters in which AIV epidemiology is studied with different approaches. In the first chapter, AIV dynamics in a natural wetland ecosystem were evaluated, taking into account both

virological aspects and ecological traits of hosts. During 2007-2009 and 2012-2014, AIV were studied in a wild avian community of a northern Spanish wetland using non-invasive sampling methods and host identification by COI barcoding. Global AIV prevalence decreased significantly during the second sampling period (0.3%) compared to the first (6.6%). Circulating subtype distributions were also different between periods, with a noteworthy H5 and H7 subtype richness during the first sampling period. The Mallard *Anas platyrhynchos* was identified as the main AIV host, although not all positive samples could be ascribed to a host. We modelled AIV prevalence in relation to the avian host community composition and meteorological data from the wetland. Statistical analysis revealed seasonal differences in AIV detection, with higher prevalence during the breeding season as compared to other phenological events. The model also showed that the lower AIV prevalence during the second study period was associated with a significant reduction of breeding Anseriformes in the wetland, revealing a long-term fluctuation of AIV prevalence driven by the breeding Anseriformes community. This longitudinal study on AIV epidemiology in a natural ecosystem reveals that although prevalence follows seasonal and annual patterns, long-term prevalence fluctuation is linked to the breeding community composition and size. These results are relevant for preventing and managing influenza emergence by understanding the influence of host ecology on pathogen transmission. In the second chapter, the epidemiology of AIV in Passeriformes was studied for their ubiquitous nature as well as for the ecological characteristics of its integrating species. This work allowed us to ascertain that species belonging to the Atlantic bioregion and with less altitudinal restraints, were the most frequently ones infected with AIV. AIV were detected in five out of 22 studied taxonomic families including Fringillidae, Turdidae, Sylvidae, Muscicapidae and Sturnidae. Hence, this work highlights the importance of the environment and host intrinsic characteristics in AIV detection. The third chapter focuses on AIV surveillance at landfills. Since targeted monitoring of AIV in bird species that forage at landfills but also use to frequent urban and agricultural habitats, could be a useful means for monitoring of AIV, especially during periods of bird aggregation. The present study identified circulation of AIV in aquatic bird species foraging at the studied landfills, evidencing that these places may also act as appropriate environments for AIV transmission. AIV prevalence differed significantly among the sampled taxonomic groups, being highest in gulls, but also present in Cattle Egrets *Bubulcus ibis* and White Storks *Ciconia ciconia*. Our results indicate that wild birds foraging at landfills may carry different LPAIV subtypes. Thus, landfills could be relevant in AIV epidemiology providing new AIV transmission pathways between different bird species and as a link at the wildlife-human interface. This habitat type should be considered for routine AIV surveillance in potential bridge species and for anticipation to future outbreaks, considering their proximity to urban settlements and to poultry farms. Finally, the last chapter aims at verifying whether AIV excretion is related to the presence of other coinfecting microorganisms in wild waterbirds. Wild birds often harbour infectious microorganisms. Detections of certain microorganisms have been shown to increase host susceptibility to infections by other microorganisms, leading to coinfections and altered host-to-host transmission patterns. We investigate in naturally low pathogenic AIV infected and non-infected birds the presence of the following microorganisms, some of which have zoonotic potential: *Salmonella* spp., *Mycobacterium avium* subspecies, *Mycobacterium tuberculosis* complex,

Mycobacterium spp., *Yersinia enterocolitica, Yersinia pseudotuberculosis*, West Nile virus and avian avulavirus 1. Coinfections were found more frequently in AIV-positive animals. *Mycobacterium* spp. and *Salmonella* spp. were found to be significantly more prevalent among the AIV-positive samples than among the AIV-negative samples. Prevalence of coinfections differed significantly among sampling years, host families, host species, AIV subtypes, and type of sample. Multiple coinfections (more than one of the tested microorganisms excluding AIV) were found in 9.6% of all the AIV-positive samples, accounting for 20% of the coinfections. In contrast, in AIV-negative samples we never detected more than one of the selected microorganisms. These results show that AIV detection in wild aquatic birds was associated with the detection of other microorganisms concomitantly. In conclusion, this thesis provides new and relevant information about AIV epidemiology in relation to the ecology of its wild hosts.

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The White-throated Dipper *Cinclus cinclus* L., 1758 in Gipuzkoa: distribution and demographic parameters.

[El mirlo acuático Cinclus cinclus *L., 1758 en Guipúzcoa: distribución y parámetros demográficos.]*

Key words: *Cinclus cinclus,* demography, distribution, Gipuzkoa, long term monitoring.

Palabras clave: Cinclus cinclus*, demografía, distribución, Guipúzcoa, monitorización a largo plazo*.

Abstract:

Birds are known to respond rapidly to environmental changes what makes them good indicators of the conservation status of the ecosystem they inhabit. The evaluation of their distribution, abundance and other aspects of their life cycle can be readily used to monitor environmental changes at various spatial and temporal scales. The White-throated Dipper *Cinclus cinclus* (hereafter, Dipper), is a semi-aquatic riparian bird which meets the necessary conditions to act as a good indicator for disturbances in aquatic ecosystems, mainly due to its low tolerance threshold to the alteration of its habitat and, especially, to its environmental preferences (well-preserved rivers). The occurrence and abundance of Dippers may indicate the extent of the environmental alteration given an adequate identification, detection and reliable censusing what, in turns, requires an accurate knowledge of this species' biology. The fluvial network of the Historical Territory of Gipuzkoa, as well as the Autonomous Community of the Basque Country, is under anthropological alteration. This, together with Global Change requires an evaluation of their consequences on this habitat type. To address this concern, I performed this thesis, that has two main objectives: (i) develop an effective and long-term method for censusing Dippers at the Autonomous Community scale, so as to detect changes in its distribution and population size; (ii) describe the main demographic parameters of the Dipper population in Gipuzkoa and establish their relationships with biotic characteristics and habitat quality, including the possible effects of climate change. Regarding the first objective, we developed a method to study the population of Dippers in Gipuzkoa, based on occupancy models that, in the long term, allow the assessment of the population's trends. These models are suitable for species that naturally occur at low densities or with low detectability due to the habitat they dwell on (e.g. impaired visibility owing to the orography and dense vegetation along the banks). This censusing methodology was also applied to model the occurrence of

the species for the whole Basque Country. Additionally, the method was conceived to be used by volunteers (citizen science). In the case of Gipuzkoa, our results show that a combination of 60 sampling points with four annual visits of 20 minutes each, is optimal for an accurate census. In the case of the Autonomous Community of the Basque Country, the total number of sampling points raises to 199. This network would provide information on common but little-known species, thus contributing to increasing our knowledge about the distribution and conservation of the Basque Country's biodiversity. Regarding the second objective, a ringing campaign was carried out in several rivers of Gipuzkoa during the breeding period (March-August) of seven consecutive years (2008-2014). Capture and recapture data were analysed using the Cormack-Jolly-Seber models to estimate the apparent annual survival of the population under study and its relationship with the variations of extreme winter water flow. Winters with heavy floods negatively influence the inter-annual survival of the studied population. This is discussed in a context of climate change. Additionally, the reproductive biology of Dippers in Gipuzkoa is described as well as the influence of food availability on their reproductive parameters. We found that the average clutch size (4.3 eggs/nest) was significantly lower than that described for the species in the rest of Europe (4.6 eggs/nest), while the average reproductive success (number of nests where at least one nestling fledges) (72%) was significantly higher than the European average (62%), which suggests that the breeding conditions of the studied population are better than the ones of populations located to the north of the Palearctic. The relationship of productivity with food availability is weak, probably due to the interference of other factors that also influence reproduction. The analysis of the recaptures and sightings of marked birds allowed to estimate for the first time natal dispersal of this species in the Iberian Peninsula. The data obtained suggests a very high dispersal, with only 3% of the ringed chicks recaptured after three years (2014-2016), that agrees with the results obtained in the continent for this species. It is necessary to continue the long-term monitoring of the abundance and reproduction of this species to determine more accurately the Dipper population in Gipuzkoa, its demographic parameters and life history strategies and the main factors that influence this population. All this information will also be crucial to better understand how Dippers could respond to climate change.

Academic year: 2017-2018.

Universidad Rey Juan Carlos

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Sexual asymmetry of avian life histories: a comparative study in Sturnidae, and experimental and theoretical approaches in the polygynous Spotless Starling (*Sturnus unicolor*).

[Asimetría sexual de las estrategias vitales en aves: una aproximación comparada en Sturnidae, y experimental y teórica en el polígínico estornino negro (Sturnus unicolor).*]*

Key words: natal dispersal, nest ornaments, sexual selection, sexual-size dimorphism, Trivers-Willard hypothesis.

Palabras clave: dimorfismo sexual, dispersión natal, hipótesis de Trivers-Willard, ornamentos del nido, selección sexual.

Abstract:

Although biologist have long investigated the evolutionary mechanisms and consequences of sexual selection, several outstanding questions still require deepening the

theoretical implications of sexual selection, compare model predictions with long-term data from wild populations, and investigate macroevolutionary patterns across taxa. This thesis investigates the ultimate (evolutionary) causes of sexual-size dimorphism and sexual behaviour in starlings, combining comparative approaches in the Sturnidae family with long-term studies and theoretical models in the Spotless Starling. Many starling species are sexually dimorphic (males are bigger than females) and display sex-specific behaviours such as the addition of green plants and flowers to nests by males and the addition of ornamental feathers by females. So far, two broad frameworks aim at explaining the evolution of such behaviours either via natural selection (green plants and feathers reduce nest parasite load and improve offspring condition), or via sexual selection (nesting materials serve as sexual signals). This thesis makes the most of these conflicting frameworks to (i) investigate how sexual and natural selection modulate the use of green plants in nests and the evolution of sexual-size dimorphism in the Sturnidae family (chapter one); (ii) investigate the consequences of green plants and feathers for offspring fitness (chapter two) and natal dispersal strategies (chapter three); (iii) investigate whether sex differences in demography can explain sexual-size dimorphism in the Spotless Starling (chapter four); and finally, (iv) investigate whether sexual-size dimorphism of fledglings influence the optimal parental reproductive strategy (chapters four and five). The results of the comparative study indicate that both natural and sexual selection are necessary to explain the use of green plants in starling nests, as they are more frequent among sexually-dimorphic species (suggesting a role of sexual selection) and among species that reuse nesting cavities (supporting their use as sanitary nest components) (chapter one). The species-specific study with Spotless Starlings reveals complex demographic processes involved in the use of green plants and feathers, with a striking effect of green plants reducing offspring recruitment rates and affecting their natal dispersal strategies in a sex-specific way (chapter two and three). In the Spotless Starling, males are bigger than females and depend more on their body mass at fledging to maximize their lifetime reproductive success (chapter four). Moreover, stochastic events affecting body mass and condition of male fledglings determine their fitness to a greater extent than that of their sisters (chapter five), which ultimately influences the best reproductive strategy of their parents (chapters four and five). In conclusion, this thesis shows that sexual behaviours such as the use of odd nesting materials results from a complex interplay between natural and sexual selection, suggesting that the former can explain their evolutionary origin, and the latter its current use as a sexual signal by sexually-dimorphic species such as the Spotless Starling. Although sexual competition is the most likely cause of the sexual-size dimorphism in starlings, understanding its consequences for the optimal parental strategy still requires a better understanding of sex-specific demographic processes, offspring recruitment and natal dispersal.

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Universidad de Santiago de Compostela

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Effects of agricultural and forest practices on biodiversity in North-West Spain.
[Efectos de prácticas agrícolas y forestales sobre la biodiversidad en el noroeste español.]

Key words: biodiversity, *Eucalyptus* plantations, native Atlantic forests, North-West Spain, organic farming.

Palabras clave: agricultura ecológica, biodiversidad, bosques atlánticos autóctonos, noroeste español, plantaciones de Eucalyptus.

Abstract:

Agricultural and forest practices affect biodiversity. In North-West Spain, agricultural intensification and plantations of exotic tree species are the main land-use changes that have occurred during the past 50 years. This thesis focused on how these changes on agricultural and forest management practices affect plants, butterflies and birds that depend on the agro-forestry environments of inland Galicia. This thesis aimed to evaluate: (i) if and how birds benefited from organic farming, (ii) if multiple aspects of butterflies and plants diversity benefited from organic farming, and (iii) if and how *Eucalyptus* plantations affect biodiversity. To reach these aims I compared plant, butterfly and bird species richness, abundance and diversity between organic and conventional farms, and between native forest patches and exotic *Eucalyptus* plantations. Ultimately, the aim of the thesis was to propose ways to improve management of agro-forestry systems, in order to unite social interests and biodiversity conservation. The effects of farming and forest practices on biodiversity were analysed during three years by means of transects in 16 paired organic and conventional farms, and 14 paired native forests and *Eucalyptus* patches. Birds benefited from organic farming, as both species richness and abundance were higher in organic than in conventional farms, being this effect most important during the winter period and for granivorous species. In addition, birds were also benefited by the presence of native forests surrounding organic farms. My results suggest that organic farming can favour farmland birds in heterogeneous landscapes, particularly during winter, probably due to increased food availability. Butterfly species richness was higher in organic than in conventional farms. Furthermore, organic farming resulted in a higher functional diversity of butterflies, showing that organic farms provide higher-quality habitat for butterflies than conventional farms by providing a wider niche space, fostering functionally diverse butterfly communities. Regarding native forests and *Eucalyptus* plantations, we found that species richness of both herbs and birds was consistently lower in the latter. Furthermore, the abundance of bird species characteristic of agricultural, forest, scrubland and other habitats were all much lower in *Eucalyptus* plantations than in native forests, with a total relative abundance of cavity-nesting forest birds being at least 64% higher in native forests. Finally, herb and bird communities were also significantly dissimilar between the two habitats, but because of different ecological processes. Species turnover explained variation between habitats in herb composition, so that species present in native forests were typical for both farmland and forest habitats, whereas those present in *Eucalyptus* plantations were typical for scrub and farmland habitats. In contrast, bird assemblages showed a significant nested subset pattern, with fewer species in *Eucalyptus* plantations compared to native forests. These results showed that *Eucalyptus* plantations constitute a much poorer habitat for both plants and birds than native forests, with significantly lower species richness, abundance and diversity in both taxa. In addition, because *Eucalyptus* plantations drive biotic homogenization of birds and species turnover in herbs, an increasing extent of exotic plantations would most likely lead to further loss of biodiversity, with highest effect on forest specialist species. Therefore, the results of my thesis suggest that both organic agriculture and native forests have a key role in biodiversity conservation, and that policies aiming for

sustainable agricultural practices and conservation of native forests should be prioritized and promoted.

Academic year: 2018-2019.

Universidad de Sevilla

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Linking different worlds: migration ecology in two species of hirundines.

[Conectando mundos distintos: ecología de migración en dos especies de hirundínidos.]

Key words: carry-over effects, hirundines, migration, solar geolocation, stable isotopes.

Palabras clave: efectos pospuestos, geolocalización solar, hirundínidos, isótopos estables, migración.

Abstract:

Migratory behaviour constitutes one of the most amazing adaptations of life to face the changing conditions on Earth. This behaviour has evolved in a wide variety of animals, but undoubtedly, it has developed to the greatest extent in birds. Knowing the whereabouts of birds has always been a mystery that we started to unveil in the late XIX century thanks to the ringing methodology. The low recapture rate of ringed birds led to the development of new tracking techniques, which has rendered detailed data on migratory behaviour. This information is necessary for an effective conservation and management of declining migratory populations. In this PhD, we have used stable isotope analyses and light-level geolocators to study the migration ecology of Barn Swallows *Hirundo rustica* and House Martins *Delichon urbicum*. First, we described the migratory behaviour of Barn Swallows breeding in south-western Spain. We reconstructed migratory routes from light data in order to determine migratory schedules, non-breeding areas along west Africa, migratory connectivity and factors determining variability in migration. We highlighted spring migration as the main link between the winter and the breeding stage. Along this line, we focused on how environmental conditions experienced during winter in Africa affected subsequent reproduction of Barn Swallows breeding in northern Denmark. For this purpose, we combined stable isotope analyses with ringing recoveries to identify the wintering areas across south and central Africa. We were able to detect that environmental conditions in the winter quarters have deteriorated during a 30-year period, as inferred by Normalized Differential Vegetation Index (NDVI). Moreover, we quantified the indirect effect of winter conditions on subsequent breeding success. Interestingly, females advanced onset of breeding, laid more eggs and raised more fledglings under good ecological conditions during the previous winter. This response was age-dependent, yet it was increasingly stronger as females aged. Males showed a similar response to winter conditions, but weaker. Regarding House Martins, we monitored a single breeding site in south-western Spain. By using isotopic clusters (δ13C, δ15N, δ2H), we inferred two most-probable wintering areas with different isotopic signature in west Africa. We found that experienced males (i.e. two years or older) winter in the isotopic cluster number two with a greater probability than experienced females, whereas first-year females winter in this isotopic cluster with a greater probability than first-year males. In addition, House Martins wintering in the isotopic cluster two started reproduction earlier than those wintering in the isotopic cluster number one. For individuals wintering in the isotopic cluster two, there was no relationship between age and onset of breeding. However, yearling birds wintering in the isotopic cluster one initiated their clutches earlier than experienced birds wintering in this area. Further-

more, using a causal statistical framework, we found that experienced male House Martins wintering in habitats of higher rainfall (as inferred from lower feather δ2H values) were in better body condition and produced more offspring during the subsequent breeding season than the ones wintering in habitats of lower rainfall. In contrast, we did not find any effect of winter habitat on reproductive success of young males or females. Finally, we tested if winter habitat choice determined the prevalence of blood parasites in House Martins. We found that experienced birds wintering in habitats of higher rainfall (2H-depleted) had higher probability of haemosporidian infection than the ones wintering in habitats of lower rainfall (2H-enriched). Hence, there appears to be a trade-off for experienced House Martins wintering in west Africa, in which habitat quality and risk of blood infection interact as opposite selective forces. In contrast, young birds wintering in habitats of lower rainfall had higher probability of haemosporidian infection than those wintering in habitats of higher rainfall. Our results reveal that winter habitat choice affects subsequent breeding performance in a complex way, depending on species, sex, age class and also on several mediator variables. In this thesis we provide important insights within theoretical migration ecology that can be helpful for conservation and management of aerial insectivores.

Academic year: 2018-2019.

Universidad de Vigo

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Environmental determinants of individual phenotypic differences in two vertebrate species.
[Determinantes ambientales de las diferencias fenotípicas individuales en dos especies de vertebrados.]

Key words: behavioural strategies, gene expression, maternal effects, melanic colouration, phenotypic plasticity.
Palabras clave: coloración melánica, efectos maternos, estrategias de comportamiento, expresión génica, plasticidad fenotípica.

Abstract:

Understanding the structure and origin of phenotypic variation and the role of the development of organisms in evolutionary processes have been considered key pieces to complete the neo-Darwinian theory of evolution. The formal inclusion of these pieces has constituted a newly expanded synthesis of the current evolutionary theory, which also integrates the role of development (evolutionary developmental biology or "Evo-devo"). Thus, it has been pointed out the importance of the study of the genetic and environmental mechanisms that influence the diversity of characters through modifications of the traits of organisms during development. In this thesis, we aim to study the variation of the phenotypic characters at early ages and the effect of environmental factors that contribute to this variation during the early development of the phenotype of two vertebrate species, the Yellow-legged Gull *Larus michahellis* and the Three-spined Stickleback *Gasterosteus aculeatus*. Specifically, we evaluate how sex, the early social environment and the risk of predation influence the behaviour, growth, colour and expression of genes related to physiological stress, as well as the relationship between these phenotypic traits. We address the following objectives: (i) to determine sexual dimorphism in the melanic colouration of the Yellow-legged Gull and the Three-spined Stickleback during the juvenile phase; (ii) to study the plasticity of the melanic coloration and the habitat colour selection behaviour in response to predation risk in juvenile Three-spined Sticklebacks; (iii) to study the influence of maternal effects on eggs and of

the social environment on the behaviour and growth of the Yellow-legged Gull during the first days of life; (iv) to investigate the relationships between the melanic coloration of Yellow-legged Gull chicks and the expression of genes functionally involved in coping with stress by the regulation of redox balance, apoptosis, immune response, cellular stress, and DNA damage. The main results are: (i) dorsolateral melanic coloration in juvenile Three-spined Sticklebacks is dimorphic in males and females, males being darker than females; (ii) juvenile Three-spined Stickleback do not modify their dorsolateral melanic coloration in response to predation risk, suggesting that the plasticity of this trait is limited or too costly; (iii) in juvenile Three-spined Sticklebacks, the behaviour of habitat colour selection in response to a risk of predation is plastic, and constitutes a camouflage strategy in heterogeneous environments; (iv) the hatching order, and not the substances supplied by mothers to eggs, determines the different behavioural strategies of Yellow-legged Gull chicks; (v) both the egg laying order and the hatching order of chicks within the nest affect the growth of Yellow-legged Gull chicks; (vi) the melanic colouration of the down feathers of Yellow-legged Gull chicks is dimorphic in males and females, males being darker than females; (vii) the expression of stress-related genes in the blood is related to the melanic coloration of Yellow-legged Gull chicks; (viii) the level of melanic colouration of Yellow-legged Gull chicks is inversely correlated with the expression of genes related to oxidative stress, DNA damage and cellular stress which suggests that darker chicks suffer less stress during development. Together, these results confirm the importance of sex intrinsic factors, the early social environment and the risk of predation in the development of the phenotype at early ages in vertebrates.

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