

Phd-Dissertation Reviews in Ornithology (2017-2018 Academic Year)

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PHD-DISSERTATION REVIEWS IN ORNITHOLOGY (2017-2018 academic year)

Edited by Francisco VALERA

This section includes the abstracts of some of the PhD-Dissertations submitted in Spain during the 2017-2018 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 2017-2018, 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 bienal 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 Alcalá

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West Nile virus: experimental study on its interaction with a natural host, the House Sparrow (*Passer domesticus*), and development of a quantitative method for its differential detection.

[El virus West Nile: estudio experimental de su interacción con un hospedador natural, el gorrión común (Passer domesticus), y desarrollo de un método cuantitativo para su detección diferencial.]

Key words: host competence, House Sparrow, Mediterranean, real-time RT-PCR, West Nile virus.

Palabras clave: competencia de hospedador, gorrión común, Mediterráneo, RT-PCR en tiempo real, virus West Nile.

Abstract:

West Nile virus (WNV) has a great impact on animal and public health. The North American epidemic starting in the city of New York in 1999 is the largest registered to date, affecting tens of thousands of people. In Europe, the history of outbreaks caused by strains belonging to lineages 1 and 2 of WNV is extensive. Likewise, Usutu virus is responsible for several outbreaks in recent years and co-circulates in some areas along with WNV. Both viruses are (re-) emerging zoonotic arboviruses belonging to the Flaviviridae family, genus *Flavivirus* and are included in the *Japanese Encephalitis* serocomplex. Their co-circulation in similar ranges of hosts and vectors requires efficient differential diagnostic methods to enable appropriate surveillance systems. WNV is maintained in nature in an amplification cycle relying on ornithophilic mosquitoes as the main vectors for its transmission, and wild birds as main reservoir

hosts. When this enzootic (also called “rural”) cycle overflows, a spillover to accidental (dead-end) hosts such as horses and/or humans may occur, initiating an epidemic (also called “urban”) cycle. This cycle takes place when the ecological conditions of mosquitoes and/or birds vary. Birds belonging to the Passeridae family have been described as particularly competent reservoirs due to the high viremias reached during the infection, acquired after being bitten by an infected mosquito. This means that they transmit the virus to the mosquitoes that feed on them in a more effective way. House Sparrows (*Passer domesticus*) are abundant and widely spread birds, both in North America and Europe. Several authors have demonstrated their susceptibility to infection by WNV North American type strain NY99 but there are no studies to date that address their susceptibility to WNV strains of European origin. The thesis is organized in four chapters. In the first one, the epidemiological role of the House Sparrow in relation to WNV in Europe is discussed. The second chapter describes the development of novel quantitative real-time RT-PCR for the detection and differential quantification of lineages 1 and 2 of WNV and Usutu virus, which may be useful for surveillance purposes. Briefly, in vitro transcripts were developed from specific regions of WNV lineages 1 and 2 and of Usutu virus, which, after calibration of the corresponding dose-response curves, allowed quantifying the number of existing copies of viral RNA from each of these viruses in different types of samples. This method is useful to discriminate the presence of these viruses in field samples where they are co-circulating. The third and four chapters deal with two experimental inoculations made in House Sparrows with different WNV strains. In the first one (chapter 3) groups of eight sparrows were infected each with a different WNV strain: three from southern Europe (Spain/2007;

Italy/2008; Italy/2009) and one from north America (NY99), while in the second experiment (chapter 4), WNV strains from two different lineages (lineage 1: NY99 strain, and lineage 2: Austria/2008 strain) were used to inoculate two different groups of House Sparrows. In both experiments, parameters such as mortality, morbidity and viral load in blood, tissues, feathers and swabs were analyzed. Furthermore, the competence index of the House Sparrow for the transmission of each WNV strain was calculated. The results showed that the House Sparrow is susceptible to infection by European strains of WNV, supporting it as a useful model for the study of the pathogenicity of strains of WNV circulating in Europe. Likewise, host competence of the House Sparrow is lower for the strains of European origin than for the north American strain, which may help to explain some of the epidemiological differences observed in both territories.

Academic year: 2016-2017.

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Trophic ecology and nesting habitat selection of the Northern Goshawk (*Accipiter gentilis*) in *Eucalyptus* plantations in northwestern Spain.

[Ecología trófica y selección de hábitat de nidificación del azor (Accipiter gentilis) en plantaciones de eucalipto del noroeste de España.]

Key words: breeding success, conservation, forest plantations, forest raptors, surrogate species.

Palabras clave: conservación, especies diurna, éxito reproductor, plantaciones forestales, rapaces forestales.

Abstract:

Birds of prey, as top predators, can exert a great influence on the distribution and abun-

dance of their prey, affecting ecosystem functioning. Their populations are frequently threatened, which, together with its important role in ecosystems, make these species a conservation concern. They generally need large areas of good quality habitat so they can be used as surrogate species, whose management and conservation can provide, directly or indirectly, wider conservation goals. Thus, the trophic ecology and habitat selection of raptors are central issues in theoretical ecology, evolutionary biology and conservation ecology. The Northern Goshawk (*Accipiter gentilis* L.) is a common top predator in European agroforestry systems. It is generalist and opportunistic regarding food habits, with a diet based on medium-sized birds and mammals. Goshawks nest in a wide range of forest habitats, though often show preference for mature forest patches. This species has been used as an ecological indicator of habitat change, of effects of forest management and as a surrogate species in applied conservation. Its trophic ecology and habitat selection in the Atlantic area of southwestern Europe is relatively unknown. This thesis studies the trophic ecology and nesting habitat selection of a Goshawk population dwelling in low-intensity-management, exotic *Eucalyptus* plantations in northwest Spain (Galicia). Specifically, it addresses four important questions according to four main chapters: (i) study methods of the diet of this raptor species during the breeding season; (ii) diet and prey preferences of the Goshawk; (iii) relationship between reversed sexual dimorphism (RSD) of the Goshawk and its trophic behaviour; (iv) Goshawk nesting habitat preferences in *Eucalyptus* plantations. Chapter I evaluates the usefulness of trail-cameras installed in 80 nests for analysing the diet of the Goshawk, and compares it with other indirect diet study methods (analyses of prey remains and pellets). The cameras registered the greatest number of prey items and were

probably the least biased method for estimating diet composition, but yielded the largest proportion of prey unidentified to species level, and they underestimated small prey. This technique is limited by technical failures and difficulties in identifying certain prey types. Goshawks showed distrust toward the cameras but they usually became habituated to its presence within 1-2 days. Therefore, the use of trail-cameras in nests should be done with caution to minimize possible negative impacts of research activities. Chapter 2 assesses Goshawk diet during the breeding season in a region where the species has been poorly studied. This diet is compared to prey abundance in order to recognize Goshawk prey preferences and identify its most important prey species. Changes in diet between the 1980s and the present and its relationship with changes in prey abundance are also studied. The Goshawk was mainly ornithophagous. Feral Pigeon (*Columba livia*) was the most important prey. Within avian prey, Goshawks preferred prey of 100-400g and forest prey species. Goshawk diet has changed significantly over the last few decades, reflecting changes in the abundance of preferred prey species caused by an increase in forest cover, colonization of new species, and changes in the abundance and management of domestic prey. Chapter III investigates the causes of reversed sexual dimorphism (RSD) in the Goshawk. Different life-history processes (territory acquisition, breeding success) and the mechanisms involved (hunting efficiency, diet, body condition and mate choice) in relation to the size of both sexes were analysed. Small males hunted fewer non-forest preys (Feral Pigeon, Eurasian Collared Dove *Streptopelia decaocto*, Magpie *Pica pica*), had better body condition and produced more fledglings than larger males. The mean body size of breeding females was greater than that of female fledglings. Hence, the greater

reproductive success of small males and the greater recruitment of large females could be important mechanisms explaining the RSD of the Goshawk. Chapter IV studies nesting habitat preferences of the Goshawk at several spatial scales and the relationships between such preferences and its breeding success. The smallholder regime and low-intensity forest management of the studied *Eucalyptus* plantations favoured a high Goshawk breeding density, a regular spatial distribution of the territories and a high breeding success, demonstrating that such plantations provided a good nesting habitat for the Goshawk. This species selected tall trees (*Eucalyptus*), in forest stands of significant structural complexity, and greater abundance of native tree species (mature-like patches). Habitat selection was strongly influenced by territoriality, which also reduced reproductive success in the preferred nesting habitat, where the distances between active nests and the size of the territories were smaller. The intense preference of the Goshawk for the most mature forest patches would support the use of this top predator as a surrogate species to identify forest management practices to enhance biodiversity in plantations. In summary, this thesis makes original contributions to the ecology of birds of prey and the Goshawk. The characteristics of the Goshawk –top predator status, wide distribution, diet, habitat selection, strong RSD and relative ease to monitor their populations–, make it a good model species to deepen our knowledge on several ecological and evolutionary questions involving birds of prey. In addition, the study and promotion of raptors in forest plantations can improve the conservation value of these expanding ecosystems.

Academic year: 2016-2017.

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Contribution to the knowledge of the biology of the Dupont's Lark (*Chersophilus duponti*) in its Iberian distribution area.

[*Contribución al conocimiento de la biología de la alondra ricotí (Chersophilus duponti) en su área de distribución ibérica.*]

Key words: beetles, connectivity, lark, mites, scrub.

Palabras clave: ácaros, alondra, coleópteros, conectividad, matorral.

Abstract:

The Dupont's Lark *Chersophilus duponti* is one of the least known European passerines. Although aspects such as its distribution or threats to its conservation are known in some detail, its basic biology is still poorly known, probably due to its elusive behaviour and the small size of its populations. Therefore, the purpose of this thesis is to contribute to the knowledge of the biology and ecology of the Dupont's Lark in its Iberian distribution. The main conclusions of this thesis are: (i) the largest Spanish populations are found in the high plateaus and mountains of the Iberian System, in the cold lands of the northern Sub-Plateau and in the Ebro Depression. In these three zones, plant communities endure extreme weather conditions, including cold winters and extremely hot and dry summers. These climatic features and a poor soil quality (rendzinas, rankers, lithosols) lead to a vegetation landscape dominated by scrub subclimaxes. According to regional climate, the areas sought out by Dupont's Lark are those whose potential climax are oak or mixed evergreen forests (juniper-oak forests), although forests no longer exist due to deforestation practices in many of these zones. In places where the forest climax cannot develop, permanent

communities of scrubs appear as regional or local subclimaxes. These same scrubs, characterized by predominant herbivore-adapted chamaephytes, have expanded as consequence of forests removal, and by the subsequent pressure by livestock and wild herbivores. The Dupont's Lark never colonizes highly evolved preclimax scrub, in which the dominance of meso- and macrophanerophytes renders a shaded microhabitat similar to that of a climax forest. Dupont's Lark populations always occur on plains with serial scrublands showing a similar structure: a predominance of chamaephytes c. 40cm high conferring an average cover of around 75% including graminoid chamaephytes. Among the chamaephytes, thorny shrubs and, above all, aromatic shrubs generating growth-inhibiting allelopathic substances can be found. The scrublands that shelter Dupont's Lark tend to evolve naturally as they are not the stable climax. The lark inhabits two main types of successional scrub: permanent and slightly evolved serials. In the former, succession is extraordinarily slow. Supramediterranean cushion scrubs are very stable communities, settled on windy crests and on lithosols or leptosols, and are often subjected to extensive grazing, promoting their very slow colonization. In gypsum areas, besides grazing pressure, succession is slow because these scrubs occur in semiarid or dry areas sustaining unfavourable soils for the development of forest stages. The conservation of such gypsophilous scrub usually requires grazing. Nevertheless, under excessive grazing pressure, they evolve into very open communities with few scrubs, resulting in the loss of optimal structure for the lark. In undisturbed conditions, the development of the vegetation can be very fast in the slightly evolved serials scrubs. The disappearance of traditional activities can rapidly lead to more advanced scrubland stages and, thus, to the extinction of the spots occupied by Dupont's

Lark. Thus, maintaining practices that have sustained the rural economy, such as traditional livestock rearing, is essential for the conservation of Dupont's Lark in this type of scrub; (ii) 59.74% of Dupont's Larks were parasitized by at least one ectoparasite taxon. Three ectoparasite orders were identified: Phthiraptera, Diptera and Acarina. Among the Phthiraptera, two families of chewing lice were detected (Philopteridae –genus *Philopterus* and *Brueelia*– and Menoponidae). Only one genus (*Menacanthus*) was found in the family Menoponidae. We also collected a louse fly (Diptera: Hippoboscidae) identified as *Ornithophila metallica*. Finally, mites were detected (Acari: Astigmata), mainly among the birds' primary feathers and, to a lesser extent, on their secondary feathers. Our data is the first European record of the genus *Philopterus* for the family Alaudidae; (iii) Dupont's Lark feeds mainly on insects during the spring. This diet includes many beetles, most of them from the Scarabeioformia taxa, highlighting the Scarabeidae family. The consumption of Carabidae species is also high. Some of the beetles on which the Dupont's Lark feeds are coprophagous species, many of them feeding on very specific mammalian feces. These beetles (mainly of the genus *Onthophagus*) feed on sheep droppings to complete their development. Thus, Dupont's Lark is favored indirectly by the presence of sheep; (iv) the Dupont's Lark population studied has excellent connectivity at the sub-population level. A very marked population decrease in the areas where wind farms have been installed (–90.47% for the study period) has been recorded. The ZEPA areas have stable populations with a positive trend of 9.65% for the study period. In contrast, in those areas not classified as ZEPA and in which wind farms have not been installed, the trend is negative, with a decrease of –50% for the 2009-2016 study period.

Academic year: 2016-2017.

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Ecology and natural history of the Horned Guan *Oreophasis derbianus*: a mountain cracid.

[*Ecología e historia natural del pavón Oreophasis derbianus: un crácido de montaña.*]

Key words: cloud forest, cracids, foraging behaviour, individual recognition, population monitoring.

Palabras clave: bosque mesófilo de montaña, conducta de forrajeo, crácidos, monitoreo poblacional, reconocimiento individual.

Abstract:

The Horned Guan *Oreophasis derbianus* is a globally threatened bird species of the Cracidae family; it is geographically restricted and highly dependent on pristine montane cloud forests. In Mexico, the Horned Guan's distribution ranges from the Chimalapas region in the state of Oaxaca to Sierra Madre in the state of Chiapas, between 1,600 and 3,500masl, and through Guatemala, from the central mountains to Sierra de Las Minas in the southern region, between 2,000 and 3,600masl. Globally, the IUCN classifies the Horned Guan as an endangered species with priority for immediate conservation. The objective of this thesis was to investigate the ecology and natural history of the Horned Guan, both under natural and captive conditions. This investigation was carried out at three study sites: El Triunfo Biosphere Reserve, Chiapas, Mexico, where birds were studied in their natural environment, and in two aviaries of the states of Mexico and Puebla, Mexico. We addressed the following aspects: (i) the individual variation in the calls of adult males in captivity; (ii) the diet and foraging behaviour, and (iii) the density and abundance of the Horned Guan. Our result demonstrate that the Horned Guan in captivity emitted stereotyped calls of low fre-

quency and that each call is formed by seven notes that varied in duration and bandwidth. The individual variation of calls between adult males suggests a distinction between individuals that remains stable over time, which is essential for the acoustic monitoring of the wild population. The significant variables are related to the temporal domain, that is, to the duration of the notes and the interval between notes. Discrimination between individuals was strongly associated with the duration of the second section of the call (4 notes) and the duration of the fifth and third notes. Regarding the diet of the Horned Guan, we found that in El Triunfo, it fed on 63 species of plants from 32 families, whereas 101 species of plants were identified in its diet throughout its geographical range. In El Triunfo, the Horned Guan consumed only fruits from 48 species, leaves from 11 species and a single species of flower. Both fruits and leaves were consumed in four plant species. Males consumed a greater proportion of fruits and a lower proportion of leaves than females and tended to use higher trees and forage at higher strata than females. We also found that the estimated global density for the Horned Guan in the study area was 5.40 ± 0.64 individuals/km² ($N = 144$ observations, 95% CI = 4.29-6.81). The estimated density ranged 2.21 to 8.94 individuals/km² during the reproductive seasons and 1.65 to 4.97 individuals/km² during the non-breeding ones. Likewise, a standardized protocol has been developed with field and analytical methods for long-term population monitoring of the Guans to generate quality data and robust estimates of its abundance. This study presents for the first time a detailed panorama on some biological aspects of captive and wild Guans in a cloud forest. This information is useful to support strategies of management and conservation throughout its current geographic range and ex situ reproduction programs. The protection of cloud forest should be a priority. Although we have made substantial advances in the knowledge of the

natural history of *O. derbianus*, both in Mexico and Guatemala, it is still necessary to implement additional studies and actions for a better understanding of the biological, ecological and social factors needed to guide strategies for its long-term conservation. Finally, we included a manuscript on the state of knowledge and perspectives of research and conservation of the Horned Guan in El Triunfo Biosphere Reserve, Chiapas, Mexico.

Academic year: 2016-2017.

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Ecophysiological factors affecting oxidative balance in penguins.

[Factores ecofisiológicos que afectan al equilibrio oxidativo en pingüinos.]

Key words: Antarctica, immune response, oxidative stress, parasitism, penguins.

Palabras clave: Antártida, estrés oxidativo, parasitismo, pingüinos, respuesta inmune.

Abstract:

The relationship between oxidative balance and life history has been in the spotlight of evolutionary ecologists during the last decade. Ecological as well as physiological factors can affect such balance. Oxidative stress is defined as the imbalance between pro-oxidants and antioxidant defences. If such imbalance is in favour of the former, leading oxidative damage, oxidative stress would increase. However, the way animals adjust their oxidative balance in relation to ecological (e.g. diet, foraging strategies or parasitism) and physiological (e.g. breeding or moulting) factors in free-ranging animals is poorly known. This thesis aims to highlight the relationship between oxidative balance and life history at different ecophysiological levels in the wild, using penguins as model species. The topics under study were: (i) diet and feeding

strategies might influence the antioxidant defences or the production of reactive oxygen species (ROS). Penguins are adequate models to assess such comparison because their diet (krill and/or fish) differ in terms of dietary antioxidant absorption depending on their habitat. Therefore, we investigated by means of stable isotopes, diet and foraging strategies ($\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ respectively); dietary antioxidants (α -tocopherol and astaxanthin) and oxidative balance, antioxidant capacity (OXY) and oxidative damage (ROMs) of *Pygoscelis antarcticus*, *P. papua*, *P. adeliae* and *Spheniscus magellanicus*. We found interspecific differences for all variables analysed except for α -tocopherol. Whereas *S. magellanicus* would feed on anchovies foraged at inshore locations, *Pygoscelids* would be caught mainly krill off-shore and in pelagic places, although *P. papua* appears to exploit less krill in favour of fish in more coastal and benthic waters. *Spheniscus magellanicus* showed the highest retinol levels and the best oxidative status. In contrast, *P. papua* presented the worse oxidative status even showing the highest astaxanthin values, a compound with high antioxidant capacities. Overall, no common pattern appeared among species. (ii) Energy use has been related with oxidative balance. It is then expected that activities requiring much energy could generate higher oxidative stress. We compared the incubation and chick rearing periods of *S. magellanicus*. Incubating adults unbalanced their oxidative status showing significantly lower antioxidant levels than those rearing chicks. However, oxidative damage did not show a significant variation between breeding periods. Further, we did not find differences in oxidative status between sexes. Our results suggest that incubation is highly demanding compared to chick rearing in terms of oxidative balance since antioxidants have probably depleted to limit oxidative damage by ROS. Differential foraging effort could explain such results as *S. magellanicus* adjusts its foraging location to prey availability per-

forming longer foraging trips during incubation than during chick rearing, which increases the energy costs and therefore imbalances oxidative status. (iii) The oxidative cost of reproduction has been under debate in recent years. Based on the hypothesis that different brood sizes produce differential reproductive costs, an experimental manipulation on breeding *P. adeliae* was conducted to study oxidative status and stress. We randomly assigned nests with two chicks to a control reproductive effort group (CRE), and nests where only one chick was left to an experimental, low reproductive effort group (LRE). As predicted, individuals in the LRE group had higher antioxidant capacity than the ones in the CRE group. We also found marginally significant interactions between sex and treatment in the three variables analysed. Females had higher OXY, lower ROMs and lower heterophil/lymphocyte ratio (H/L), when rearing one chick, whereas males did so when rearing two chicks, except for OXY which was high regardless the treatment. Moreover, there was a significant negative correlation between H/L and OXY in females. Finally, we found a negative and significant relationship between the duration of the experiment and OXY and ROMs and positive with H/L. This shows that breeding penguins are paying a physiological effort in relation to the duration of the chick rearing. Overall, a reduction of the reproductive effort decreased oxidative stress in this long-lived bird, meaning that a link exists between breeding effort and oxidative stress. However, our findings suggest different sex strategies. (iv) We also examined the breeding and moult phases to find out whether they compromised homeostasis using *P. antarcticus* for which these two activities do not overlap. Our results suggest that breeding is a more stressful period than moult, although the oxidative imbalance seems to be similar in both critical periods, thus resulting in similar oxidative costs. (v) In the Antarctic Peninsula, the tick *Ixodes uriae* is one of the most

prevalent ectoparasites. Here we show for the first time its effects on *P. antarcticus*. Ticks produced a greater mortality when chicks grew on a high tick density area. The presence of ticks increased the immunoglobulin levels in adults but not in chicks, suggesting that surviving chicks are better individuals with an excellent immunity. Moreover, we also report for the first time *Borrelia burgdorferi* in Antarctica as well as its consequences when present (higher values of OXY, IgY and lymphocytes, and lower values of heterophils and H/L). The influence of *Babesia* sp. has been also assessed for the first time in the Antarctic region, reducing penguin immunoglobulin levels when present. Finally, three cases of coinfection of *B. burgdorferi* and *Babesia* sp. have been reported. Ticks could be used as climate change indicators and hence, more knowledge is needed to disentangle future implications under a warmer scenario.

Academic year: 2016-2017.

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[Ecological response of marine predators to environmental heterogeneity and spatio-temporal variability in resource availability.](#)

[*Respuesta ecológica de depredadores marinos a la heterogeneidad ambiental y variabilidad espacio-temporal en disponibilidad de recursos.*]

Key words: foraging behaviour, ocean productivity, remote sensing, seabirds, tracking.

Palabras clave: aves marinas, comportamiento de forrajeo, productividad oceánica, teledetección, seguimiento remoto.

Abstract:

Seabirds have evolved within an open and dynamic environment, the ocean. As meso-top predators, seabirds are greatly influenced

by the oceanographic conditions driving marine productivity, and therefore, distribution of their prey. Consequently, seabirds' behaviour and, ultimately, their life-history traits, are considerably affected by the ever-changing oceanographic conditions. However, the latter are currently changing at ever-increasing rates due to global warming and human harvest on marine ecosystems. Thus, seabirds have become particularly vulnerable to these changes. In this thesis, we investigated the ecological responses of seabirds, in terms of foraging and breeding performance, to the spatio-temporal variability of environmental conditions imposed by oceans and exacerbated by climate and human stressors. In particular, we (i) identified the climate and human stressors impacting the world's ocean; (ii) investigated the actual scale at which seabirds interact with their environment; (iii) assessed how seabirds respond to oceanographic variability by changing their foraging and reproductive strategies; and (iv) proposed an integrative tool for the design of marine reserves protecting seabirds and their environment. The objectives of this thesis were accomplished through advanced procedures in the fields of satellite remote sensing and animal tracking. Our results confirmed the unprecedented changes experienced by oceans in the last decades. However, we were able to provide deepest insights on the uneven distribution of climate and human driven environmental changes. When investigating the link between such environmental variability and seabirds' behaviour, we found that dynamic processes as ocean currents were key factors determining the scale at which seabirds interact with their environment. Environmental features driving the spatiotemporal distribution of prey (e.g., sea surface temperature, chlorophyll-a, sea fronts and persistent areas of productivity) along with industrial fisheries played a fundamental role in determining the foraging distribution of seabirds. However, seabirds' foraging strategies were largely

constrained by limitations imposed by their central-place foraging behaviour and by dynamic factors such as prevalent winds, which influenced individual decision-making in heading directions when foraging. Intra and interspecific competition for resources also modulated foraging distributions, avoiding conspecifics or segregating foraging areas among sympatric species in appropriate stages. In general, we have provided a complete picture of environmental processes affecting seabirds. We argue that this information would be extremely useful for designing suitable management and conservation strategies. Thus, we finally proposed an adaptive framework for delimitation of more meaningful marine reserves that maximises conservation targets for seabirds, while accounting for human activities, environmental and biological factors that largely drive seabird performance and, remarkably, the dynamism inherent to marine systems.

Academic year: 2016-2017.

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Local adaptation by birds to human-altered habitats: the Great Tit *Parus major* and the House Sparrow *Passer domesticus* as model species.

*[Adaptación local de las aves a hábitats alterados por el hombre: el carbonero común *Parus major* y el gorrión común *Passer domesticus* como especies modelo.]*

Key words: DNA methylation, epigenetics, local adaptation, mitochondrial genes, personality traits.

Palabras clave: adaptación local, caracteres de la personalidad, epigenética, genes mitocondriales, metilación del ADN.

Abstract:

Human-altered environments have expanded rapidly in the past decades and made a huge impact on living organisms. Inhabiting

in such a habitat can modify several types of traits in animals, allowing for a better adaptation to these human-altered environments. The main aim of this thesis was to investigate the mechanisms of local adaptation during the process of urbanization. In the first two chapters of this thesis, we investigated patterns of recent (contemporary) adaptation to the urban habitats, focusing on the role of behavioural, genetic and epigenetic variation in Great Tits. We investigated the relationship between personality and DRD4 SNP830 polymorphisms using two standard experiments of boldness and exploratory behaviour in captive conditions comparing urban and forest Great Tits from Barcelona. We found that urban-dwelling birds are more explorative in novel environments and bolder in front of new objects than forest individuals. However, there was no relationship between DRD4 SNP830 and the behavioural scores in our populations. Additionally, we showed that the exploratory behaviour correlated with boldness in the forest but decoupled in the urban habitat, supporting the view that birds are showing a microevolutionary process of adaptation to the cities. In chapter two, we performed methylation profiling of two candidate genes for personality traits (DRD4 and SERT) in the same populations of the Great Tit (urban and forest) to ascertain whether personality traits within different habitats have evolved with the aid of epigenetic variation. Two well-known epigenetic methods were used including bisulfite conversion to determine the methylation profile in the promoter of these two genes and also in the exon 3 DRD4 and pyrosequencing to quantify the total methylation level at each CpG location. In this study, we found out that methylation was 1-4% higher in urban than in forest birds for all loci and tissues analyzed, suggesting that this epigenetic modification is influenced by environmental conditions. In addition, the methylation at a single CpG dinucleotide located 288 bp from the transcription start site of the SERT gene was re-

lated to exploration score in urban birds. Our results suggested that epigenetics adjustment can be different in the urban-dwelling Great Tits in comparison to the forest birds. In the third chapter, we searched for the link between Melanocortin-1 (MC1R) polymorphisms and black belly melanin coloration of the Great Tits, which had previously been found to differ between urban and forest individuals. However, our results showed that there is no polymorphism in this gene in relation to the size of the black belly stripe. In chapter four, we investigated patterns of adaptation to human-made habitats in a larger time-scale, focusing on the origin and expansion of the House Sparrow. We analyzed genetic variation of mitochondrial DNA control region and three nuclear loci to estimate the level of genetic differentiation between subspecies and describe the phylogeographic pattern of this species. Here, we found that the commensalism of this species with humans has a single origin and probably initiated in the Middle East. Then, it expanded rapidly in the Palearctic region with the aid of agriculture and human civilizations expansion. Finally, in the last chapter of my thesis, we estimated genome-wide methylation variation within and between five subspecies of House Sparrow in the Middle East, within the Iranian plateau, using methylation-sensitive AFLP (MSAP) method to evaluate the role of epigenetic variation in local adaptation and rapid expansion of the species in its native range. Additionally, we used the subspecies from Spain as an outgroup. We discovered that the genome-wide methylation pattern of House Sparrows has a general stability within five subspecies in the Middle East despite high phenotypic and environmental variation, yet the non-commensal subspecies was differentiated from some Middle Eastern subspecies. Further, the European subspecies was differentiated from all other subspecies. Our results indicate that variation in DNA methylation does not strictly follow subspecies designations. We detected a corre-

lation between methylation level and some morphological traits, such as standardized bill length, and we suggest that part of the high morphological variation in the native populations of the House Sparrow is influenced by differentially methylated regions in specific loci throughout the genome.

Academic year: 2016-2017.

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Approximation to the ecophysiology of Black Kites (*Milvus migrans*): intrinsic and socio-environmental effects on the regulation of glucocorticoids and carotenoids.

[Aproximación a la ecofisiología del milano negro (Milvus migrans): efectos intrínsecos y socioambientales en la regulación de glucocorticoides y carotenoides.]

Key words: aging, coloration, corticosterone, environmental challenges, nest-bound nestlings.

Palabras clave: coloración, corticosterona, envejecimiento, pollos nidícolas, retos ambientales.

Abstract:

The last decades have witnessed a surge in the number of studies aiming to unravel the way in which internal mechanisms mediate the physiological and behavioural responses to environmental and ecological conditions under natural settings. Such recent interest for this approach stemmed from the recognized necessity to transfer the hypotheses and conclusions generated in the laboratory to more realistic contexts, where animals experience the simultaneous effects of multiple interacting factors and selective pressures. In this sense, both glucocorticoids and carotenoids have received considerable attention so far, given their respective roles as important physiological mediators of homeostasis and

health-related processes in animals. However, to date, much of the accumulated literature regarding these two physiological systems in wild birds has largely focused on small, short-lived species (mainly passerines), which differ greatly from long-lived birds both in terms of their general ecology and their vulnerability to environmental challenges. To shorten this gap in knowledge, this thesis explores different approaches to the eco-physiology of a wild, long-lived, territorial raptor (the Black Kite *Milvus migrans*). In particular, the first two chapters provide an in-depth assessment of the environmental, social and intrinsic factors that regulate endocrine secretion of glucocorticoids (in particular that of corticosterone; CORT) in nest-bound nestlings, using two different sampling methodologies (plasma versus feathers; chapters 1 and 2). Chapters 3 and 4, by contrast, focus on the adult segment of the population. In chapter 3, feather CORT is measured in individuals of all ages (including both juveniles and adults), with the purpose of investigating, for the first time, lifelong changes in adrenocortical function in a long-lived, non-marine and non-colonial avian species. To finish, chapter 4 delves into the effect of background environmental conditions (here exemplified by high and low marshland inundation levels) on the regulation of circulating carotenoids and the expected relationship between individual quality and intensity of carotenoid-based ornamentation. Overall, variations in feather CORT levels revealed that Black Kite nestlings at the study population were most negatively affected by low ambient temperatures, sibling rivalry and food scarcity. Plasma CORT levels instead best reflected the predictable short- and long-term fluctuations in the energy demands of nestlings, showing marked diel rhythms in adrenocortical function and age-related increases in both baseline and stress-induced CORT levels. These results highlight the importance of combining several methodologies to obtain a more complete picture of the factors that are most chal-

lenging for species and populations. In adults, feather CORT levels exhibited a gradual decline across the initial life-history stages, reaching lowest levels in prime age individuals (7-11 years old), but increasing again thereafter. Interestingly, the observed pattern mirrored the age-related changes in reproductive performance and survival previously reported for the same study population, thus pointing to a possible role of CORT as a major physiological determinant of fitness throughout life. Kites also exhibited elevated circulating carotenoid levels in years of high inundation compared to years of drought, possibly reflecting a higher availability of these pigments in the environment through larger macrophyte communities and/or higher prey densities. On top of this, observed differences in plasma carotenoid concentrations between non-breeders and breeders, and between individuals in good and poor body condition in years of drought, dissipated completely in years of high inundation, while others became evident instead (e.g. differences between males and females). The results thus highlight the importance of taking into account the full range of environmental conditions experienced by individuals at the time of sampling in order to fully understand the mechanisms behind the regulation of carotenoid pigments. They also provide a plausible explanation for the frequent discrepancies observed so far in the results reported by different studies. Finally, inter-individual variation in tarsus colour scores during wet years showed a strong association with age, similar to that observed for reproductive success, survival probabilities, migration performance and stress levels in this population. The fact that the relationship came out in years in which differences in individual quality at the plasma level were completely lacking suggests that both internal carotenoid demands, as well as the endogenous machinery responsible for the incorporation of carotenoids into the integument, actively maintain the honesty of the informa-

tion conveyed by this bodily trait regardless of the availability of these pigments. Such finding lends considerable support to the idea that carotenoid-based coloured traits in Black Kites play a role in intraspecies communication.

Academic year: 2015-2016.

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Winter distribution and niche dynamics in migratory passerines.

[*Distribución invernal y dinámica de nicho en paseriformes migratorios.*]

Key words: birds, distribution, migration, niche, ring-recoveries.

Palabras clave: anillas, aves, distribución, migración, nicho.

Abstract:

Many avian populations are migratory and make regular movements as responses to seasonal changes in environmental conditions. As a result, the individuals involved in these movements have to face up a variety of environmental conditions and threats throughout the year. Nevertheless, the inherent advantages for migratory populations are higher than the risks associated with these movements. This trade-off may be disrupted by global change, which could affect the migratory behaviour of many birds. The understanding of the relationships between migratory birds and the environment is thus a key issue in any assessment of the impact of global change on these species and the design of conservation measures. The factors that determine the distribution and abundance of migratory birds are difficult to determine precisely since they usually occur throughout the whole migratory circuit. The lack of data on bird movements during all the year hampers the study of migratory species; this is the case of their distributions in winter, a critical period for migratory birds in which they have to cope with low tem-

peratures and food shortages. However, the growing wealth of data provided by tracking devices (e.g., Movebank), ringing schemes (e.g., EURING) and other citizen-science programs (e.g., eBird), along with today's unprecedented access to modelling techniques, now offer exciting opportunities for advancing knowledge of migratory bird ecology throughout the whole year. This thesis aimed to improve our understanding of the environmental drivers shaping migratory bird distributions throughout the year by combining ring-recovery data and species-distribution modelling techniques. More explicitly, we aim to describe the features affecting the location and seasonal niche dynamics of the birds wintering in the western Palearctic. The western Mediterranean is used by vast amounts of migratory birds from central and northern Europe, and it is thus a region where the efforts aimed at protecting wintering birds will benefit the conservation of European avifauna at a broader scale. This thesis is arranged in three main parts. First, we validate the use of ringing recoveries as a means of predicting birds' winter distribution. Then, we discuss different aspects of the relationship between migratory behaviour and the responses to seasonal environmental changes. Finally, we apply these concepts and methods to two studies related to the conservation of migratory birds wintering in the Iberian Peninsula and the Maghreb. This thesis provides support for the value of ring-recovery data in research on migration strategies and the seasonal distribution of passerines. The testing of the models (a highly crucial methodological part of the process) shows that the results of ringing recoveries are useful for unravelling the features affecting the seasonal distribution of small migratory passerines. We agree, however, that the development of satellite trackers and other increasingly smaller devices will provide fresh (and better) information about migratory patterns and threats to songbirds. Nevertheless, our approach to ringing recoveries does pro-

vide three exciting results that merit further investigation: (i) migratory and sedentary birds differ in environmental tracking, a trait that could affect their ability to cope with global change; (ii) range contraction on wintering grounds may jeopardize the migratory populations of partially migratory passerines since habitat alteration in small wintering areas will affect individuals over larger breeding areas; (iii) climate change will potentially modify these wintering areas and, according to our predictions, its effects will be buffered by the vast expanses of mountains in the Iberian Peninsula and the Maghreb. Thus, data resulting from the selfless work of thousands of ringers provide excellent material for studying and conserving migratory passerines.

Academic year: 2016-2017.

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Spatial ecology of Bonelli's Eagle (*Aquila fasciata*) in Aragón.

[*Ecología espacial del águila de Bonelli (Aquila fasciata) en Aragón.*]

Key words: conservation, home range, population dynamics, raptors, spatial ecology.

Palabras clave: conservación, dinámica poblacional, ecología espacial, rapaces, territorio.

Abstract:

Spatial ecology has traditionally attempted to comprehend how the configuration of space affects organisms. This includes understanding how species use space and establish themselves in a particular area. Findings from spatial ecology help applied ecology, especially in relation to the management and conservation of endangered territorial species. Ecological processes restrict the movements of many animals to a particular area or terri-

tory. They not only depend on the individual characteristics but also on spatiotemporal scales under which these processes are interpreted. For conservation biology, scales are important in establishing guidelines for the management of endangered species. For example, patterns related to the use of space identified at large scales might be masking others only detectable at smaller scales. The same can be applied to temporal scales. The use of a single approximation can also have a limiting effect. Therefore, ecologists and conservation biologists often include multiple approaches to understand patterns and processes. The general objective of this study was to better characterise the spatial ecology of Bonelli's Eagle in the northeast of the Iberian Peninsula. Using long-term monitoring data gathered by GPS satellite telemetry, we attempted to identify patterns and processes that may be informative for the design of novel conservation strategies for the species, and which can be applied to other species with similar characteristics. Particularly, we analysed basic aspects of territorial behaviour. We characterized home range size and shape of breeding Bonelli's Eagles during three periods of the year. Specifically, we focused on the non-breeding season (from September 1 to February 14), the breeding season (from February 15 to June 14) and the nestlings' dependence period (June 15 to August 31). Also, we verified individuals' home range fidelity, a decisive factor for territorial species. Home range fidelity was high for all individuals over the three periods in all the study years. Females changed home range size and its use throughout the year, with significant differences during the breeding season. Nevertheless, fidelity to nesting areas was low during all periods. Another important aspect to understand the spatial ecology of this territorial species is habitat selection. We studied the habitat selection of the Bonelli's Eagle at different temporal (years and seasons) and spatial scales (Re-

gional scale, including Aragón Region; Study Area scale, including the space with valid locations obtained by GPS; and Home Range scale, within each territory calculated from GPS data) through habitat structure. Also, we investigated how habitat structure influenced resource distribution. We found a heterogeneous selection of wooded, rocky and scrub areas alternating with agricultural areas at a regional scale. At the home range scale, individuals selected forests and scrubland over the entire year, except during the breeding season, when, surprisingly, they selected humanized areas. Although Bonelli's Eagle is considered a forest raptor, during the breeding season they selected other habitat types, such as dense scrub and humanized areas, probably due to the high prey availability in these areas. To understand how trophic resources influence home range behaviour, we tested whether biomass availability acted as a limiting factor for the establishment of home ranges. Specifically, we tested if there were biomass differences between home ranges and potentially favourable adjacent areas. Also, we checked the annual and seasonal variation in biomass availability and how such variations determined the establishment of home ranges. We detected variations in biomass availability between territories but no annual or seasonal variation within territories. Differences in biomass availability were identified between each of the territories and their potential adjacent areas. Although biomass availability was lower inside the territories, it remained stable throughout the year, while strong fluctuations in biomass availability were detected outside of the territories. The Eagles, thus, might follow a strategy that we called Trophic Stability Hypothesis. To identify underlying dynamics in the population, we analysed the relationship between distribution and reproductive success. In the study population, biotic variables (presence of competitors, such as the Golden Eagle *Aquila chrysaetos*, or prey availability) were

more important for the distribution of the species than breeding success. However, abiotic traits (related to habitat structure and climate), which negatively influenced reproductive success, did not strongly condition the distribution of the species. Nevertheless, the replacement of one of the members of the breeding pairs affected reproductive success and population dynamics. We found ecological sink patterns in the population under study. In areas that were environmentally optimal for the presence of the species, breeding success was lower, mainly because of the replacement of breeders within the population. In conclusion, for the conservation of endangered territorial species, a long-term monitoring of the different aspects related to the use of space is recommended. It is interesting to use several temporal and spatial scales that may reveal underlying problems and give specific guidelines for action. In addition, the use of integrative approaches can reveal population dynamics that are not identified a priori.

Academic year: 2016-2017.

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Ecology and population dynamics of the Red-legged Partridge (*Alectoris rufa*) in Spain.

[Ecología y dinámica poblacional de la perdiz roja (Alectoris rufa) en España.]

Key words: *Alectoris rufa*, management-conservation, radio tracking, Spain, wild populations.

Palabras clave: Alectoris rufa, España, manejo-conservación, poblaciones silvestres, radioseguimiento.

Abstract:

The Red-legged Partridge is classified as Species of European Conservation Concern

category 2 based on its marked population declines, particularly in the second half of the 20th century, and its limited distribution. Habitat quality plays an important role in the population dynamics of this species. We radio tracked for the first time free-living individuals from four different populations in southern and central Spain. This enabled us to define the spectrum of habitats used by the species and their relative importance, what allows a better understanding of the causes of mortality and the population dynamics and, therefore, a proper management of this species. Habitat selection at two levels (home range and landscape) and the descriptors influencing home range were studied considering gender, age, body condition, season, landscape structure, agricultural management and species daily cycles. The intensity of habitat selection was affected by the average patch size in each study area. Three variables affected home range: patch size and agricultural disturbance increased home range whereas the abundance of edges decreased it. Food availability and type of vegetal cover (the latter being important as an anti-predatory defence) were key for habitat selection. Our models showed that, after controlling the effects of pesticides and herbicides, marginal areas and edges were particularly important during the breeding season, probably because these habitats provide both food and refuge. The home range of a Red-legged Partridge population can be a good indicator of habitat quality at least in natural populations. The decline of this species in Spain was preceded by agricultural transformations such as land concentration and an increase in cultivated surface, which increased patch size and decreased edge and marginal areas. Regardless the spatial scale considered, any management action neglecting habitat quality is doomed to failure or will not produce satisfactory results for the conservation of this species. Four causes of death were recorded during this study: hunting, predation, disease

and trauma. Body condition, the diversity of vegetation and the number of edges were positively related to the survival of the Red-legged Partridge, whereas the last two variables were negatively related to predation and disease risks. The survival rates in agricultural areas with low management were more constant and higher all year round than the ones found in intensely managed areas. Predation was commoner in the first ones whereas losses due to disease were more frequent in heavily managed areas during the annual cycle. Diseases played an important role in the population dynamics of the Red-legged Partridge, being the most important cause of death for females in our study areas. This was related to the high density of individuals that favoured contact and aggregation. Hunting was also an important cause of mortality that can lead to the decline of populations. Casualties due to hunting increased with low cover of scrubland and with high frequency of agricultural practices. The likelihood of disease losses decreased with landscape diversity, and increased with low occurrence of scrubland and edges. Thus, landscape diversity was important for the survival of partridges and, consequently, is a key factor in the population dynamics of this species. This study reports for the first time an outbreak of avian pox in a dense, free-living Red-legged Partridge population in an agricultural area, affecting 41% of the juveniles. Infected individuals belonged to family groups and were not distributed randomly. The prevalence of avian pox was 30.3% in June and 60.6% at the end of the summer. The gregarious behaviour of young partridges at night could facilitate contagion by physical contact within a family group. None of the 45 radio-tagged adults recaptured throughout the study period showed injuries. We stress the need of knowing the potential negative effects derived from animal manipulation to determine its likely influence in the information sought. The location of the radio

transmitter (in our case on the neck), weather conditions and the method and timing of capture are risk factors that should be considered in further studies.

Academic year: 2017-2018.

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[Role of uropygial gland volume in the host-parasite interaction.](#)

[El papel de la glándula uropigial en la interacción hospedador-parásito.]

Key words: antimicrobial activity, avian malaria, uropygial secretion.

Palabras clave: actividad bactericida, malaria aviar, secreción uropigial.

Abstract:

The general aim of this thesis was to explore the role of the uropygial secretion on host-parasite interactions in different bird species. We specifically investigated the role of the preen gland as a defensive barrier against malaria parasites and its potential contribution to bird fitness. Our outcomes showed that malaria-infected House Sparrows *Passer domesticus* had larger uropygial gland and higher antimicrobial activity on its secretion than uninfected ones. We also found that the effect of gland size on survival prospects of House Martins *Delichon urbicum* depended on malaria infection, so that infected House Martins with larger uropygial glands were better able to survive to the next breeding season. In addition, we showed that reproductive success of Barn Swallows *Hirundo rustica* varied with the interaction term between uropygial gland volume and abundance of conspecifics: individuals with larger uropygial gland had higher breeding success when living in environments with

higher abundance of conspecifics. Moreover, we revealed that invasive House Sparrows from Peru had larger uropygial gland and higher antimicrobial activity of the uropygial secretion than native Spanish House Sparrows, thus suggesting a role of this defensive mechanism on invasion success. Finally, we found that mean corrected uropygial gland volume was significantly larger in bird species from the tropics than from temperate areas, which is consistent with the idea that the relative size of this defensive organ is driven by selection imposed by parasites.

Academic year: 2017-2018.

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Waterbird populations role in anthropogenic wetlands of south Europe.

[\[Papel de las poblaciones de aves acuáticas en humedales antrópicos del sur de Europa.\]](#)

Key words: anthropogenic wetlands, Extremadura, long-distances migratory dabbling ducks, rice fields, waterbirds.

Palabras clave: ánades de superficie migratorios de larga distancia, aves acuáticas, campos de arroz, Extremadura, humedales antrópicos.

Abstract:

Waterbird use of rice fields has increased as natural wetlands continue to decline, and currently many migratory waterbird species on several flyways depend on the former cropland. The aim of this thesis was to deepen knowledge of the foraging ecology of waterbirds in rice fields, with emphasis on dabbling ducks (*Anas* spp.). Information on the geographical origin of dabbling ducks overwintering in rice fields of southern Europe is scarce and mostly limited to ringing recoveries. Male and female dabbling ducks differ in the distance covered between the breeding and wintering grounds. Thus, un-

derstanding the geographical origin of both sexes would provide a range-wide perspective of migratory connectivity in dabbling ducks. Furthermore, as many waterfowl species pair up in winter, determining the geographical origin of both sexes would also be useful to explain gene flow and population structure. Within this context, we used intrinsic isotopic markers to assess the geographical origin of male and female Northern Pintails *Anas acuta* and Eurasian Teal *Anas crecca* wintering in rice fields of Extremadura, a key wintering area for both species that use the Eastern Atlantic Migratory Route. Additionally, we fitted Northern Pintails with GPS-GSM tags to complement the isotopic data. Isotopic values ($\delta^2\text{H}$) varied significantly between male and female Northern Pintails, suggesting different geographical origins. However, male and female Eurasian Teal showed marginal differences in their geographical origin. Data from tagged individuals supported the isotopic data, showing that males can migrate more than 5,000 km to reach their breeding areas. Accordingly, for Northern Pintails, pair formation could occur between individuals with different geographical origins, which could contribute to the genetic variability of their offspring. The nocturnal foraging behaviour of migratory dabbling ducks has hampered the study of micro- and macro-habitat use and selection by ducks in the rice fields, which is imperative to design appropriate management strategies for their conservation. Using the cosmopolitan Northern Pintail as a model species, we monitored home-range and fine-scale resource selection by GPS-tagged individuals throughout the winter season. Our findings showed that nocturnal space use of Northern Pintails is influenced by availability of flooded fields and moonlight levels, whereas nocturnal foraging within rice fields is driven primarily by straw manipulation, water level and substrate pebble size. Food abundance, rice paddy size, and other environmental and

landscape features were not significant predictors. The presence of standing stubble in flooded paddies (water depth range: 9-21cm) with soft bottoms should therefore be prioritized to improve foraging areas for dabbling ducks. Our findings are of global importance because these management procedures would not increase economic costs or affect rice production, and could be applied for dabbling-duck conservation throughout the world. Lastly, many conservation plans of waterbirds have focused on the conservation of diurnal roosting areas, but these plans should also consider the large areas that these birds may use at night. It is assumed that long-distance migratory dabbling ducks overwintering in south or western Europe store large amounts of fat and, to a lesser extent, proteins as fuel for successful migration. The physiological changes of dabbling ducks at wintering or stopover sites in relation to sex and their next non-stop flights have seldom been studied. We studied body mass changes in wintering male and female Northern Pintails. We also measured changes in the levels of plasma triglycerides and total proteins as indices of lipid and protein metabolism, respectively. Both sexes increased their body mass in late winter (pre-migration period) and showed a similar increasing pattern of body mass and plasma metabolites, albeit they did not follow the general pattern described by the 'wintering strategy' for migratory dabbling-ducks wintering in western Europe. This was most likely due to the milder environmental conditions (i.e. weather and food availability) in southern Europe, compared to wintering areas at northern latitudes. Lastly, waterbirds can reallocate a considerable amount of nutrients within agroecosystem landscapes. However, their effects on biogeochemical cycles have rarely been quantified. We estimated bird numbers, diet, food supply, and food consumption on rice fields by various overwintering waterbirds species (migratory and resident) in Extremadura's

rice fields. Herein, we modelled the nutrient (N and P) recycling in rice fields, and their transport to reservoirs. The energy consumption by waterbirds ($96,605 \pm 18,311$ birds) on rice fields during winter averaged $89.9 \pm 39.0 \text{ kJ} \cdot \text{m}^{-2}$, most of it (89.9%) belonging to foraging on rice seeds (birds removed about 26% of seeds leftover after harvest). Waterbird foraging and roosting in the rice fields recycled more than 24.1 and 5.0 tons of N and P, respectively. Additionally, we estimated that 2.3 tons of N and 550 kg of P were removed from rice fields and transported to reservoirs. The seasonal foraging of wildlife should result in a direct benefit for rice farmers by improving nutrient recycling through defecation by waterbirds. The results shown in this thesis may therefore be especially helpful to implement landscape-scale conservation plans involving management decisions in areas that are important for the conservation of migratory waterbirds.

Academic year: 2017-2018.

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Trade-off between the risk of overheating and camouflage on eggs of ground-nesting birds.

[Compromiso entre el riesgo de sobrecalentamiento y camuflaje en huevos de aves que nidifican en el suelo.]

Key words: eggshell coloration, Kentish Plover, nests, pigments, spottiness.

Palabras clave: chorlitejo patinegro, coloración de la cáscara de huevo, moteado, nidos, pigmentos.

Abstract:

Many Charadriiform birds (shorebirds and allies) nest on the ground in sites with no vegetation, receiving in that case direct solar

radiation. Thus, when incubating adults depart from nests, the eggs may reach critical temperatures for embryos. Nest predation is also an important cause of breeding failures, thus having well camouflaged nests may be critical to reduce the risk of predation while the nests are unattended. Eggshell pigmentation and spottiness have been suggested to improve camouflage, but making the eggs darker may increase the rates of overheating. Then, this may lead to a trade-off between both factors (camouflage and temperature) on eggshell coloration. The aim of this thesis was to show whether there is such a trade-off, and to analyse whether ground-nesting birds mitigate the adverse thermal conditions of their nesting sites in hot environments by means of biophysical mechanisms (e.g., egg colour and spottiness, use of nest materials with favourable thermal properties), as well as by behavioural mechanisms (e.g., risk-taking by incubating birds in relation to nest camouflage, choice of sites where eggs are better camouflaged). First, we showed that darker eggs of shorebirds were better camouflaged when the nests were not attended by adults, but suffered quicker overheating than light-coloured eggs due to direct solar radiation. We also showed that, after controlling for environmental temperatures, eggs overheated more in the Tropics, likely because of a more intense solar radiation than in the Mediterranean region. Thus, the benefits of increasing pigmentation and spottiness for a better camouflage are counteracted by the increased risks of overheating when eggs remain exposed to direct solar radiation. Accordingly, we found that eggshell reflectance in the Kentish Plover (*Charadrius alexandrinus*) is primarily determined by latitudinal variations in solar radiation, with eggshells of lower reflectance (darker) found at higher latitudes. However, in the southern localities (nearer to the equator), where solar radiation is very intense, eggshells are darker in spite of high ambient temperatures, likely to pro-

tect embryos (through pigmentation acting as a parasol) from the dangerous UV radiation. We also tested the hypothesis that eggshell coloration and spottiness are related to pigments content in the Kentish Plover. As expected, we found that protoporphyrin was more abundant than biliverdin in eggshells. However, eggshell coloration was not related to pigment concentrations, which may be due to a different allocation of pigments either between eggshell's background and spots, or between different eggshell's layers. Besides eggshell coloration, the use of nest materials may be another biophysical mechanism with which to counteract the adverse effects of high ambient temperatures on egg overheating. We found that Kentish Plovers added into their nests lighter materials (pebbles) than those available around nest sites. Because light materials are thermally reflective (having lower heating rates), the microclimate of nests was likely improved. However, light materials worsened egg camouflage. In a field experiment, we found that the Plovers removed most of the experimental materials independently of their thermal properties, so that egg camouflage returned within a week to the original values of the experimental treatments. Although the thermal environment may affect the choice of nest materials by the Plovers, at our study sites it was not likely too stressful as to determine the acceptance of the lightest experimental materials. Beyond those biophysical mechanisms, ground-nesting birds may use behavioural strategies to enhance egg camouflage and mitigate the risk of overheating when eggs are not attended. By applying predator visual models, we analysed whether microhabitat and nest material selection by three ground-nesting birds (Pied Avocet *Recurvirostra avosetta*, Kentish Plover, and Little Tern *Sternula albifrons*) facilitated camouflage. Plovers and Avocets selected microhabitats and nest materials that matched their individual egg appearance. In contrast, the lighter and less

spotted eggs of the Terns did not effectively match nest microhabitats and nesting materials, despite choosing lighter substrates, and their eggs matched worse their background than eggs of the other two species. The paler and poorer camouflaged eggs of the Terns could reflect a trade-off between thermal protection and camouflage, because this species breeds later in the season, facing a greater risk of egg overheating. Finally, we tested whether incubating birds decide when to leave or return to the nest when predators approach their nests depending on the camouflage of the eggs and their risk of overheating. We found experimentally that Terns allowed closer approaches to their nests at midday, when the eggs appeared better camouflaged, than at the morning. Return times to the nests were affected by ambient temperature, with the Terns shortening such times at high ambient temperatures (i.e., in midday), thus diminishing the risk of egg overheating. As a whole, these results show that the decisions of the birds on when to leave or return to their nests depended on shifting payoffs, as a consequence of diurnal variations in both the thermal risks (incurred by embryos) and egg camouflage. In conclusion, our observational and experimental studies can help to understand trade-offs among factors involved in the evolution of coloration and patterning of eggshells of ground-nesting birds that also affect embryo performance. This thesis may then be useful to understand the evolution of eggshell appearance and to predict the responses of ground-nesting birds under a scenario of global warming.

Academic year: 2017-2018.

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Cooperation and conflict among White Stork (*Ciconia ciconia*) nestmates.

[*Cooperación y conflicto entre hermanos de nidada de cigüeña blanca (Ciconia ciconia).*]

Key words: begging, cooperation, life history, parent-offspring conflict, sibling rivalry.

Palabras clave: agresión fraternal, conflicto paterno-filial, cooperación, historia vital, petición.

Abstract:

Genetic conflicts among siblings in species with sexual reproduction and parental care, such as birds, manifest as sibling rivalry when nestmates compete for parental resources. Sibling competition is implemented through a diverse array of behavioural mechanisms, ranging from overt aggression and fratricide through non-virulent forms of scramble competition (e.g. begging signals) which may include a high level of tolerance among broodmates or even mutualism. Previous studies suggested that White Stork *Ciconia ciconia* nestlings showed little or no aggression or physical interference because parents feed nestlings simultaneously, by regurgitating food on the nest floor. This pattern, which is shared by other stork species, is however exceptional among other bird families with close ecological and phylogenetic affinities, such as herons, ibises or pelicans. In these groups, nestmates usually compete despotically, often by overt aggression. The aims of this study were: (i) to elucidate the precise behavioural mechanisms regulating nestmate competition and communication within White Stork broods, and (ii) to unravel the ultimate evolutionary causes underlying variation in levels and mechanisms of nestmate competition among the highly diverse clade of subaltricial birds. First, we obtained behavioural samples from video recordings of natural feeding events involving 108 nestlings from 46 broods less than four weeks old, as well as data from three experimental setups. Second, we performed a phylogenetic comparative study based on a dataset including 192 species belonging to 16 families of altricial birds to determine ecological, behavioural and life-history predictors of the level of inter-

ference competition among nestmates. Results showed that White Stork broods are characterized by a high level of broodmate tolerance, where interference competition is weak if not completely absent. Moreover, White Stork nestlings display an elaborate repertoire of signals containing information about chick nutritional state, which seems to be involved in cooperative begging and sibling negotiation. This suggests a highly prosocial evolutionary scenario. The comparative study revealed that the observed diversity in levels of interference competition among subaltricial birds is closely linked to a species' life history: more virulent sibling rivalry is associated with a slow life history pace (low fecundity and mortality rates). It is suggested that this association is mediated by both short- and, specially, long-term effects of early nestling behaviour upon viability and fecundity later in life.

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Universidad Politécnica de Madrid

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Applied aspects of Turtle Dove (*Streptopelia turtur*) ecology in a forestry Mediterranean environment.

[Aspectos aplicados de la ecología de la tórtola común (Streptopelia turtur) en un ambiente forestal mediterráneo.]

Key words: *Echium*, farmland birds, forest management, trasaharian migrant birds, weed seeds.

Palabras clave: aves esteparias, aves migratorias transaharianas, Echium, gestión forestal, semillas silvestres.

Abstract:

The aim of this thesis is to contribute to the knowledge of the ecology of the European Turtle Dove (*Streptopelia turtur*, L.) in

Mediterranean forest areas, so that this contribution is useful for the management and conservation of its breeding populations in Mediterranean Spain. In order to reach this objective, three different studies have been carried out based on the knowledge of (i) the singing activity of the species, (ii) the diet and (iii) the breeding habitat requirements in the Sierra de Andújar Natural Park. The first study showed that the peak of detectability of singing Turtle Doves occurs in the first half of June and tends to decrease as the breeding season progresses. Therefore, the temporal changes in the singing activity of the Turtle Dove in the Mediterranean area are similar to those in central Europe. Additionally, singing activity is significantly lower in point counts with a low abundance of breeding birds. Regarding diet, thirty wild seed species were identified in the diet, but only a few species represented most of the volume and had a high frequency of occurrence. Although the main wild seed species consumed each year varied annually, certain species were found in the diet every year in high volume and frequency. Adults showed a more diverse and numerous consumption of wild seeds than did juveniles. Interestingly, plastic granules were also found in 3.8% of individuals. Finally, we assessed the relation between the abundance of the wild species locally consumed by Turtle Doves and the nesting habitat suitability in two protected forest farms of Mediterranean southern Spain. The results showed that local abundance of breeding Turtle Doves was significantly high in the nesting sites where two particular herbaceous species (*Echium plantagineum* and *Silene* sp.) abounded. Likewise, the abundance of Turtle Dove was greater in one of the farms notwithstanding their vegetal similarity, which can be linked with its vicinity (only a few kilometers) to cereal crops.

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Fine-scale population differentiation: ecological and evolutionary mechanisms involved.

[Diferenciación de poblaciones a pequeña escala: mecanismos ecológicos y evolutivos implicados.]

Key words: dispersal, evolutionary dynamics, habitat selection, morphological differentiation, population structure.

Palabras clave: diferenciación morfológica, dinámica evolutiva, dispersión, estructura poblacional, selección de hábitat.

Abstract:

Dispersal and gene flow have traditionally been thought to counteract the effects of divergent selection and thus prevent evolutionary differentiation. However, recent research suggests that, if non-random, dispersal may promote population differentiation even at microgeographic scales. Examples of the eco-evolutionary consequences of non-random dispersal are still very scarce in the literature, possibly because long-term data from continuously monitored populations of marked individuals are needed. I document the effect of phenotype-dependent dispersal with respect to body size (tarsus length) on the evolutionary dynamics of a wild population of Pied Flycatchers *Ficedula hypoleuca* between 1988 and 2016. I characterized the natal dispersal patterns and phenotypic trajectories of dispersers and philopatric individuals originating from ecologically distinct (coniferous vs. deciduous), adjacent (1km) habitats, and investigated the genetic architecture of, and patterns of selection on, tarsus length. Pied flycatchers breeding in the oak and the pine forest showed strong divergence in tarsus length during the colonization phase of the pinewood, despite geographic

proximity and extensive dispersal (ca. 25% of each cohort change habitats). However, the initial degree of differentiation was not sustained over the 29-year period. Differential dynamics of phenotype-dependent dispersal between habitats seem to be the key force shaping the phenotypic trajectories of the study populations. Males moving from the pine to the oak forest tended to be smaller over time, whereas those that remained in the pine forest tended to be larger. Dispersers from the oak to the pine forest also tended to be larger over time, and thus the positive trend of philopatric birds was furthermore reinforced. No clear evidence of phenotype-dependent dispersal was found in females but, importantly, an analysis of both sexes combined confirmed the patterns observed for males alone. Temporal changes in breeding density and the level of nest-site competition likely provided the ecological mechanism for the habitat segregation of size classes. Breeding density increased in both habitats following nest-box addition. Nevertheless, due to the lack of natural cavities, nest-site competition –and therefore the relevance of body size in territorial contests– was probably magnified in the pinewood. Based on density and dispersal rates dynamics, it seems that the pine forest became progressively more attractive for Pied Flycatchers at the expense of a decrease in the attractiveness of the oakwood. Because large-dominant and small-subordinate males are generally sorted into preferred and non-preferred habitats, the steep increase in breeding density in the pinewood resulted in a shift in the patterns of phenotype-dependent dispersal. No evidence of adaptive habitat choice in relation to body size was found in this population possibly because, as demonstrated here, most Pied Flycatchers, regardless of their phenotype, return to the habitat they imprinted on as fledglings. Quantitative genetic analyses revealed a substantial component of additive

genetic variance underlying tarsus length, although there were substantial differences among pools of dispersers and philopatric birds. Specifically, individuals genetically predisposed to be larger preferentially dispersed into the oak forest. However, selection gradients on this group, unlike the other groups, were negative and, therefore, resulted in a negative response to selection. Dispersers to the oak forest actually showed a decline in tarsus length over time that, nevertheless, deviated from the lack of trend observed in the entire oak population. No such discrepancy was found in the pine forest, indicating a greater genetic contribution of dispersers to the pine forest in shaping the distribution of phenotypes within their recipient population. Examination of the breeding success of each group suggested that this unusual asymmetry resulted from uncoupled patterns of dispersal and gene flow in the oak forest, since the reproductive output of immigrants into the oakwood was lower than that of the other groups. Overall, these results indicate that the effect of dispersal on microevolutionary processes may vary from being positive to non-existent depending on the habitat type, although the ecological factors responsible for such discrepancy remain to be elucidated. Collectively, the five chapters presented in this thesis represent a major step forward in our understanding of the specific role of gene flow on eco-evolutionary dynamics and phenotypic evolution.

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On the diversification of highly host-specific symbionts: the case of feather mites.

[Sobre la diversificación de simbiosistas altamente específicos en término de hospedador: el caso de los ácaros de las plumas.]

Key words: cospeciation, diversification, feather-mites, host-switching, symbionts.
Palabras clave: ácaros de las plumas, co-especiación, diversificación, salto de hospedador, simbiosis.

Abstract:

One of the most relevant and poorly understood topics in Evolutionary Biology is symbiont evolutionary diversification. Since Fahrenholz's rule (1913), the idea of symbionts speciating following hosts speciation (i.e., cospeciating) has been pervasive. Recent studies, however, have shown that host-shift speciation (speciation after switching to a new host) is almost as relevant as cospeciation in explaining symbiont diversification. Also, these studies have revealed that methodological biases have favored cospeciation. Nonetheless, most symbiont groups, especially those highly host-specific and specialized in which cospeciation is expected to be the rule, such as the feather mites of birds, were yet to be studied. Symbionts are the most plentiful and diverse organisms on Earth, and thus essential components of ecosystems. However, symbionts have attracted historically less attention than other organisms, and their study entails numerous methodological challenges, so not surprisingly little is understood about the basic biology and ecology of many symbiont groups, especially the non-parasitic. By studying vane-dwelling feather mites, which live permanently on the surface of flight feathers of birds (Acariformes: Astigmata: Analgoidea and Pterolichoidea), this thesis is a contribution to fill this gap. This thesis is divided into three parts: first, resources and molecular tools enabling large-scale studies of feather mites are developed. Then, these and other tools are used to investigate eco-evolutionary aspects relevant to understand feather mite diversification, such as their mode of transmission and the type of interaction they have

with their hosts. Finally, feather mites diversification at a macro- and microevolutionary scale is investigated. The first part compiles a global database of bird-feather mites associations. Also, it evaluates and adjusts DNA barcoding and metabarcoding to be suitable methodologies for studying feather mites. The second part reveals feather mites as highly specialist and host-specific symbionts whose main mode of transmission is vertical. Analyses of feather mites diet reveal them as trophic generalists which maintain a commensalistic-mutualistic relationship with birds. Finally, the last part of the thesis shows host-shift speciation as the primary process driving the diversification of feather mites. Also, it highlights that major-host switching, despite being an infrequent process, is highly relevant for the diversification of this group. Lastly, analyses of straggling reveal a high rate of preferential straggling governed by ecological filters. Overall, despite feather mites be revealed as highly specialized and host-specific symbionts, the coevolutionary scenario is highly dynamic. Straggling and host-switching are prevalent processes which allow the colonization of new hosts in highly specialized and host-specific symbionts. Accordingly, coevolution and codiversification do not operate in isolated host-symbiont interactions but are more likely in a manner compatible with the geographic mosaic of coevolution. Finally, ecological fitting and interspecific competition might well be the main factors governing the (co)eco-evolutionary dynamics.

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[Impact of the interactions between hosts, vectors and pathogens on the transmission of avian malaria and flavivirus by mosquitoes.](#)

[*Impacto de las interacciones entre hospedadores, vectores y patógenos en la transmisión de malaria aviar y flavivirus por mosquitos.*]

Key words: ecology disease, House Sparrow, *Plasmodium*, vector-borne diseases, Zika virus.

Palabras clave: ecología de la enfermedad, enfermedades transmitidas por vectores, gorrión común, *Plasmodium*, virus Zika.

Abstract:

Vector-borne pathogens cause important diseases such as malaria and are nowadays a major public health concern, because they cause human –and animal– fatalities worldwide and have a significant impact on local economies. Factors associated to global change, such as habitat alteration and introduction of invasive species, have largely contributed to the spread of potential insect vectors and the pathogens they are able to transmit, thus creating novel epidemiological scenarios. Therefore, it becomes essential to study the factors that modulate the transmission risk of these disease agents involving the interactions between vertebrate hosts (humans and other animals), pathogens and insect vectors in natural ecosystems. In this thesis, I used a multidisciplinary approach combining molecular tools, experimental bioassays and statistical analyses to assess the ecological and evolutionary factors that affect the transmission success of two mosquito-borne pathogens. In particular, I considered the interactions between insect vectors, vertebrate hosts, the avian malaria parasites and the flavivirus Zika virus. I focused on two major steps directly influencing the pathogen transmission success: (i) the contact rate between mosquitoes and infected/susceptible vertebrate hosts, and (ii) the development of the pathogen in the mosquito and its consequences on the pathogen transmission risk. To do that, first I tested

the potential causes underlying differences in the biting patterns of mosquito species. I exposed two bird species to two mosquito species to determine the role of mosquito species identity and the effect of three host-related factors (i.e. body mass, gender, and infection status by avian malaria) on host-vector contact rates. I found clear interspecific differences in the biting rates of mosquitoes, which were also influenced by variation in hosts' traits, although these effects differed depending on the particular mosquito-host assemblage. Therefore, the biting patterns of mosquitoes are far from being generalizable. Secondly, I assessed the vector competence of different mosquito species for the transmission of Zika virus and avian malaria using mosquito saliva. I found that the ability of mosquito-borne pathogens to develop in mosquitoes differed between insect species, which may be the result of complex co-evolutionary processes. In addition, I assessed the consequences of parasite development in the mosquito vectors and their implications for the pathogen transmission risk. I found that host parasite load and parasite identity affect the impact of parasites on mosquito longevity finally determining the transmission risk of the parasites. With this information mostly derived from studies under controlled conditions, I assessed the importance of environmental conditions affecting the host-parasite-vector assemblages in the wild. I found that habitat characteristics, which determine the existence and abundance of insect vectors, and host related factors (i.e. immune-competence) determine the prevalence of avian malaria parasites in insular ecosystems. Altogether, in this thesis I identified key factors affecting the transmission success of vector-borne pathogens affecting humans or wildlife, thus allowing a better understanding of the complex transmission dynamics of vector-borne pathogens.

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Ecology of vector-borne diseases: effects of host traits on mosquito feeding preferences and its implications for disease transmission.

[*Ecología de las enfermedades transmitidas por vectores: efectos de los rasgos del hospedador sobre las preferencias de alimentación de los mosquitos y sus implicaciones para la transmisión de enfermedades.*]

Key words: avian *Plasmodium*, host metabolism, host selection, phenotypic traits, vector attraction.

Palabras clave: atracción vectorial, metabolismo de hospedador, *Plasmodium* aviar, rasgos fenotípicos, selección de hospedador.

Abstract:

Last decades have seen an accelerated emergence or re-emergence of vector-borne diseases (VBDs) worldwide, representing a major threat to public health and biodiversity conservation involving human, wildlife and domestic animals. Despite the medical and economic impact of VBDs, the ecology of VBDs, especially the interaction between hosts and vectors is still poorly understood. Previous studies on epidemiology assumed a random host-vector interaction and ignored the potential effects of heterogeneity in host traits on the transmission rates of pathogens. Failure to recognize and incorporate the potential effects of host traits into epidemiological models could result in biased estimates of disease transmission dynamics. Therefore, this thesis explores the effects of host trait heterogeneity on host-vector interactions at both inter- and intra-specific levels. Given the importance of mosquitoes and wildlife hosts in the transmission cycle of vector-borne pathogens (VBPs), this thesis mainly used a mosquito-borne pathogen, i.e. avian *Plasmodium*, as the study system, in-

cluding some of their natural vectors *Culex pipiens* and *Culex restuans* and vertebrate hosts, i.e. the House Sparrow *Passer domesticus*. Host traits may have profound influence on avian host-mosquito vector interaction, as host-seeking mosquitoes may rely on certain host traits to locate potential hosts, resulting in mosquito feeding preferences that produce heterogeneous host-vector contact rates. In this thesis, I first reviewed the role of host morphological, behavioural and physiological traits in mosquito attraction. This chapter identified knowledge gaps on the role of different host traits in mosquito feeding preference, and highlighted the need of both theoretical and empirical studies on such topic. In chapter 2 I conducted a comparative study by combining data of mosquito forage ratios in an avian community with data of avian morphology and behaviour. Birds with lighter colors, bigger body size and solitary roosting behaviour were bitten more often than expected from their relative abundance in the community. This study highlights the role of host morphological and behavioural traits in interspecific differences in host use patterns of mosquitoes. To figure out the role of host physiological traits in mosquito blood-feeding preference, I performed dual-choice experiments by exposing House Sparrows with different metabolic rates to blood-seeking *C. pipiens* and analyzed the relationship between mosquito feeding preference and host metabolism. Individual birds with lower resting metabolic rates were bitten more often than their conspecific counterparts by mosquitoes. This represents the first experimental evidence of a link between host metabolism and vector feeding preference. In addition, birds with greater body mass were bitten more frequently by mosquitoes. To assess the impact of host infection on blood feeding patterns of mosquitoes, I carried out two dual-choice experiments by exposing House Sparrows

with different infection status (i.e. *Plasmodium*-infected vs. uninfected) and with different infection intensity (i.e. higher *Plasmodium* load vs. lower *Plasmodium* load) to blood-seeking mosquitoes respectively. Individual birds with higher parasite loads were bitten more often than their counterparts with lower loads. However, the infection status of birds did not significantly affect mosquito feeding pattern, with *Plasmodium*-infected and uninfected birds bitten similarly by mosquitoes. Our findings partially support the parasite manipulation hypothesis and highlight the importance of considering parasite load in studies on host-vector-pathogen interactions. By using interdisciplinary approaches that combine comparative methods, molecular analyses as well as empirical bioassays, this thesis identifies several key links between host traits and mosquito feeding preferences at both inter- and intra-specific levels, which may help to better understand the dynamics of host-vector contact rates and hence, the transmission dynamics of VBPs. Incorporating heterogeneity from host traits in future studies may improve our understanding on the ecology of VBDs as well as the surveillance and control efforts in the complex transmission network of VBDs.

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Effect of temperature on Great Tit *Parus major* nestling growth, development and survival, in a climate change scenario.

[*Efecto de la temperatura sobre el crecimiento, desarrollo y supervivencia de pollos de carbonero común Parus major en un entorno de cambio climático.*]

Key words: climate change, high temperatures, low temperatures, Mediterranean habitat, *Parus major*.

Palabras clave: altas temperaturas, bajas temperaturas, cambio climático, hábitat mediterráneo, *Parus major*.

Abstract:

In a bird population, nestlings' survival is determined by the interaction of both biotic and abiotic factors. Among the latter, temperature may play a critical role on nestlings outcome. Moreover, nestling condition at fledging (determined by all factors affecting their previous development) and fledging time are two of the most influencing factors affecting first year post-fledging survival, a period characterized by a high mortality rate. This thesis analyzes some of the factors that may affect growth, development and survival of nestling Great Tits *Parus major* in Mediterranean habitats, focusing on the impact of temperatures in the present context of global climate change. Methodologically, reproductive and thermal data collected during more than two decades in a Mediterranean population of the species were used to determine which set of factors influenced nest survival, as well as first year post-fledging survival. Additionally, long-term annual trends of selection differentials for laying date were analyzed in the population from the yearly recruits, and their relationship with temperatures experienced during the breeding period was determined. On the other hand, in an experimental approach, temperatures inside a set of nests were manipulated in order to assess the effect of sub-optimal thermal conditions on nestling growth and survival, as well as changes in parental behaviour. Furthermore, radio tracking was used to analyze the effect of temperatures experienced during the nestling stage on immediate post-fledging survival. The results of this thesis highlight the importance of brood size on

nest survival and fledging output. Larger broods produced more fledglings, although mass prior to fledging may have been compromised. On the other hand, hatching date and fledging size (i.e., tarsus length at fledging) had a significant influence on juvenile first-year post-fledging survival. In essence, survival probability was lower for smaller individuals, as well as for those born in either very early or late broods. Moreover, the analysis of breeding onset in our population revealed that mean laying date had not advanced significantly during the studied period (1992-2013), despite an overall selection for earlier breeding. Breeding date was earlier in warmer years, a response that was mainly explained by phenotypic plasticity. In addition, temperatures experienced during the incubation and nestling stages had major influence on selection differentials. On the

other hand, the experimental results of this thesis evidence that sub-optimal thermal conditions may affect nestling development, as heated nestlings were lighter on day 15, whereas cooled nestlings developed smaller tarsi. On this sense, thermal stress may have weakened the nestlings, which in turn may have led to reduced immediate post-fledging survival, at least in the case of heated individuals. Parental behaviour, however, was not significantly altered by the thermal manipulation of the nests. The results of this thesis are integrated in the present context of global climate change, as they evidence the vulnerability of nestlings to adverse nest temperatures and the likely impact of sub-optimal thermal conditions during development on the future survival of the juveniles.

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