

PHD-Dissertation Reviews in Ornithology (2015–2016 Academic Year)

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PHD-DISSERTATION REVIEWS IN ORNITHOLOGY (2015-2016 academic year)

Edited by Francisco VALERA

This section includes the abstracts of some of the PhD-Dissertations submitted in Spain during the 2015-2016 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. For the first time, this section 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 2015-2016 junto con otras no recogidas en reseñas anteriores. Se ha seguido una ordenación alfabética por universidades y, dentro de ellas, por año y autor. Por primera vez esta sección 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 (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 (ardeola@seo.org). El Comité Científico de SEO/BirdLife otorga con carácter bianual un premio a la mejor tesis doctoral reseñada en esta sección, que es entregado en el Congreso Español de Ornitología correspondiente. Esperamos vuestras noticias como buena señal de la pujanza de la investigación ornitológica en nuestro país.

Universidad de Alcalá de Henares

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Territoriality and spatial relationships in diurnal raptors. Patterns and process at global and local scales.

[*Territorialidad y relaciones espaciales en rapaces diurnas. Patrones y procesos a escala global y local.*]

Abstract:

Understanding and predicting the spatio-temporal dynamics of animal populations remains a challenge and one of the main aims in Ecology. In this context, the study of territoriality can provide valuable information on the population dynamics, density and spatial organization of organisms. Raptors have often been used as models to study territorial behavior and its ecological implications. However, certain aspects remain poorly explored, such as the factors that promote this behavior at global scale, the influence of this behavior on other characteristics of raptors such as the reverse size dimorphism (RSD, i.e. females are larger than males in some taxonomic groups of birds), or how territoriality and the interactions with other species affect the spatial organization of their populations. The aim of this thesis is to deepen the knowledge of both territoriality and spatial relationships in diurnal raptors, addressing four key aspects: (i) the determinants of territorial behavior, (ii) territoriality as a determinant of other characteristic traits in raptors (i.e. RSD), (iii) territoriality of predators as an indicator of the ability of ecosystems to support wildlife populations, and (iv) the interspecific spatial relationships as indicators of interactions between species of a raptor guild. The first section of this dissertation focuses on general patterns associated with territorial behavior of diur-

nal raptors, through comparative analyses between species of the Western Palearctic and the New World, and taking into account their phylogenetic relationships. First, we analyze several factors –main prey type, nesting site type, average prey size and average body size– as determinants of territorial behavior and territory size of 74 raptor species. Territorial behaviour was mostly associated with agile prey and structurally complex nesting sites, probably because of the difficulty to hunt agile prey, and because of the protection or inaccessibility conferred by complex nesting sites upon predators. Within the territorial species, those hunting the most agile and largest prey had larger territories, probably because these prey are less available than most vulnerable, or than smaller and more numerous, prey. Second, we examine the relationship of territorial behavior, territory size, agility of the main prey and hunting habitat complexity with the degree of RSD in 75 species of raptors. The most important factor was prey agility, followed by hunting habitat, and finally the variables associated with territoriality. This is the first study suggesting that hunting habitat complexity increases the RSD in raptors. Territorial species and species with the largest territories also showed the highest degree of dimorphism. However, part of the RSD variation explained by these two variables overlapped with the variation explained by the agility of the main prey; therefore, further research is needed for understanding the importance of territoriality in the evolution and maintenance of RSD in diurnal raptors. The second section focuses on intra and interspecific spatial relationships of a guild of forest raptors comprised by northern Goshawk *Accipiter gentilis*, Eurasian Sparrowhawk *A. nisus* and Common Buzzard *Buteo buteo* in eucalyptus woods (*Eucalyptus globulus*) on the northwestern part of the Iberian Peninsula. First, we estimate the intra-specific nests distances among the three

species of raptors, taking into account habitat preferences, and compared them with other Palearctic populations, in order to evaluate the ability of this novel forest ecosystem to support a community of predators. The distances found were similar and, for some species, even shorter than those reported in the literature. All three species nested preferably in stands of eucalyptus that were mixed with native species, with high structural complexity and large trees. Thus, the function of the forest in the study area may be mostly structural, providing a high amount of suitable sites to nest, whereas the surrounding non-forest areas may complement the forest's function by providing high numbers of prey. All these results suggest that the study area, as a whole, provides a similarly good or even better nesting habitat for these three predators than other forest ecosystems. Finally, we study the spatial organization of the raptor guild and its relationship with the interspecific interactions, taking into account the territoriality of the species and their habitat preferences. The guild of top-predators studied presented a very organized and hierarchical spatial distribution with a dominant predator (Goshawk) and a subordinate one (Sparrowhawk), and within the guild, both negative (super-predation) and positive (commensalism and possible mutualism) relationships were established. The mechanisms that promoted the coexistence of these predators were the different breeding phenology of the species, the spacing from the dominant predator, the spatial refuges, the low interspecific synchrony between neighboring territories, and the segregation of the predator's diets. In conclusion, the results of this dissertation highlight some key factors related to territoriality, spatial distribution, and RSD of raptor species. First, the complexity of the nesting habitat (nesting sites and hunting habitat) proves to be key for all the factors studied, at both global and local scales. Additionally,

availability of prey is also very important for these predators at both scales, although the relationship between these factors needs further study, since it was indirectly analyzed through related variables, such as prey agility and size. Finally, interspecific interactions between raptors are also key in our understanding of the spatial distribution of top-predators, not only because of the negative interactions but also the positive, as shown in this thesis.

Academic year: 2015-2016.

Universidad de Alicante

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Ecology and conservation of Kentish Plover *Charadrius alexandrinus* in Mediterranean dune ecosystems subjected to human disturbance.

[*Ecología y conservación del chorlitejo patinegro Charadrius alexandrinus en ecosistemas dunares mediterráneos sometidos a perturbaciones humanas.*]

Abstract:

Beaches are probably one of the ecosystems where more ecological processes converge on a relatively small surface. The confluence of multiple stressful abiotic factors for life explains the high specialization of the fauna and flora characteristic of this ecosystem. But beaches are also natural spaces frequented by humans and are often managed exclusively for recreational purposes. Coastal birds are excellent indicators of the impact of human disturbances on the beach ecosystem. The main objective of this thesis was to study the breeding ecology of the Kentish Plover *Charadrius alexandrinus* in Mediterranean beaches subjected to different levels of human disturbance. Nevertheless, the final goal of this thesis is to

contribute to an adequate management of the recreational uses in beaches with reproductive populations of coastal birds, by promoting measures of coexistence between people and birds. The first section of this thesis is a review of the knowledge about the impact of beach recreation on different aspects of coastal bird biology. In the second section we evaluated different methods to determine the existence of nest activity during the incubation period and egg hatching evidence for several species of coastal birds (i.e. *Charadrius alexandrinus*, *Charadrius dubius* and *Glareola pratincola*). The results showed that the accuracy of the breeding success estimates for ground nesting birds can be increased by combining several types of evidence of nest activity. However, at least one method relative to the development (i.e. egg flotation) or to the movement of the eggs within the nest (e.g. changes in the angle of the egg or egg-rotation evidence) should be included. Moreover, eggshell evidence can classify successful nests, but their effectiveness is limited by environmental and temporal variables. The third section examines some key aspects of the reproductive biology of the Kentish Plover on beaches subjected to different human pressure. The results of chapter 5 showed a high nest success on disturbed beaches as a result of lower predation rates. Human activity excluded natural predators from the beaches. However, nest success of disturbed and undisturbed beaches was similar, because new causes of nest mortality emerge in the beaches most frequented by people (i.e. nest abandonment and egg mortality by thermal stress). In chapter 6 we found that plovers selected embryonic dunes and tidal debris to place their nests. But this selection was different on disturbed beaches, where birds were forced to nest in suboptimal habitats. Indeed, the periodic removal of tidal debris for recreational purposes and the con-

tinuous presence of people forced plovers to move to inland sites. In chapter 7 we studied the relationship between density and location of people on the beaches on both habitat selection and breeding success. Birds placed their nests away from beach users more than expected by random, but this pattern is reversed by coastal regression. No relationship was found between the proximity or density of people and nest survival, thus suggesting that human presence has a greater influence on habitat selection than on breeding success. In chapter 8 we studied the response of incubating birds to the approach of different types of beach users. We found that plovers flushed from their nests more frequently when dogs or walkers were approaching, especially if they were inside breeding habitats. The flushing behavior was modulated by the ambient temperature, so that birds left their nests less frequently at higher temperatures. Consequently, nest return times once the disturbance event ended were shorter in situations of higher thermal stress. Moreover, the flushing behavior was different in disturbed beaches, so that plovers that were habituated to the human disturbance stimuli left their nests at shorter distances and reduced nest return times. These results suggest that habituation to the human disturbance stimuli may alleviate the trade-off between the flushing behavior to reduce the risk of adult predation and the effects of thermal stress for unattended nest. The fourth section focuses on two ecological trade-offs between nest survival and adult survival. In chapter 9, we tested the hypothesis that plovers select exposed sites according to a predator detection strategy, and the hypothesis that more concealed nests survive longer according to a crypsis strategy. To this end, we obtained an accurate estimation of the incubating adult's field of vision through a custom built inverted periscope. Our results showed that plovers selected nest sites with

higher visibility with regards to humans and dogs, although nests located in sites with higher vegetation cover survived longer. In addition, the flushing distance (i.e., the distance at which incubating adults leave the nest when they detect a potential predator) decreased with vegetation cover. Consequently, the advantages of concealing the nest were limited by the ability to detect predators, thus indirectly supporting the existence of the trade-off between crypsis and predator detection. In chapter 10 we study the influence of distraction displays on breeding success in order to explore the role of the defensive behavior on nest survival. We quantified the intensity of defensive behavior of adult plovers in response to nest disturbance caused by an approaching researcher. Our results show a positive correlation between male and female defense behaviors within pairs and that nests in which parents invested more on defense survived longer. Nevertheless, there were differences in the risks assumed by the two members of breeding pairs in nest defense, with females performing riskier defensive behaviors than males.

Academic year: 2015-2016.

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Neotropical lentic wetlands as strategic habitats for the biodiversity conservation of plants and birds in the Andean-Orinoco Piedmont of Colombia.

[Humedales lénticos neotropicales como hábitats estratégicos para la conservación de la diversidad de plantas y aves en el piedemonte Andino-Orinoquense de Colombia.]

Abstract:

Despite the high variety of freshwater lentic wetlands in the Neotropic, of its

ecological importance and its fast loss, the study of their associated biodiversity and the assessment of their importance for conservation purposes is still incipient. The Piedmont of the Meta Department (Colombia) is one of the most biodiverse areas and with greater availability of lentic wetlands of the Orinoco River Basin region. However, in the last decades it has undergone a major transformation, affecting natural wetlands and creating new wetlands with productive and recreational purposes. Through this thesis I assess the importance of the natural and human-made lentic wetlands (artificial and mixed) of Piedmont of the Meta Department as key ecosystems for the maintenance and conservation of Neotropical birds and plants biodiversity. Bird's diversity was studied in accordance with the ecological guilds (aquatic, semi-aquatic and land birds) and plant's diversity according to vegetal formations (woody, aquatic and herbaceous plants) and then in relation to the wetland management. For this, we classified the wetlands according to their origin (natural, mixed and artificial) and types (swamps, heronries, rice fields, semi-natural lakes, constructed lakes and fish farms). Hill numbers and measures of diversity were used to evaluate richness, structure and composition of the communities of plants and birds, as well as the relationship between the diversity of birds and plants as a potential method for selection and prioritization of wetlands. We found a high diversity of plants, with 628 vascular species (407 woody species, 122 herbaceous and 99 aquatic plants). As to birds, we registered 275 species (196 land birds, 60 strict aquatic and 19 semi-aquatic bird species), that represent 16% of all birds in the Piedmont physiographic region and 66% if compared to the richness of species of the Meta Department. There was a strong effect of the type of wetland on the patterns of diversity of birds and plants, differences being greater within the

categories of wetland management than between them. This suggests a high landscape and habitat heterogeneity of the wetlands. The species turnover was mainly high in the plant formations and the species composition was influenced by wetland management, which depended on the activities performed in each wetland. The diversity of birds and plants showed a direct and positive relationship, being strongly associated with the diversity of woody plants and with the origin of the wetlands. Also, the aquatic bird's richness showed an increasing relation with the area of the wetland. Therefore, we suggest the use of the relationship between the diversity of birds and plants for the selection and prioritization of wetlands of conservation interest. During this study bird species of interest were detected. For instance, the American Flamingo *Phoenicopterus ruber* was watched in rice fields. The origin of this species in the region is unknown and two possible explanations are proposed for its occurrence in the area: the extension of its range or human-related introduction. In addition, we report the expansion of the range of four bird species: Pied-billed Grebe *Podilymbus podiceps*, Yellow-chinned Spinetail *Certhiaxis cinnamomeus*, Yellow-browed Tyrant *Satrapa icterophrys* and Glossy Ibis *Plegadis falcinellus*. We also report new sightings of other four species in the region: Prothonotary Warbler *Protonotaria citrea*, Least Grebe *Tachybaptus dominicus*, Oilbird *Steatornis caripensis* and Epaulet Oriole *Icterus cayanensis*. This study confirms the use and importance of lentic wetlands in the region for the reproduction of birds and describes the reproductive phenology of Little Blue Heron *Egretta caerulea* and reproductive events of Rufescent Tiger-Heron *Tigrisoma lineatum*, Whistling Heron *Syrigma sibilatrix* and Black-crowned Night-heron *Nycticorax nycticorax*. In general, the results reveal that the lentic wetlands studied

have a high diversity of plants and birds at local and regional scale, despite high human intervention and accelerated transformation. It is suggested that these wetlands are refuges of the diversity of native plants of the forest of the Meta Piedmont and are key habitats for aquatic, semi-aquatic and land birds. Man-made wetlands (both artificial and mixed) act as complementary ecosystems for the maintenance of diversity, and together with natural wetlands constitute a key, complex system for the Neotropical biodiversity. Therefore, it is necessary the implementation of management actions aimed at the conservation of the wetlands. We propose the creation of a conservation area in the region (called "reserve archipelago") that integrates different types and sizes of wetlands, as a strategy for biodiversity conservation through to the environmental conciliation and the joint work of all local stakeholders. This dissertation provides a scientific basis for decision-making of the management and conservation of wetlands and their biodiversity.

Academic year: 2015-2016.

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Study of the ecology of Whiskered Tern *Chlidonias hybrida* in the Pego-Oliva Natural Park and other wetlands in the Valencian Community, Spain.

[*Estudio de la ecología del fumarel cariblanco Chlidonias hybrida en el Parque Natural del Marjal de Pego-Oliva y otros humedales de la Comunidad Valenciana, España.*]

Abstract:

A study on the Whiskered Tern *Chlidonias hybrida* was developed in wetlands of Valencia Community (SE Spain), particularly on the Pego-Oliva Natural Park,

between 2002 and 2009. This is a rare species in the Iberian Peninsula and both its population and the number of breeding pairs fluctuates widely among years. This species is included in the Special Interest category (Annex II, Royal Decree 439/1990, 30 March, National Catalogue of Threatened Species) and is classified as Vulnerable in the Valencian Community (Decree 32/2004, 27 February, Valencian Catalogue of Threatened Species, Annex IV). The survival of this species in the wetlands depends on the variation of water level, since the nests are anchored on the aquatic vegetation. Thus, increases of the water level may destroy the nests whereas low levels may enhance predation by the Water Vole *Arvicola sapidus*. The main objective of this project was to study the breeding phenology and productivity of the species and to highlight how water fluctuations affect the reproductive biology of this bird. Our study includes 18 colonies from 5 areas, covering 663 nests, 1,618 eggs, 777 nestlings and 225 fledglings. The colonies were visited at least twice per week during the breeding period. The number of eggs and/or nestlings in each nest was annotated, and hatching and fledgling success and breeding success was estimated. We found that the reproductive success was significantly influenced by the interaction among the various categories of water level fluctuation and the different areas. We found that, in human-managed wetlands (that use sluices), it is crucial to keep their water levels as stable as possible during the breeding season, so that it should not vary more than ± 5 -6 cm in a short time (1-2 days) once the nests are established. Otherwise, reproductive failure will increase. Unfavorable climatic events, such as strong wind, rain or hail, also caused loss of nests, eggs and nestlings, even when the wetland water levels remained constant. Our study evidences that a thoughtful management

of the breeding areas would increase the number of breeding pairs and their reproductive success.

Academic year: 2015-2016.

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Applied studies for Dupont's Lark *Chersophilus duponti* conservation in Central Spain.

[Estudios aplicados a la conservación de la alondra ricroí Chersophilus duponti en España central.]

Abstract:

This thesis studied the ecology and conservation status of the Dupont's Lark *Chersophilus duponti* in Spain where the species is classified as "Vulnerable". The fieldwork was carried out in the Layna moorland (Soria) and the Rincón de Ademuz (Valencia). The analysis of the conservation status of the species concluded that its current situation is worrying in Spain and, in particular, in Valencia. In the latter locality, the species showed an annual decline rate of 10% during the period 2004-2011, whereas in the whole country (for which 33 populations were considered) the mean decline in five generations (12.5 years) was 70%. Thus, we propose to catalogue the species as "Endangered" (i.e. "En peligro de extinción") in the Catálogo Español de Especies Amenazadas. By comparing densities estimated by four counting methods, we concluded that the best one to monitor the species is the mapping method with a minimum number of four visits. The line transect method with 500 m inner belt width yielded similar densities and thus might be used for surveying large areas. Point counts and Finnish line transects should not be used to monitor the species, since both methods overestimate population sizes by about 35% after comparison with

the results obtained by the mapping method. We also studied habitat selection of the species at different spatial scales in Valencia. The results obtained are similar to the ones found for populations located in the Iberian core area, regardless the dominant vegetation. The lark selected flat areas, with low number of trees and high cover of small shrubs. This habitat type might be considered as priority management areas for the conservation of the species. Habitat management should be performed at different scales to increase its effectiveness. At the patch scale it should be a priority to maintain or enlarge the extent of habitat patches. At the macro-habitat scale our results advice a reduction of tree density in low-slope areas, while at the microhabitat scale, the presence of small and medium-sized shrubs should be promoted either by clearing certain scrubs (e.g. large brooms *Genista* spp. and rosemary *Rosmarinus officinalis*) or by means of traditional low-level extensive grazing. These measures would increase the availability of high-quality habitat for the species, and thus, the number of potential territories within a patch. We evaluated the short-term effects of a summer wildfire (in 2009) on the abundance and habitat use of the species in Layna. We detected a significant negative effect two years after the fire since it eliminated the scrub cover used by the lark, which led to local extinctions. Thus, fires should be avoided as a habitat management tool in areas occupied by the Dupont's Lark. However, controlled burning may be beneficial in neighbouring areas to create new open habitats that may be subsequently colonized by this species. Previous studies in other regions showed that habitat fragmentation affect the communication system of the species. In Ademuz we detected large differences in song type diversity and song sharing degree among populations. At an individual level song sharing degree between males was negatively related to distance, so

that individuals from nearby territories shared more song types than non-neighbouring birds, which originated microdialects in each population analyzed. Such differences in song might reduce the exchange rate of individuals among populations and cause smaller repertoire size in males. The breeding biology of the Dupont's Lark is poorly-known and our knowledge is restricted to studies carried out two decades ago. In this thesis we presented new data in this regard. Basic breeding parameters (clutch size, brood size, egg measurements, etc.) did not differ among populations (Layna and Valencia). Predation was the main cause of breeding failure in both areas (50%). Breeding success (50%) was relatively high and did not seem to lie behind the general decline detected for the species. We video-monitored Dupont's Lark nests and we detected an intraspecific aggression toward one incubating female, which finally caused nest abandonment. This is a non-previously described cause of breeding failure for the species and for the Alaudidae family that might be important in shrinking Dupont's Lark populations living in small habitat patches, where the species reaches high densities. Lastly, we reviewed the conservation measures proposed by scientists and those applied by managers by sending questionnaires to Regional Communities where the species breeds. The comparison shows that the measures most frequently proposed by researchers agreed only in part with actions implemented by managers. Due to the lack of studies evaluating the effectiveness of the measures proposed, conservation actions with greater scientific consensus might be considered as the baseline for future conservation plans for the species. Nonetheless, it is essential to evaluate their effectiveness to perform evidence-based conservation strategies and develop more effective actions in the future.

Academic year: 2015-2016.

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Global change and the uncertain future of biodiversity in Mediterranean-type ecosystems: insights from a strategic foresight process.

[Cambio global y el futuro incierto de la biodiversidad en ecosistemas de tipo Mediterr3neo: perspectivas de un proceso de visi3n estrat3gico.]

Abstract:

Global change poses emerging challenges for biodiversity conservation. The biodiversity in Mediterranean-type ecosystems is particularly vulnerable to the combined effects of climate change, land-use/cover change and their interactions with an increasingly severe fire disturbance regime. In Europe, Natura 2000 is a network of protected areas that constitutes the cornerstone of current conservation strategies. Natura 2000 comprises Special Areas of Conservation (SAC) designated by Member States under the Habitats Directive (92/43/EEC), and also incorporates Special Protection Areas (SPAs) designated under the Birds Directive (79/409/EEC) of the European Union. However, Natura 2000 is implemented in a static manner and the degree to which it will be able to meet its conservation objectives in a changing world is still largely unknown. In this thesis, we aimed to: (i) identify fire management policies alternatives to the current fire suppression paradigm of ‘stopping all fires’ and predicting their potential effectiveness at suppressing future large fires; (ii) evaluate the potential effects of such fire management policies and their interactions with climate change on a suite of 23 threatened bird species listed in the Annex I of the Bird Di-

rective, and potentially to be affected by the concomitant effects of climate change, land abandonment and fire dynamics; and (iii) predict the future effectiveness of the Natura 2000 network for bird conservation in Catalonia (NE Spain) under climate change and novel fire regime scenarios (2000-2050). To do so, we combined scenario planning with simulation exercises. We used a storyline-and-simulation approach where storylines describe potential fire management policies in a Mediterranean-type ecosystem, and simulations reinforce storylines with numerical estimates of future environmental changes. Climate change scenarios at European level were hierarchically integrated with simulations of vegetation dynamics at Catalanian level to evaluate the future combined effect of multiple driving forces on bird species. In particular, two promising fire management policy options alternatives to the basic fire-fighting principle of tackling “all fires” as soon as possible were identified to reduce the increasing impacts of large, high-intensity fires: (i) Fire management policies based on principles of ‘letting unplanned fires burn’ has the potential to substantially reshape future fire regimes and decrease the impact of large fires under undesired, extreme climate conditions. However, this strategy by itself is not able to offset the synergistic effect of decade-long trend of vegetation encroachment caused by land abandonment, and increasing climate severity. (ii) Forest biomass extraction for bioenergy uses has proved to be a cost-effective fuel-reduction strategy to help suppressing forest fires. Therefore, both fire management policies could be strategically combined in order to achieve the stand structure and fuel reduction goals required to minimize the increasing impact of large fires under global change. According to our simulations, the greatest number of species with a decreasing amount of optimal habitats in the future is predicted under the business-

as-usual scenarios characterized by a high-efficient fire suppression policy. This pattern results from a negative effect of vegetation encroachment on open-habitat species and a negative impact of climate change on cold-dwelling forest species. In particular, our results showed that the land abandonment in synergy with high-efficient fire suppression are extremely negative for open-habitat species such as Ortolan Bunting *Emberiza hortulana*. But this negative effect can be partially counterbalanced by fire management strategies, such as 'letting unplanned fire burns'. In contrast, cold-dwelling forest bird species such as Black Woodpecker *Dryocopus martius* were predicted to be almost insensitive to the fire management because the climate warming is expected to shift their distribution up- and northwards of Catalonia where the fire occurrence is very low. However, forest spread and expansion via land abandonment processes and high-efficient fire suppression were predicted to have a positive effect on these specialist species, partially offsetting the negative impact of wild fires. The effectiveness of Natura 2000 for the protection of the target bird species will likely increase over the next decades as the proportion of optimal habitats within Natura 2000 relative to the whole of Catalonia is predicted to increase. In a context of climate change and especially in lowland areas, this effectiveness maybe considerably improved through the implementation of novel fire management strategies that are not in line with those that have been typically implemented so far. Although the effectiveness of Natura 2000 is expected to increase in the future, the total amount of optimal habitats for birds will strongly decrease both inside and outside the network. This sheds light on the need of implementing proactive conservation strategies inside Natura 2000 so as to maintain and improve biodiversity conservation under changing environmental conditions. The

continuation of the current fire suppression paradigm of tackling of 'all fires' is not the most desirable scenario. Two main emerging conservation opportunities should be prioritized in order to effectively protect community-interest bird species in the near future: (i) promoting early-successional stages of vegetation for open-habitat dwelling species via 'letting unplanned fires burn' policies; and (ii) increasing the resilience of key forest habitats to climate change for forest-dwelling species. This thesis emphasizes the need for an integrative conservation perspective wherein agricultural, forest and fire suppression policies should be explicitly considered to effectively preserve key habitats for threatened birds in fire-prone, highly-dynamic systems. This visioning and simulation exercise also sheds light about the importance of considering landscape dynamics and the synergies between different driving forces when assessing the long-term effectiveness of fire management at reducing fire risk and safeguarding biodiversity in Mediterranean-type ecosystems.

Academic year: 2015-2016.

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Sublethal effects of the Aznalcóllar toxic spill on long-lived birds.

[Efectos subletales de la exposición al vertido tóxico de Aznalcóllar en aves de larga vida.]

Abstract:

Wildlife exposure to environmental contaminants is a worldwide problem derived from our industrial and technological society. Its effects on the health of individuals and populations have been a focus of research interest for several disciplines including eco-

toxicology and conservation biology. Most of the studies performed on this issue have been focused on the effects of short-term exposure to high levels of contaminants. However, wildlife is more often exposed to sublethal levels of pollutants i.e., levels that, being non-lethal, are able to impair organisms' physiology and functioning, affecting their health, and ultimately causing a potential impact on individuals' fitness. In 1998, the rupture of the tailings dam at the Aznalcóllar pyrite mine (Sevilla, southwestern Spain) released approximately six million cubic meters of acidic wastes into the Agrio-Guadimar river system, threatening an ecologically sensitive area, the Doñana National Park. Clean-up operations started immediately after the spill, and a few years later the affected area was apparently recovered. Nonetheless, short-term monitoring on humans and wildlife reported levels of metals and metalloids that, although often below threshold toxicity values, were higher in exposed than in reference populations. In this scenario, the main objective of this thesis was to evaluate the potential impact (i.e., sublethal effects) of the exposure to the Aznalcóllar mine spill on Doñana birds, both in the short- and in the long-term. To achieve this goal, we used a biomarker approach and specifically examined the relationships between blood levels of the most abundant metals (and metalloids) in the spill (i.e., Pb, As, Cd, Zn and Cu) and molecular, cellular, biochemical, and physiological aspects of vital importance to the organisms functioning such as the immune system (chapter 1), the DNA damage (chapter 2), the adrenocortical stress response (chapter 3), and bone development and metabolism (chapter 4). We used the White Stork *Ciconia ciconia* and the Black Kite *Milvus migrans* as sentinel species. In the case of the storks, the long-term monitoring carried out in the study area before and after the spill (with banded individuals of known age) allowed us to investigate, under natural

conditions, the long-term effects of the developmental spill exposure on reproduction. We found that: (i) the cellular immune response (PHA-skin test) was negatively related to blood Cu concentrations in stork nestlings; (ii) the associations between DNA damage (comet assay) and blood metal concentrations were not consistent between years or between species. The presence of other genotoxic agents or stress factors in the study area probably interfered with metals in this regard; (iii) the adrenocortical stress response (corticosterone levels induced after performing a standardized capture and restraint protocol) in stork nestlings was positively related to low Pb levels. The association was stronger in individuals which have been reported to suffer additional stress from other environmental factors; this result would support the argument that contaminants acting in concert with other stressors may have a greater impact on individuals and populations than would be elicited by either contaminants or other stressors acting alone; (iv) the morphological deformities detected on stork nestlings after the spill were related to a disrupted bone metabolism (levels of Ca, P; Ca:P, bone alkaline phosphatase), especially in younger birds; (v) female storks developmentally exposed to the spill experienced a premature breeding senescence compared with their non-developmentally exposed counterparts, doing so after departing from an unusually higher productivity in their early reproductive life. Following life-history theory, we propose that costly sub-lethal effects reported in stork nestlings after low-level exposure to the spill-derived contaminants might play an important role in shaping this pattern of reproduction, with a clear potential impact on population dynamics. In conclusion, the biomarker approach used in this thesis (short-term) is revealed as a useful tool to detect long-term effects of contaminants on bird biology (i.e., early alert). The results demonstrate that the

exposure to environmental contaminants during early development, even at low levels, may compromise individual fitness (reproduction) in the long-term, and clearly show that long-term studies are needed in order to perform a correct assessment of the real impact of environmental contaminants on wildlife. The Aznalcóllar mine spill is the most likely cause of the effects detected in storks and kites. However, it cannot be completely discarded that these effects may result from the combined exposure to the spill-related metals and those other contaminants associated with the industrial and agricultural activities carried out in the surroundings of the Doñana National Park.

Academic year: 2015-2016.

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Breeding ecology of Tawny Pipit *Anthus campestris* in the Iberian steppe.

[*Ecología de la reproducción del bisbita campestre Anthus campestris en los páramos ibéricos.*]

Abstract:

Despite the huge interest in evolutionary and ecological studies on the reproduction of steppe passerines in Mediterranean climates, there is still a surprising lack of information about many of these species. In this sense, the Tawny Pipit *Anthus campestris* is one of the Palaearctic passerines for which information concerning breeding ecology and life history traits is mostly lacking. The main purpose of this PhD thesis is to increase our knowledge on the breeding biology of the Mediterranean Tawny Pipit, in the hope that will be useful for conservation of the species, and to improve our knowledge of the reproductive ecology of birds in general and steppe species from Mediterranean latitudes in particular. This thesis involves ecological

studies during the reproductive period in two Spanish populations, including descriptive studies on reproductive parameters, the first endeavour exploring how natural enemies (predators and parasites) impacts on the species, and the first comprehensive study on genetic mating systems in this species and its effects on individual's fitness. Overall, our results suggest that breeding performance and reproductive output of Tawny Pipits in Spanish shrubsteppes are controlled by two main related factors: (i) the timing of breeding/seasonality of resources, which greatly affects the number of reproductive opportunities in a given breeding season and, therefore, the number of offspring per pair; and (ii) the predator/parasite pressure. The high nest losses attributed to predation detected in our populations impose a severe limit to population productivity, and parasites (avian malaria) were highly prevalent and notably affect body condition in adults and growth in nestlings. Finally, this thesis provides the first genetic evidence for the co-occurrence of different strategies (monogamy, polygyny, polyandry and polygynandry) in the same Tawny Pipit populations. The first noticeable result of our study is the considerable individual variation in mating decisions, both among and within individuals, which results in a predominantly promiscuous mating system at the population level in spite of the assumed socially monogamous character of the species. The existence of such a variety of mating types in the same population invokes large plasticity in copulation and/or mating decisions, possibly in relation to proximate ecological factors. We discuss to what extent some features of our Tawny Pipit populations, such as reduced parental care or high predation rates, may be involved in the decision-making of individuals about with whom to mate (parental care and predation rates).

Academic year: 2015-2016.

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Islands within islands: biology and conservation of the Macaronesian palaeoendemic *Navaea phoenicea* (Vent.) Webb & Berthel. *[Islas dentro de islas: biología y conservación del paleoendemismo macaronésico Navaea phoenicea (Vent.) Webb & Berthel.]*

Abstract:

This dissertation studies life history traits of a flagship species from the Canarian flora, *Navaea phoenicea* (Malvaceae), in an ecological and evolutionary insular context. The species presents a series of features of great scientific interest: its paleoendemic taxa, constrained to the oldest mountain massifs in Tenerife, known as palaeoislands, Teno and Anaga, which are separated by a large central area subject to many geological events. On the other hand, it is a hexaploid, big sized shrub, characteristic of the insular woodiness phenomenon. Finally, it is included under the “Macaronesian Bird flower element”, the ensemble of Macaronesian endemic plants which have convergent developed sets of floral traits adapted to bird pollination. Its origin is on the way to be disentangled. It is also a threatened taxon which has been included under several risk categories. In this work, we have applied several techniques to study phylogeography, the evolution of the reproductive system of this plant species and its adaptation to bird pollination, its demographic trends and risk factors. The combination of high resolution ecological niche modelling, unedited for Tenerife, (chapter 1) along with dominant molecular markers (AFLP, chapter 2) has allowed analysing the proposed disjunction scenarios. The ecological niche is dependent from climate parameters related to topography and confirms the affinities for steep

habitats. Disjunction therefore appears to be linked to geological history rather than to a human driven fragmentation. Molecular markers, in turn, revealed high rates of gene flow, both within and between populations, mediated by generalist passerines as pollinators. These passerines are the Canarian Chiffchaff *Phylloscopus canariensis*, several warblers species (*Sylvia atricapilla* and *S. melanocephala*) and the Canarian Blue Tit *Cyanistes teneriffae*. Under this proposed phylogeographic scenario, gene flow between Teno and Anaga could have been mediated by putative intermediate populations currently extinct which could have enhanced gene flow despite existing barriers. High gene flow mediated by passerine pollinators could explain as well the unexpectedly high genetic diversity found for such impoverished populations. The three following chapters are dedicated to the evolution of ornithophily in *Navaea phoenicea*, as part of the ornithophilous plant species assemblage. The Macaronesian Bird-flower element consists on independent endemic plant lineages which show convergent floral characters adapted to pollination by birds. This has led to research line in the Macaronesia to interpret the existence of the ornithophilous syndrome, as there are no specialist nectarivorous birds or fossils providing evidence of such specific mutualism. In chapter 3, we reveal that the plant species, despite being self-compatible, does not show a functional mechanism to ensure delayed self-pollination, contrary to other mallow species. We interpreted this as an adaptation to increase genetic diversity in the insular context. In chapter 4 we measured the qualitative and quantitative components of pollination efficiency of each flower visitor, including both insects and birds. We reveal that insects, surprisingly, are frequent visitors but merely as nectar robbers. Birds acted very different. *Cyanistes teneriffae* acted as antagonists on

flowers, while the behaviour of *Sylvia* spp. and *P. canariensis* conditioned their efficiency as pollinators. The higher efficiency of warblers appears to be related to the behaviour of African sunbirds (Nectariniidae) which perch on the flowers from the branches. This suggests, together with the phylogeny of mallow species, that ornithophily is an ancestral character originated in the African continent, and maintained by current passerine visitors. These generalist species, in turn, would incorporate nectar in the diet as a response to density compensation occurring in oceanic islands. In chapter 5 we explore fundamental traits of attraction and reward of flowers, showing that UV reflectance is present in the flowers allowing an easy detection by insects. Nectar production shows a strategy to increase perching visits by birds, and increase the fitness of the very short male function. Large amounts of diluted nectar rich in simple sugars are typical in passerine pollination as they appear to be unable to digest complex sugars. However, this hypothesis lacks enough evidence. The amount of nectar secreted by the flowers is such that nectar robbing by insects does not affect reproductive success. Therefore, there would be no selective pressure to exclude insects from the flowers. However, Scanning Electron Microscope images shows a shift in the epidermal cell types of the surface of the flower, consistently with other ornithophilous species, which hinders nectar robbing by insects. In chapter 6 we analyse 10 years of demographic surveys where we classified individuals in 4 ontogenic stages combined with dendrochronological work. Demographic projections that account for climate constraints and stochasticity show that the reduction on rainfall is key for the finite growth rate of the population along with seedling predation. Besides ex situ conservation measures, habitat and mutualism conservation together with local assisted migration need to be accounted.

Academic year: 2015-2016.

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The role of biotic interactions in the ecology and conservation of the Little Bustard *Tetrax tetrax*: from niche relationships to behavioral responses.

[*El papel de las interacciones bióticas en la ecología y conservación del sisón común Tetrax tetrax: desde las relaciones de nicho a las respuestas comportamentales.*]

Abstract:

Biodiversity loss is one of the most crucial problems of our society. Many species have become extinct and many others are seriously threatened because of the worldwide impacts caused by humans, which reach almost any ecosystem in the world. In order to design effective conservation policies that protect wildlife, we must understand which factors determine species distribution and the environmental conditions warranting the viability of populations. There are multiple factors governing the distribution of species and they presumably operate in a hierarchical way. Climate has been recognized as the major force determining the distribution of species at global or continental scales while land use influences the distribution at regional scale. Biotic interactions and dispersion become main drivers at local scales. However, it has been questioned whether the effects of biotic interactions are only relevant at local scale and many ecologists urge to gain a better comprehension on their role on population and community dynamics in order to incorporate this knowledge on conservation strategies, a fact that seldom occurs. This thesis is focused on an endangered steppe bird, the Little Bustard *Tetrax tetrax*, that inhabits open landscapes, mainly natural steppes and agricultural croplands. This species has undergone dramatic population declines over the last 60 years mainly due to processes of agricultural intensifica-

tion that cause landscape change and habitat loss. Because the outcome of biotic interactions may change due to habitat modification, this thesis tries to improve the poorly explored issue of the role of biotic interactions in Little Bustard's ecology and its potential effects on population dynamics. The first three chapters address the potential competition with a close related species, the great bustard, and provide some guides for their conservation. The first work explores the potential effects of intra- and interspecific competition on the little bustard realized habitat niche. By using data from allopatric and sympatric sites with different densities of both species and a novel methodology to build multidimensional niches, we evaluate shifts on niche breadth, position, and overlap. We found a positive relationship between the degree of niche overlap and great bustard density as well as variations in niche breadth and position that may be the result of competitive interactions with the great bustard. In addition, intraspecific competition increases the use of a secondary habitat like cereals in a density-dependent manner. The existence of interspecific competition is supported by a second study that analyzes the density-dependent habitat selection of both species by multispecies isodars. Furthermore, results reveal that interspecific competition is asymmetric. The Great Bustard acts as the dominant competitor that gradually displaces Little Bustards from cereals towards its preferred habitats (fallow, natural vegetation of low height and legume crops) when its density increases in cereals. These findings have relevant implications for the conservation of the species. The viability of Little Bustard populations could be compromised in those regions with low availability of good quality habitats and high density of great bustards. A third study modeling the spatial distribution of little and Great Bustards at landscape level using MaxEnt shows that conservation schemes promoting higher proportions of

legume crops and fallow fields would have positive effects for both species. In addition, conservation strategies should include the effects of biotic interactions and implement landscape measurements that facilitate the segregation of each species into their preferred habitats. However, not only competition has a prominent role in population regulation. Positive interactions may also play a critical role. Therefore, we also investigate whether conspecific attraction to male displaying areas affects the distribution of females with offspring. Little Bustard families tend to move closer to areas previously occupied by displaying males than expected by chance. The previous male distribution may be a cue of good quality sites and resource abundance. Females with offspring use preferentially habitats of semi-permanent vegetation that may fulfill food and shelter requirements. Consequently, conspecific attraction is an important force driving the distribution of Little Bustard females during the rearing period. This study also reveals the low productivity values of the studied populations and alerts about the worrying future for this species if this trend is not reverted. Finally, this thesis investigates the effects of human activities on wintering Little Bustards' behavior and physiological stress by measuring levels of glucocorticoid metabolites in feces. During weekends, when human activities are mainly hunting, Little Bustards devote more time to anti-predator behaviors like increased vigilance and flight movements, and also increase the use of stubbles that offer concealment. After weekend, little bustards adopt a behavioral strategy clearly directed towards energetic recovery. Levels of fecal glucocorticoid metabolites also peak during weekends and are associated to hunting activities, showing that hunting triggers a physiological stress response on wintering little bustard. The findings presented in this thesis demonstrate the important effects of biotic interactions in

the ecology of the Little Bustard that should be considered to aid in the conservation of this declining species.

Academic year: 2015-2016.

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Wildlife in a human-dominated world: impacts of anthropogenic landscape changes on birds and mammals in Spain.

[*La vida animal en un planeta humanizado: efectos sobre aves y mamíferos de los cambios en el paisaje producidos por el hombre en España.*]

Abstract:

As a result of the age-old co-evolution between farming systems and natural habitats in the Mediterranean basin, the agricultural landscapes harbour an extraordinary amount of biodiversity. However, farmland is today the habitat in Europe with the highest proportion of bird species with unfavorable conservation status. Agricultural intensification is considered responsible for the negative trends of biodiversity in farmlands. But we live on a human-dominated planet, and during the last decades other drivers of landscape change have also been operating and extending across the Mediterranean basin at an unprecedented rate. The aim of this PhD thesis is to analyze the influence of intensive land-uses –namely infrastructural development, urban sprawl, and agricultural intensification– on Mediterranean landscapes and wildlife populations, with a special focus on farmland birds. The studies comprising this dissertation illustrate the process that led me to address this challenge. I started my PhD working on the effects of road building on a population of an emblematic bird of agricultural landscapes, the Great Bustard *Otis tarda*, in central Spain (chapter 1). I analyzed changes in its spatial distribution and

population trends before, during, and after the construction of a road in areas close to the road and far away. I found solid evidence for effects of the road construction on the Great Bustard population, including avoidance behaviour and declining population trends. Based on this work it was imperative to further study the relevance of the negative effects of this and other type of infrastructure on wildlife populations in agricultural landscapes. Despite the ubiquity of human infrastructure, few attempts have been made to spatially quantify their impact at large scales. In Chapter 2, I show an analysis of the pervasiveness of European transportation infrastructure. Highlighting the Spanish case, I present a novel method for assessing the spatial extent of the impacts from infrastructure on wildlife populations at large scales, based on taxa-specific functional distance-decay response curves. I revealed both the pervasiveness of human infrastructure and its potential to negatively influence wildlife populations, particularly of wide-ranging mammals. In addition, farmlands turned out to be the habitat most exposed to both transportation infrastructure and built-up areas, and therefore where the strongest effects of infrastructure are predicted. One of the most widely recognized effects of human infrastructure is landscape fragmentation. Landscape fragmentation patterns are commonly assumed to be strongly correlated to other drivers of environmental change like urban sprawl, representing a growing threat to biodiversity. In chapter 3, I tested the hypothesis that sprawl and fragmentation patterns strongly match, based on spatially explicit quantifications of urban sprawl and landscape fragmentation gradients in Spain. I conclude that the sprawl-fragmentation relationship does not prevail, is non-stationary, and depends on scale. Thus, the assessment of the impact of intensive land-uses should report on both with separate indicators. In light of these insights, I

developed a landscape experiment in the Iberian Peninsula, in which I quantified the changes in agricultural intensification, landscape fragmentation and urban sprawl in the last sixty years, controlling by the effect of climate change and the cultivated area (chapter 4). These changes can cause immediate loss of species but also time-delayed extinctions. In this study, I found strong evidence for time-lagged responses in the farmland bird community. Present-day richness of species is better explained by past predictors of the landscape and the climate. A time-lag in the habitat breadth of the bird community is less clear. The major predictors for present-day richness of species were the degree of urban dispersion and the mean temperature in the past, which affected negatively the richness. However, habitat breadth of the bird community was better explained by agricultural intensification and landscape fragmentation. Conservation decisions in agricultural landscapes based on the analysis of how species respond to present-day landscapes and only focused on agricultural intensification are likely insufficient to prevent the species loss in the future.

Academic year: 2015-2016.

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Bird population dynamics in the wintering season: the case of the Mediterranean Gull *Larus melanocephalus*.

[Dinámicas poblacionales en aves durante la invernada: el caso de la gaviota cabecinegra Larus melanocephalus.]

Abstract:

The winter period is typically associated with harsh weather conditions and reduced

food availability, which may lead to increased mortality. In birds, a common strategy to avoid such risks is to migrate to more favourable grounds, but its demographic costs are largely unknown. The wintering season remains a black box in our knowledge of the life cycle of birds. From the perspective of a wintering area, I study the population ecology of a migratory species, based on the hypothesis that winter aggregations of birds constitute true populations, instead of random aggregations of individuals. I look at the population composition, structure and dynamics across several spatial scales, and the link between the wintering and breeding areas through connecting migratory routes. My study model is a population of wintering Mediterranean Gulls *Larus melanocephalus* made of birds from multiple origins, a significant proportion of which have been individually marked with individually-coded colour rings in their natal or breeding colonies. The study system constitutes the species' main winter quarters globally and is situated on the Mediterranean coast of E-NE Spain. Capture-recapture analyses reveal high estimates of apparent local interannual survival after the first year (0.81 on average), indicating a high individual winter site-fidelity that does not vary with age. This attachment to the wintering area models the distribution of individuals, shaping them into a spatially structured population with metapopulation dynamics, as each subpopulation has independent demography, determined by area-specific survival and low levels of dispersal. Using a probability model, I infer the migratory route followed by first-winter birds; the most likely path is a combination of fluvial and coastal routes, seeking minimal distance along favourable terrain. In the focus species, wintering populations are made of individuals from different sex and age classes, in one of the few documented cases of non-differential migration. Exceptionally, the species also exhibits

synheimy (the population in each distinct wintering area is made of birds from all the breeding populations), possibly as a result of its recent history. Individual choice of wintering area is made in the first migration according to a probability rule determined by distance, and is maintained through life. On a local scale, I find a very high turnover of individuals and a frequent movement, in no particular direction, among sites. The low monthly probability of local residency (0.56) contrasts with the species' strong site-fidelity to the general wintering area. Individual turnover shows that a single site may be visited by a large proportion of the regional (43%) and global (18%) populations every season. Thus, the population home range extends over an area much larger than a single locality or a protected area, showing evidence of a mismatch between the distribution of protected areas and the spatial needs of the population. Compared with data from 60 years ago, Mediterranean gulls have undergone a huge expansion of their breeding distribution range (750% area increase) while the wintering distribution has increased only moderately (25%). The global population size has remained stable, indicating that its growth may be limited by events taking place in the wintering season. As the breeding distribution continues to expand, where breeding and wintering populations come in contact, they interact little and follow independent dynamics. This work contributes to a better understanding of bird population dynamics in the wintering season and shows how the detailed study of a species' ecology during one part of the annual cycle can help comprehend what happens during the rest of the year. The 'view from the winter quarters' can bring important and complementary information to the study of birds during the breeding period.

Academic year: 2015-2016.

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Decline of the Lesser Grey Shrike *Lanius minor* at the western limit of the distribution area: causes, mechanisms and conservation proposals.

[*Declive del alcaudón chico Lanius minor en el límite occidental del área de distribución: causas, mecanismos y propuestas de conservación.*]

Abstract:

To correctly preserve and manage threatened species or populations, it is crucial to understand the causes and mechanisms that have led to their unfavourable conservation status. This thesis aims (i) to describe the decline in the last 10-20 years of the Lesser Grey Shrike *Lanius minor* populations in Western Europe and to verify possible consequences at the genetic level, (ii) to identify the main causes of regression and the most relevant demographic mechanisms for population dynamics, and (iii) to propose conservation and management measures. In parallel to a negative population trend of the five extant western populations (two in France and three in Spain), the distribution area has decreased to less than 50% since 1990, leading to the extinction of two of those populations until 2010. As a result of this decline, the Spanish population shows less genetic diversity than the rest of European and Asian studied populations. Genetic analyses identify three evolutionary units (ESU) within the whole distribution area: one European and two Asian, suggesting a re-evaluation of the two subspecies considered by some authors. Some western populations show a spatial synchrony of the breeding population size across years, indicating the existence of a common regulation factor that may be related to climate (temperature increase) and/or environmental (degree of plant development) factors at the breeding

and wintering area, according to a correlational analysis. It is also confirmed the importance of natural habitats in farmland areas for conservation purposes, because they offer more availability of insects, they are positively selected for hunting within the breeding territories and they enhance the reproductive output (fledgling success) of shrikes breeding early in the season. Furthermore, fledgling success of the Spanish population is the only breeding parameter that differs from a stable and healthy population in Central Europe, being lower in the former, so it could be one of the demographic mechanisms to explain the decline of this shrike in Western Europe. However, a population viability analysis indicates that the return rate (survival and philopatry) is the most relevant parameter (much more than breeding rates) driving population dynamics. Finally, assuming that there is currently no immigration from other source populations, vital rates should improve to very high levels to prevent the extinction of the Spanish population. Therefore, a conservation strategy based only on improving reproductive performance through local habitat management in the breeding territories (i.e. increasing the area occupied by natural habitats) would not be sufficient, and habitat management on a larger spatial scale would be needed, creating corridors and facilitating dispersal between populations.

Academic year: 2015-2016.

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Effects of agricultural management on small bird communities (Passeriformes) in Mediterranean olive groves.

[*Efectos del manejo agrícola sobre las aves passeriformes en el olivar mediterráneo.*]

Abstract:

Olive farming is one of the predominant land-uses in the Mediterranean basin where 5 million has. are dedicated to this crop (half of which are in Spain), with significant social, environmental and economic implications. Over the last decades agricultural intensification has led to a homogenization and simplification of farmland landscapes across Europe with negative environmental consequences. Water pollution, biodiversity loss and, especially, soil erosion, have been reported as major concerns in the Mediterranean Region following agricultural intensification. To prevent soil erosion and following recent agricultural policies, many farmers have started implementing herbaceous ground cover within the crops and maintaining small residual habitats like hedgerows. Both agri-environment measures (AEMs) can render benefits in terms of biodiversity in agroecosystems because they increase structural complexity of the habitats and provide resources for foraging and breeding birds. However, a patchy configuration of good quality habitat, i.e. olive groves with herbaceous ground cover, may have unexpected consequences if they act as an ecological trap. This thesis focuses on the assessment of the effectiveness of AEMs in woody crops of the Mediterranean area, for which little information exists. Most studies have been conducted in temperate areas of Europe, and their management implications might not be transferrable to Mediterranean perennial crops. Using songbird communities as an indicator, I analyze for the first time the effect of different AEMs when applied in combination to perennial woody crops. The effectiveness of such measures is assessed using several criteria. In addition to traditional approaches comparing diversity indices of foraging birds (i.e. species richness and abundance) in areas with and without AEMs, we also take into account their breeding success to evaluate the potential role of

AEMs in agricultural fields as ecological traps. My results showed that herbaceous ground covers and hedges consistently promote songbird diversity in Mediterranean olive groves. Hedges and ground covers, when applied in combination, have additive effects on the diversity of songbird communities. However, hedges seem to have a stronger effect in promoting bird diversity in olive agro-ecosystems. I found no evidence that olive groves with ground cover are acting as ecological traps, since songbirds did not preferentially breed in olive groves with herbaceous cover. Also, for those birds breeding in areas with ground cover there was no hindrance in breeding success, so these patches of good quality habitat are not acting as a sink. This thesis demonstrates that effective solutions to promote biodiversity in conventional olive groves are available and sometimes already implemented. In most cases, relatively small changes in farming practices may be sufficient to attain biodiversity goals. For instance, the maintenance of hedges and herbaceous cover on the soil could be easily promoted. These practices have been suggested to be the most cost-efficient measures in Mediterranean agro-ecosystems. Given their environmental benefits and their agronomic values, the implementation of these AEMs could be recommended to ensure the sustainability of Mediterranean agro-ecosystems.

Academic year: 2015-2016.

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Multi-focus approach to life-histories in passerines. Studies on sperm competition, moult, parasitism and feather coloration.

[Aproximación múltiple a las estrategias vitales en passeriformes. Estudios en competencia espermática, muda, parasitismo y coloración de plumas.]

Abstract:

Life-histories are traits associated with variation in individual fertility and survival. This thesis aims a greater understanding of these strategies in passerines using an approach from different areas. The main objectives were: (i) to develop a fast, accurate and inexpensive methodology for sexing Barn Swallows *Hirundo rustica*, (ii) to explore the role of a type of melanin-based coloration in Barn Swallows, (iii) to disclose the effect of infection by hemoparasites in molting speed and fitness in the House Martin *Delichon urbicum*, (iv) a morphometric study of spermatozooids variations in different populations of Barn Swallow, and (v) to study the effect of radioactivity on the structural integrity of sperm in passerines from Chernobyl. We found: (i) two very specific discriminant functions based on three simple characters commonly measured in all studies with Barn Swallows; (ii) that the studied coloration in barn swallows was related to survival and fitness in females but not in males; (iii) that House Martins with stronger infections showed slower molting speed and less fitness than those not infected; (iv) the morphometric variations of sperm were small among European and eastern Mediterranean populations, and it was higher among these populations and the North America population, and morphometric variation levels were associated with levels of extra-pair paternity; (v) all studied species showed higher frequency of abnormalities that control populations and those with longer spermatozooids had lower structural integrity of sperm.

Academic year: 2015-2016.

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Host-parasite interaction and immune response in Antarctic penguins.

[*Interacción parásito-hospedador y respuesta inmune en pingüinos antárticos.*]

Abstract:

Parasitism and disease in Antarctic birds, including penguins, are lower than in the rest of birds, but they are not beyond their effects. The information about it is scarce and incomplete, reflecting a heterogeneous research effort in different species and areas. The aim of this doctoral thesis is to give information about the effects of some penguin parasites in their hosts and to increase the knowledge about their immune function. First, we made a review gathering current knowledge of Antarctic bird parasites, to which we contributed describing the apparent absence of some protozoan parasites (*Cryptosporidium* sp., *Giardia* sp., *Toxoplasma gondii*) on pygoscelid penguins from different locations along the Antarctic Peninsula and South Shetland Islands. We also studied the effects of gastrointestinal parasites, through a deworming experiment in Chinstrap Penguin *Pygoscelis antarctica* nestlings by means of the administration of antihelminthic drugs. We found a clear negative effect of helminth parasites on nestling body weight that would presumably affect fitness and future survival. In order to test the effect of those helminths in coloured traits, we repeated the same experiment in Gentoo Penguin *Pygoscelis papua* which has a carotenoid dependent red spot in both sides of the beak. Results showed higher body weight in the experimental siblings, but no difference in plasma carotenoid concentration or in beak colouration, probably due to

the high amount of carotenoid available in krill, which constitutes their only food source until independence. In addition, we studied different aspects of the immune response in two highly costly life stages such as the reproduction and moult. The immune response could be optimized and traded off against such costly functions. Moreover, it is also known that stressful conditions may lead to suppression of immune functions. As reproduction and moulting do not overlap in penguins, they offered a good opportunity to explore the relationships between immunity and both events. We took one measure of stress (heterophil/lymphocyte ratio) and three different measures of immunity (white blood cell counts, immunoglobulin levels and response to phytohaemagglutinin assay) in both breeding and moulting penguins. Our results showed that breeding is more stressful than moulting in the chinstrap penguin. Immunological differences in the two physiological activities showed a complex picture as cellular and humoral immunity changed in opposite directions, indicating the existence of cellular immunity trade-offs between immunity and breeding. However, although moulting was less stressful than breeding, a reduction in humoral immunity was found during moulting, probably due to hormonal interactions. Other particular aspect of the Antarctic penguin life is that they are among the homeotherms that perform under low ambient temperatures. Thermoregulation constitutes a resource demanding physiological activity that could compete for limited resources with other activities, such as immune response. We studied the relationships between thermoregulation and immunity in the Chinstrap Penguin. We measured the effort of thermoregulation as the individual ability to maintain body temperature independent of ambient temperature, and referred to it as endothermic efficiency. We related this variable to immunocompetence to know

to what extent the effort of thermoregulation compromises other energy demanding activities. Adults and chicks showed a positive relationship between both traits. Therefore, no physiological trade-offs due to thermoregulation are revealed in the Chinstrap Penguin. Instead, the positive relationship found suggests that endothermic efficiency behaves as an indicator of individual quality.

Academic year: 2015-2016.

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Bacterial diversity in the uropygial gland of Hoopoes *Upupa epops*: Seasonal dynamics and associated benefits.

[*Diversidad bacteriana en la glándula uropi-gial de la abubilla Upupa epops: Dinámica estacional y beneficios asociados.*]

Abstract:

Birds periodically spread the secretion of their uropygial (or preen) gland onto their skin and plumage in a process known as preening or grooming. Different properties have been attributed to this secretion, such as protection and waterproofing of feathers, or maintenance of hygiene against pathogens and parasites. In the case of Hoopoes *Upupa epops*, both the volume and the chemical composition of the secretion vary seasonally and between sexes, with breeding females and nestlings producing abundant, darker and more odorous secretions, while males and non-nesting females produce whitish and odourless secretions in smaller amounts. In the first case, those characteristics have been also correlated with the presence of culturable bacteria able to produce antimicrobial compounds in the gland, suggesting a defensive function of this symbiosis at least in the context of reproduction. Within this PhD thesis, the whole bacterial community

of the secretion of the hoopoe's uropygial gland has been described using culture independent methods such as community genetic fingerprints, fluorescence *in situ* hybridization (FISH), quantitative PCR (qPCR) or high throughput sequencing (pyrosequencing and sequencing by synthesis, using the Roche 454 and the Illumina MiSeq technologies respectively). This approach, combining different methodologies, offered us a better insight into the bacterial communities studied. The molecular methods used also allowed the study of the population dynamics of the bacterial communities regarding different environmental factors and along the reproductive cycle of the bird. In addition, the beneficial effects that the presence of this community of commensal and/or mutualistic bacteria could represent for the animal were experimentally tested through the evaluation of both the vertical transmission of bacteria from the female gland to the eggs, and its possible implications in hatching success. The genetic profile of the microbiome present in the uropygial secretion, obtained using fingerprints of the intergenic region between the 16S and 23S rDNA, revealed a highly homogeneous community among individuals. When the uropygial microbiome was studied by means of high throughput sequencing of part of the 16S rDNA, it was found to be clearly dominated by strict anaerobes included within the clostridia group (phylum Firmicutes, class Clostridia), although some representatives of the phyla Proteobacteria, Actinobacteria and Bacteroidetes were also present. Some of the strains frequently detected in the uropygial secretion included typical gastrointestinal bacteria, and their presence suggests the possibility of at least partial colonization of the gland from the gastrointestinal tract of the animal. This hypothesis could also explain the changes found in the composition of the uropygial microbiome of hoopoes due to

breeding in captivity, likely by means of differences in diet. However, other possible explanations for these changes (as the migratory behaviour of the studied populations) are not discarded. High throughput sequencing detected the same bacterial groups in both white secretions from males during the breeding season and dark secretions from nesting females and nestlings, although qPCR and FISH revealed that the microbial loads were much higher in dark than in white secretions regardless the season. That suggests the existence of a reservoir of symbiotic bacteria within the gland itself in all the individuals throughout the whole year. However, further studies will be necessary to fully understand the origin of the bacterial strains in the uropygial gland of hoopoes, as some environmental source of variation was detected (related to the year of sampling, but not to other environmental, meteorological or geographical factors tested). Apart from this, the only factor found to affect the composition of the microbiome of hoopoes uropygial secretion was the phase of the reproductive cycle. Particularly, the most important changes along the female reproductive cycle coincided with the shift between a whitish secretion in the non-breeding period dominated by the classes Gamma and Betaproteobacteria (phylum Proteobacteria), with some Flavobacteriia (phylum Bacteroidetes), Bacilli and Clostridia (phylum Firmicutes), and a community clearly dominated by the class Clostridia in dark secretions during the nesting period. This cyclic dynamics of the gland microbiome suggests the existence of selective pressures that favour a functional change of the system during the stay of the female within the nest. In fact, we experimentally demonstrated that the microbiota of the uropygial secretion of hoopoes contributes to the composition of the bacterial community established on the eggshells

surface. Over a particular threshold, the presence of uropygial bacteria on the eggshell was related to a decrease in its colonization by potentially pathogenic bacteria from an experimental contamination source. Moreover, some OTUs of the eggshell were found to affect the hatching success of the clutches, revealing the importance of the microbiome established on the eggs for the bird fitness. In conclusion, the results of this PhD thesis both increased the knowledge on the composition and dynamics of the uropygial microbiome in hoopoes, allowing new advances in the understanding of the functioning and evolution of this system in the future, and showed the correlation between the eggshell and the gland microbiomes, suggesting that the nest is the main context in which the selective pressures maintain this symbiotic interaction.

Academic year: 2015-2016.

Universidad de La Laguna

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Opportunistic pollination by birds and lizards in the Canary Islands.

[Polinización por aves y lagartos de dieta oportunista en las islas Canarias.]

Abstract:

In plant-animal mutualisms, plant reproductive success depends on the animal's effectiveness and the context in which the mutualism occurs. This thesis is about the interplay between these two aspects in pollination. We try to meet the challenge in a particular context, oceanic islands. The ecological conditions of oceanic islands favour the appearance of depauperate and disharmonic assemblages of opportunistic pollina-

tors, whose effectiveness and level of context dependence may differ significantly from those of continental systems. In the case of the Canary Islands, passerine birds and lacertid lizards are frequent floral visitors of native flora, but their pollination ecology has remained almost unknown. For this reason, this thesis poses the following questions: (i) Are these opportunistic vertebrates effective pollinators of the Canarian flora? To answer it, we chose two of the most representative bird-flower elements from the archipelago, the endemic plant species mainly distributed in the laurel forest of Tenerife: *Isoplexis canariensis* (Plantaginaceae) and *Canarina canariensis* (Campanulaceae). We studied the breeding system of both species using experimental hand pollinations. The identity of floral visitors and visitation frequency were estimated by focal censuses, and their effectiveness as pollinators by selective enclosures. We found that both species are self-compatible, but floral visitation by vertebrates (especially by birds) enhances the production of fruits and viable seeds. The vertebrates implied were five species of passerines (Canary Islands Chiffchaff *Phylloscopus canariensis*, Sardinian Warbler *Sylvia melanocephala*, African Blue Tit *Cyanistes teneriffae*, Atlantic Canary *Serinus canaria*, Common Chaffinch *Fringilla coelebs*), and the endemic Canarian Lacertid *Gallotia galloti*. Our results demonstrate that studied plant species crucially depend on these opportunistic vertebrates for sexual reproduction, being the first time that vertebrate pollination has been empirically demonstrated in the Canarian Archipelago. (ii) Do members of opportunistic vertebrate assemblages differ in their effectiveness as pollinators? For this question, we dissected pollination effectiveness for birds (i.e. *Phylloscopus canariensis*) and lizards (i.e. *Gallotia galloti*) on *Isoplexis canariensis* into its quantitative and qualitative components. Quantity was defined as the product of visitation rate per 30 min per plant and the

number of flowers probed per plant visit. Quality was estimated as the proportion of pollen grains removed per anther (male fitness), added to the product of fruit set and the proportion of viable seeds produced per fruit (female fitness) resulting from a single floral visit. We found that birds were significantly more effective than lizards mainly due to the higher frequency of floral visitation by birds. Unexpectedly, adult lizards were as qualitatively effective as birds because they were highly efficient in pollen removal, and their visits led to similar proportions of fruits and viable seeds than those by birds. The significant differences in effectiveness between birds and lizards resulted in a pollinator assemblage showing low functional equivalence, a potential signal of its fragility against disturbances. (iii) How variable are the effects of multispecific assemblages across space and, how do they contribute to the spatial structure of plant fitness within the plant population? In this case, we evaluated how the reproductive benefits provided by pollinators vary spatially under the presence of invertebrate antagonists (floral herbivores, nectar larcenists and seed predators). For this, we characterize the spatial structure of mutualistic and antagonistic interaction strengths using spatially explicit models. We estimated interaction strength as the frequency with which the specific guild interacted with individual plants, multiplied by its intensity. For pollinators, the intensity was defined as the proportion of flowers probed per plant visit, while for antagonists as the proportion of damaged reproductive organs. We found that mutualists and antagonists had significant, but contrasting, impacts on female fitness, resulting in the spatial segregation of both interaction types. This segregation led to the spatial structure of plant fitness into reproductive coldspots (low fitness) and hotspots (high fitness). (iv) How does spatial variation in plant fitness emerge from the overrepresentation of certain animal inter-

acting assemblages across individual plants? We tested whether this spatial segregation previously found emerged from a random distribution of mutualistic and antagonistic interactions within the plant population. With the help of complex network theory, we characterized the interacting animal assemblage of each plant, and classified all individuals along an interaction gradient that ranged from plants with fully mutualistic assemblages to plants that interacted exclusively with antagonists. We found that plant-animal interactions were not randomly distributed and detected two over-represented assemblages, which included plants interacting strongly with mutualists and weakly with antagonists, or *vice versa*. As expected, female fitness decreased from plants with fully mutualistic assemblages to those that interacted exclusively with antagonists. However, damaged plants, as long as they interacted strongly with mutualists, were even more integrated in the local mating network than plants interacting exclusively with mutualists. Therefore, antagonists may have a more prominent role in the spatial movement of genes via pollen than previously recognized. Taken together, our results demonstrate that opportunistic nectar-feeding vertebrates are effective pollinators of Canarian flora despite their generalized diet. Considering life-history traits of bird and lizard pollinators was key to understand their consequences on plant fitness. However, this understanding will be more accurate when considering the influence of the antagonistic context. The evidence obtained in this thesis strengthens the idea that integrating the diversity of animal partners, not just one type, and quantifying the strength of their interactions will provide us with a much more robust prediction of the reproductive outcomes of these opportunistic systems.

Academic year: 2015-2016.

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Spatial and temporal patterns of soaring birds migration through the Strait of Gibraltar.

[Patrones espacio-temporales de la migración de aves planeadoras en el estrecho de Gibraltar.]

Abstract:

The Strait of Gibraltar is one of the most important places for migratory birds in the world. Since the 1970s several census campaigns have been developed and since 1999 there has been an annual monitoring program operating with constant effort and standardized protocols (Migres program). Based on daily censuses data from 2009 to 2012 and applying temporal and spatial data corrections we have estimated between 425,000 and 500,000 soaring birds of around thirty species flying across the Strait of Gibraltar at each migratory event. The most abundant in transit species are storks and birds of prey following trans-Saharan migration routes. Around 135,000-150,000 storks (two species), and 290,000-350,000 birds of prey (28 species) can be seen in regular migrations across the Strait of Gibraltar. The most abundant species were: Black Kite *Milvus migrans* (> 160,000 birds), White Stork *Ciconia ciconia* (> 130,000), Honey Buzzard *Pernis apivorus* (> 59,000), Booted Eagle *Hieraeetus pennatus* (> 21,000), Short-toed Eagle *Circus gallicus* (> 19,000), Griffon Vulture *Gyps fulvus* (> 8,000), Black Stork *Ciconia nigra* (> 3,000), Sparrowhawk *Accipiter nisus* (> 3,000), Egyptian Vulture *Neophron percnopterus* (> 1,300), Montagu's Harrier *Circus pygargus* (> 1,300), Marsh Harrier *Circus aeruginosus* (> 700) and Lesser Kestrel *Falco naumanni* (> 300). The data collected allows us to confirm the great

importance of the Strait of Gibraltar within the context of soaring bird migration, as it concentrates almost all the migrant individuals of White and Black Storks, Black Kites, Honey Buzzards, Egyptian Vultures, Booted Eagles, and Short-toed Eagles breeding in Western Europe. It also accounts for a variable number of harriers, ospreys, sparrowhawks, and several species of falcons. The significant number of birds and species of storks and birds of prey makes the Strait of Gibraltar one of the most relevant places in the world for soaring birds migration. The numbers of migrant Black Kites, Egyptian Vultures, Booted Eagles, and Short-toed Eagles are the highest in the world. The medium- and long-term monitoring of soaring birds in the Strait confirms the existence of significant variations in migration behavior, especially within the last decade, which reflects a population recovery of many species of storks and birds of prey, and the decline of a few species. It also confirms changes in migration patterns, like the shortening of migration distances, the appearance of new migration routes, and the colonization of African species. Medium- and long-term censuses of soaring birds in the Strait show significant changes in migration schedules, most notably between 1976 and 1999, with some species anticipating the moment of their migration and others delaying it. These rapid changes in the phenology of migration advise us to regularly update protocols and census dates in order to adjust them to the trends detected. Local and regional weather conditions have a considerable impact on the number of soaring birds flying across the Strait of Gibraltar. These circumstances should be included and studied in migratory phenology analyses with regard to the data collected at migration observatories. Bird counts at migrant concentration sites like the Strait of Gibraltar are an excellent alternative to censuses with

other methods, as they are able to cover wider areas with relatively less effort. The combination of data collected at all the migration observatories distributed along the African-European migratory network proves to be a powerful tool to assess rapid changes in population trends as well as migration patterns of European migratory birds.

Academic year: 2015-2016.

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Fluvial territory: Landscape structure, bird communities and ecosystem services.

[Territorio fluvial: Estructura del paisaje, comunidades de aves y servicios del ecosistema.]

Abstract:

This thesis is about the ecology of three rivers from León (Spain), specifically the Torío river, the Bernesga river and Jamuz river, which have been chosen because of certain peculiarities (situation, flow regime, impacts). We study aspects related both to the river and the surrounding territory, therefore justifying the term “Fluvial Territory”, a fluvial space without definite limits where the river is the unifying force that comprises the river itself, the riparian forest and some surrounding ecosystems. The first chapter deals with the study of the landscape, under the frame of landscape ecology and applying GIS techniques. The second and third chapters are focused on the study of the bird communities of the riparian forest with a retrospective vision over twenty years, so that a comparative view of the bird community of 1994/1995 and 2012/2013 is presented. In the fourth chapter, the bird community in the poplar plantations has been studied. Finally, in chapter 5, we look over the ecosystem services, focused on two

ecoservices of the riparian forest, namely the regulation of river floods and the role of the birds of this ecosystem in the regulation of potentially harmful invertebrates.

Academic year: 2015-2016.

Universitat de Lleida

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Fallow land as a tool for farmland biodiversity conservation.

[El barbecho como herramienta para potenciar la conservación de la biodiversidad en zonas agrícolas.]

Abstract:

Agri-environmental schemes (AES) have been designed to counteract the dramatic decline in farmland biodiversity across Europe driven by agricultural intensification. Despite protection efforts, many species of conservation concern are showing ongoing decline, opening the debate regarding the efficiency of current measures applied. This study aimed to shed light on these aspects for the specific case of fallow fields located in a semi-arid region of the north-eastern Iberian Peninsula. Farmers traditionally managed fallow lands with the aim to control diseases, pests or serious weeds that could affect the future crop. However, today the important role of these temporal semi-natural areas as suitable habitats for the enhancement of farmland biodiversity and ecosystem service development make it necessary to plan specific management regimes from a conservationist perspective. Knowledge of the vegetation assembly response (in terms of functionality) to the different agricultural management and landscape conditions improves understanding of their effect on higher trophic levels, and may

potentially contribute to enhancing their viability. In this study, different management practices were experimentally tested to show their effects on the habitat suitability of two groups of species which represent farmland biodiversity and ecosystem services: steppe bird species and insect pollinators, respectively. Moreover, the surrounding area assemblage was also taken into account. The presence of semi-natural habitats around fallow fields improves the diversity of flower features available for insect pollinators, and additionally, is related with a more active presence of steppe birds. However, a highly heterogeneous configurational landscape composed of irregular fields with many boundaries is avoided by the majority of steppe bird species mainly because of the high predation risk associated with this type of environment. Also, the high disturbance pressure suffered in field border areas by the neighboring crops leads to a homogenization of the functional weed communities, represented by annual graminoids which are not at all attractive to pollinators. Within fallow fields, there is the need for field practices on account of the lack of suitability shown in non-managed fallows. Tillage management leads to weed colonization of ruderal species, which thereof promotes floral features related with generalist pollinators, but enhances plant material palatability and seed ground availability as a result of the open habitats created. This habitat type fits into the requirements of Pin-tailed Sandgrouse *Pterocles alchata*, Black-bellied Sandgrouse *Pterocles orientalis*, Short-toed Lark *Calandrella brachydactyla* and Stone-Curlew *Burhinus oedicnemus*. Little Bustard *Tetrax tetrax* males also prefer these conspicuous areas for their sexual display activity during breeding time. While alfalfa sowing was not a successful treatment, shredding and herbicide action encouraged a denser vegetation habitat structure related with a

high invertebrate biomass. Little Bustard females and Calandra Lark *Melanocorypha calandra* respond positively to these habitat characteristics. The heterogeneous patchy habitat configuration resulting from the selective action of an early herbicide application (February) promotes the coexistence of diverse plant phenotypes which in turn allow for a longer period of forage availability for pollinators. Management effects, however, often follow a common trend leading to homogenization of vegetation cover over the years. Due to this, a maximum of three years under the same management is recommended to maintain habitat suitability. This study aims to improve current conservation measures by providing valuable information about the different aptitudes of management strategies, according to the preferences of the target species studied. Moreover, an economic analysis was taken into account to merge effective conservation strategy goals with feasible budgets for farmers.

Academic year: 2015-2016.

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Parental care of Greater Flamingo *Phoenicopterus roseus* in a seasonal wetland.

[*Cuidado parental en el flamenco común (Phoenicopterus roseus) en un humedal temporal.*]

Abstract:

Parental care has been defined as any parental trait that enhances the offspring's fitness, and that is currently maintained for this function. Parental care depends on multiple factors interacting in a complex fashion. The study of how these factors affect breeding success is fundamental to understand the ecology of organisms and allows for more accurate population-

dynamics models. In this thesis, I studied parental care patterns in the Greater Flamingo (*Phoenicopterus roseus*) in a seasonal wetland. Particularly, I analyzed how these patterns interact with intrinsic (e.g., sex and parental age) and extrinsic (e.g., food availability and chick age) factors during the breeding period. Greater Flamingos are the largest waterbird species of the Western Mediterranean, thus the relative cost of carrying stores needed for egg formation should be low. Stable-isotopes analysis of potential prey and eggs of flamingos indicated that resources obtained for egg formation were acquired both in overwintering areas and at the breeding site, suggesting that the greater flamingos are "*partial capital breeders*". At the Fuente de Piedra breeding site, the lake dries out almost completely in the summer, and both parents commute between breeding and foraging sites > 130 km away during the chick-rearing period. Applying multi-state capture-recapture models to daily observations of individually marked parents, we determined the effects of intrinsic and extrinsic factors on the provisioning patterns. The probability of chick attendance was > 0.98. Chick desertion decreased with parental age. Females stayed in the feeding areas for shorter periods (7.5 days on average) than males (9.2 days). Isotopic signatures of males' secretions suggested that they fed on prey of higher trophic levels than females. Both parents spent approximately one day in the colony between trips to foraging areas. Females allocated more time to foraging in the flooded areas remaining in the colony, likely because they were energetically more stressed than males. Males apparently foraged less efficiently than females, whereas females' body condition seemed to be lower after feeding the chick. Flamingos feed their chicks with secretions that adults produce in glands located in the upper digestive tract. Greater Flamingo chicks store food in their crops, which protrude outwards. I determined

whether crop size (four categories) may be used as an accurate index of the amount of food ingested, as well as the timing and frequency of provisioning. I registered changes in body mass and crop fullness in eight chicks captured with turgid crops, and kept them in captivity until constant mass was achieved. The meal mass ingested by the chicks during each parental feeding was ~18% of net chick mass. Mean transition times between profile categories (full to empty) ranged from 6 to 14 hours. These results have implications for the estimation of body condition indexes because body mass should be free of the influence of the mass of the food in the crop. I also studied the feeding frequencies of chicks by applying multi-state capture-recapture models to resighting data of crop size from individually marked chicks. The probability that a chick was fed by a parent just arrived to the colony did not vary with chick age. However, younger chicks were provisioned more frequently with complementary meals before the parents left the colony to feed. Meal size increased with chick age when parents arrived to the colony, but not when a supplementary feeding was provided. These results suggest that despite adult flamingos did not vary the frequency of visits to the colony, parents could regulate the number and duration of their feedings during every visit to the colony. For long-lived species, it has been suggested that parents develop a fixed parental effort during the reproduction. However, large annual variation in environmental conditions might favour a flexible reproductive effort. Lastly, I studied if annual variations in parental effort and chick's body condition in greater flamingos were related to rainfall during two contrasting years. Chicks were fed more frequently and their body condition was higher during the wettest year. Stable-isotopes analysis ($\delta^{13}\text{C}$) from chick blood and feathers showed that parents foraged in seasonal wetlands during the wettest year. Furthermore, in the driest year

parents relied partially on endogenous reserves for the production of secretions with which the chicks were fed, while in the wetter year, exogenous nutrients sources were more significant. However, low values of $\delta^{15}\text{N}$ in secretions suggest that parents experienced a moderate physiological stress during the driest year. The positive relationship between chick body condition and $\delta^{13}\text{C}$ values in chick tissues indicates that parents provided a higher parental effort during the rearing period when seasonal wetlands (e.g., natural marshes of Doñana) were flooded, in contrast to drier years when they relied more on permanent wetlands (fish farms, salinas). These results support the flexible parental hypothesis, since the parents seem to adjust their parental effort both to their own body condition and to the needs of their chicks.

Academic year: 2015-2016.

Universidad de Murcia

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Supervisors: Ruiz de Ybáñez Carnero, M.R., Nogales Hidalgo, M. and Albino Ramos, D.J. Ecology and impact of invasive mammals on insular ecosystems: Corvo Island, Archipelago of Azores.

[Ecología e impacto de los mamíferos invasores en ecosistemas insulares: la isla de Corvo, archipiélago de las Azores.]

Abstract:

This research was focused on the direct and indirect impact of the three most common invasive mammals in insular ecosystems (House Mouse *Mus domesticus*, Black Rat *Rattus rattus* and Cat *Felis silvestris catus*) on Cory's Shearwater *Calonectris diomedea borealis*. The work has been carried out on Corvo, the most remote island of the Azores Archipelago and the last to be discovered and colonized. Consequently, the introduction of invasive mammals occurred more recently

(approximately 1600). Therefore, Corvo supports a high diversity of seabird species and the largest population of Cory's Shearwater. Although colonies of other seabird species (e.g. Madeiran Storm Petrel *Oceanodroma castro* or Little Shearwater *Puffinus assimilis*) were numerous in a recent past, today their populations have strongly declined mainly due to predation by introduced mammals. The impact of these mammals on Cory's Shearwater breeding success is unknown; however, this information is required to develop needed conservation measures. For each of the three invasive mammal species targeted in this study, evidence of their individual negative effects on seabird populations can be found within the scientific literature. However, the purpose of this research was to evaluate the overall impact of all coexisting invasive mammals on Corvo Island on the breeding success of Cory's Shearwaters. To achieve this, different ecological aspects of these mammals were studied as well as their relationships. Combining data on trophic behaviour with activity around the Cory's Shearwater colonies we observed two interactions between cats and rats, which influenced the Cory's Shearwater breeding success. Although only evidence for lethal relationships (predator-prey) has been demonstrated in seabirds, this research also addressed the indirect impact of predators influencing the ectoparasite intensity of Cory's Shearwater. The four scientific studies that encompassed this research showed that cats are principally responsible for the low breeding success of Cory's Shearwaters on Corvo Island. Among rodent species, only rats prey upon Cory's Shearwater nests; however mice could act as predators in the absence of invasive mammals occupying a higher trophic level. Even if Cory's Shearwaters were intensely preyed upon by cats during the breeding season, the availability of rats could limit cat predation of Cory's Shearwater chicks. Both predators of Cory's

Shearwater (cats and rats) can compete for the same prey (Cory's shearwaters); however rats seem to have a little impact on this bird species. This is probably due to the low abundance of rats and a high level of predation by cats since rats are their most important food source. Therefore, the predator behaviour of rats could be moderated by cats. Lastly, the presence of predators in the vicinity of the nests increased Cory's Shearwater ectoparasite intensity. This indirect impact of predators and ectoparasites on Cory's Shearwaters deserved special attention because it affects body condition, nest survival, and, hence, the health of individuals. The information included in this research about the ecology of invasive mammals in insular ecosystems, is important for developing measures than can contribute to increase breeding success. Such increases can help address threats to the adult population (for example, by-catch in fishing nets) and contribute to the survival of Cory's Shearwaters, thus avoiding irreversible damage as that suffered by neighboring species.

Academic year: 2013-2014.

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Foraging behavior of the Lesser Kestrel under the Movement Ecology paradigm revealed using biologgers.

[Comportamiento de alimentación del cernícalo primilla desde la perspectiva de la Ecología del Movimiento revelado mediante el uso de biosensores.]

Abstract:

The recent revolution of biologging technology has provided novel insights into free-ranging animal ecology with an unprecedented spatiotemporal resolution. Conse-

quently, literature on animal movement has vastly increased. This is the breeding ground over which Movement Ecology has arisen as a new discipline to unify all movement research under a common framework. Accordingly, Movement Ecology states that individual movement results from the interaction between four elements: individual motivation, motion abilities, navigation capacities, and external factors. This paradigm stresses the necessity to evaluate these elements to get a comprehensive understanding of the movement path. The Lesser Kestrel *Falco naumanni* is a small insectivorous falcon that breeds in colonies across the Palearctic and winters in Africa. This species suffered a severe world population decline during the second half of the 20th century because of the agricultural intensification. Here we investigated the foraging ecology of the Lesser Kestrel from the novel Movement Ecology perspective by deploying high-frequency GPS and tri-axial accelerometers dataloggers on 35 individuals at two breeding colonies during four consecutive breeding seasons in southern Spain. In chapter 1, we evaluated the influence of both wind speed and direction on individual decisions about which direction to head when leaving the breeding colony to forage throughout the breeding season. We did not find any strong effect of wind on Lesser Kestrel flights probably due to the prevailing winds registered in the study area that were weak and constant in direction. However, kestrels showed a uniform distribution of foraging trip departure directions when foraging early in the breeding season, which seems to be related to more exploratory flights when prey abundance is low and individuals have little knowledge about prey spatial distribution. Meanwhile, at the end of the breeding season kestrels concentrate their departure directions towards high-quality foraging areas when preferred prey abundance, individual experience, and energy demand derived from

rearing the offspring are higher. Therefore, individual internal factors (mostly navigation capacities) appear to guide kestrel decision about departure directions of foraging trips, with little effect of external factors like wind. In chapter 2, we analyzed the effect of role specialization of the Lesser Kestrel on its foraging movements throughout the breeding season. We found differences in foraging movements between sexes in accordance with the general trend of raptor role specialization. Males fly larger daily distances and perform higher number of shorter foraging trips per day than females being the main responsible for provisioning tasks. Meanwhile, females tend to stay longer than males at the colony through the day, which agrees with being the main responsible for nest protection and attendance. Furthermore, the Lesser Kestrel shows a sexual spatial segregation, with females constantly flying towards foraging areas located farther from the colony than males. This might be an adaptive foraging strategy based on role specialization in order to avoid prey depletion in the surroundings of the colony and reduce intersexual competition between members of the breeding pair to be successful in reproduction. In chapter 3, we studied the flight strategy of the Lesser Kestrel during foraging trips and the effect of solar radiation (as a proxy for thermal updrafts) on several foraging trip parameters during the breeding season. Surprisingly, we found that the Lesser Kestrel, traditionally considered as a flapping raptor, relies heavily on thermal soaring during foraging trips, especially at higher values of solar radiation. Individuals fly at slower speeds at higher altitudes and reach farther distances from the colony during foraging trips with thermal soaring events in comparison to those without them. This guides to a circadian pattern of Lesser Kestrel foraging behavior: individuals fly by flapping their wings towards foraging areas located closer to the colony when thermals are weak or absent, whereas they fly

farther away by soaring on thermals as soon as they are formed. Theoretical flight models indicate that, given the Lesser Kestrel preference for feeding on large grasshoppers and considering the average distance traveled along the trips, foraging by flapping their wings would result in a negative energy balance for the family group. In chapter 4, we built a behavioral classification model based on tri-axial accelerometer and GPS data for the Lesser Kestrel. Then, we investigated the effect of internal (breeding phenology, role specialization) and external factors (prey availability, weather conditions) on the behavioral time and energy budget of the Lesser Kestrel during the day in general and when foraging in particular. Our behavioral classification model performs well when classifying free-ranging Lesser Kestrel behaviors. Flapping and hovering flights require more energy than soaring-gliding flights, and these flight behaviors consume more energy than stationary (incubating/brooding and perching) behaviors. The daily time and energy budget of the Lesser Kestrel is mostly determined by behavior-specific costs and the role specialization between sexes. Lesser Kestrels gradually replace flapping with soaring-gliding during commuting flights as solar radiation increases, that is, as thermal updraft gets stronger. Lesser Kestrels also progressively substitute perch-hunting with hover-hunting at the foraging patch as wind speed increases, that is, as they experience stronger lifts to be aloft. However, kestrels seem to decide which hunt strategy to use regarding the activity level of the preferred prey, which is influenced by air temperature. Thus, individuals increase the use of hovering flights as air temperature, and prey activity level, also increase. Overall, our results support predictions derived from the optimal foraging theory and suggest that the Lesser Kestrel prioritizes saving energy than time when foraging throughout the breeding season.

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Ecology of the Great Cormorant (*Phalacrocorax carbo*) in Galician rivers.

[Ecología del cormorán grande Phalacrocorax carbo en los ríos gallegos.]

Abstract:

This study analyses the population trends of the great cormorant as well as habitat selection, diet and agonistic interactions and distribution within night roosts. Even though large populations of Great Cormorant winter in Galicia, there is still a considerable lack of knowledge of its ecology. Trend models show a moderately increasing population during the period 1987-2010 and link night roost desertion with road proximity, which is related to human presence and activity. Habitat modelling shows a preference for wider river stretches farther from the road, which facilitate greater vigilance and food catching and minimize anthropic perturbation. Moreover, this study shows segregation between age classes, with adults occupying mainly river stretches closer to the night roost and subadults displaced farther afield. Pellet analysis reveals very different diets in two distinct locations (one located in a freshwater environment where Cyprinids are the main prey; and the other in an environment influenced by estuarine waters, where diet is more varied and marine species are abundant). This suggests a generalist and opportunistic diet, focused in the most abundant and accessible species. The analysis of the bird's distribution within night roosts show that adults occupy higher positions than subadults do in the roost, the latter being more vulnerable to possible perturbations and prone to suffer depositions from neighboring birds. We also found that adults compete more actively and effectively than

subadults to reach these high-quality positions and that the number of attacks is density-dependent.

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Influence of environmental changes on bird populations in Galicia.

[Influencia de los cambios ambientales en las poblaciones de aves de Galicia.]

Abstract:

This thesis evaluates the changes occurred in avian communities from Galicia (NW Spain) related to major environmental drivers such as habitat alteration, climate change and land abandonment. Galicia is located in between the Atlantic and the Mediterranean biogeographical regions and in the last decades it has experienced dramatic modifications in its landscape –caused principally by rural depopulation and the abandonment of traditional farming practices. We evaluate: (i) the trends in abundance and richness of wintering waterbird communities over a period of 20 years (1990-2009) in the main 19 coastal wetlands of Galicia and the Cantabrian, as well as the effect off the *Prestige* oil spill on waterbird numbers; (ii) the shift in the distribution range of nesting Mediterranean bird species in Galicia over 19 years (1979-1998) regarding their possible relationship with climate change; (iii) the effect of agricultural abandonment on the abundance and richness of bird communities across the landscape that surrounds small rural villages; (iv) the effect of use and woodland fragment characteristics on the bird communities of ancient sweet chestnut *Castanea sativa* woodlands. The abundance and richness of wintering waterbirds showed a positive trend in the study area, but these trends were not consistent across localities.

Particularly, there was a tendency for western localities to show a negative trend and for eastern localities to show a positive one. Additionally, we did not observe significant differences in population's trends between oiled and unoled localities. Between 1979 and 1998 Mediterranean bird species in Galicia have moved northwards at an average rate of 0.8 km/year, a result that is in accordance with climate change. Rural villages in Galicia act as bird diversity hotspots, as the diversity and abundance of birds decreases as the distance to the village increases. Agricultural abandonment had a negative impact on the abundance and richness of bird communities affecting mainly finches (*Fringillidae*) and transaharian migrants. Larger chestnut woodlands showed more diverse bird communities and the level of use of these woodlands had no influence on the abundance and the composition of bird communities.

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The ecology of the Blackbird *Turdus merula* in orange plantations: a long-term study.

[La ecología del mirlo Turdus merula en los naranjales: un estudio a largo plazo.]

Abstract:

This thesis deals with demographic and reproductive aspects of the population of European Blackbird *Turdus merula* that inhabits a 17 has. orange plantation located in the surroundings of Sagunto (Valencia, Eastern Spain). The nest searching techniques and mapping methods applied allowed to calculate the number of breeding pairs from 1975 to 2015 and to obtain information on clutch size, breeding success and the causes of nest failure. The seasonal

ringing program performed during ten years provided information on natal philopatry, sex ratio and adult survival. Seasonal clutch size variation fitted the common pattern of multiple brooded-species: clutch size increases to a mid-season maximum peak and then decreases progressively until the end of the breeding season. Clutch size variation in late breeding seasons showed the same pattern. From the beginning of the breeding season, the mean number of fledglings per nest decreased linearly due to nest predation, showing that the strategy of this species, based on maximizing the reproductive effort during mid-season, failed. Since 2003 the breeding success of this population has decreased due to an increasing nest predation rate caused by the Garden Dormouse *Elomys quercinus*. Indeed, since 2012 all the Blackbirds nests have failed due to this predator. Regarding the advantages that asynchronous hatching provides, the first hatchlings were predated in 7% of successful nests whereas the last eggs laid remained undamaged. This percentage reached 10% when all factors that caused the death of the older siblings were considered. This last percentage could have been even higher (12%) if some last hatchlings, which had survived despite their siblings were predated, had not been predated a few days later. Among the fledglings from the study plot, the proportion of recovered males that joined the breeding population of the study area was higher than that of females (4:1). However, the arrival of young females from other breeding locations balanced the sex-ratio showing that young females disperse more than males. As a consequence of the lower degree of natal philopatry of blackbirds from the orange groves in relation to urban populations, most of the juvenile recruitment was constituted by immigrant individuals. In contrast to other studies dealing with sex ratio in blackbirds, the deviation from 1:1 in both the juvenile and adult population was minimum.

Furthermore, the seasonal variation of the sex ratio in both the adult and juvenile population was not significant. The capture methods based on active attraction of blackbirds to the mist nets may have contributed to decrease the catchability differences between sexes. In relation to the apparent survival of adults, annual variation was detected but not sex or seasonal variation. The Blackbird population of the orange groves in Sagunto strongly expanded from the mid-seventies until the end of the nineties. In 1999 the population reached the highest number of breeding pairs recorded in Spain (55 pairs/10 has.). Since then, the number of breeding pairs has decreased to a minimum of 3 pairs/10 has. in 2015. As a conclusion, the decline of the Blackbird population in the orange plantations of Sagunto was the consequence of the severe decrease of the breeding success as a result of the irruption and the population increase of a nest predator: the Garden Dormouse.

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The population decline of granivorous birds in agricultural areas of the east of the Iberian Peninsula.

[El declive de las poblaciones de aves granívoras en medios agrícolas en el este de la península Ibérica.]

Abstract:

The population trends of three granivorous species, House Sparrow *Passer domesticus*, European Goldfinch *Carduelis carduelis* and European Greenfinch *Carduelis chloris*, that breed in an agricultural area of orange groves in eastern Spain, were investigated. Moreover, the abundance of the House Sparrow in the province of Teruel and the breeding populations of the European Greenfinch in other agricultural areas of eastern Spain

were also surveyed. Aspects of the breeding ecology of both cardueline species were researched: onset of the breeding season, seasonal variation of clutch size, nestling diet of the European Greenfinch, breeding success and productivity. The results show that variations in all three breeding populations have occurred during the last 41 years in the orange groves of eastern Spain. The population trends were negative and none of the species breeds nowadays in the area surveyed. The causes of these local extinctions could be changes in the agricultural management of the orchards in the study area. These changes could affect food availability since the seed-bearing plants used to feed the nestlings of both cardueline species were scarce or not present in the study area at the end of the last century. Regarding the House Sparrow, the results from Teruel show the importance of fallow lands and the areas dedicated to cereal, leguminous, tubers, and sunflowers. Also, the breeding populations of European

Greenfinch were more abundant in areas with non-intensive agricultural management. Both results suggest that food supply, modified due to changes in the agricultural practices, could lead to declines in the populations. Moreover, breeding parameters of the cardueline species can have an effect on the recruitment for the next breeding population. An advance in the onset of the breeding season was not found, despite the increased temperatures in the study area; hence, the number of breeding attempts cannot be increased. Both species present a seasonal variation of the clutch size typical of multi-brooded species; nevertheless, when the breeding season starts late, the single-brooded pattern was detected. The breeding success and the productivity have decreased during the study period. The seasonal variation of the number of fledglings is different to the variation of the clutch size; this difference suggests that predation and drastic changes in food availability are not predicted.

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