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Survey effort requirements for bird community assessment in forest habitats

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Abstract. A reasonably-complete bird inventory is the crucial starting point for the analysis of the bird community. We evaluated the efficiency of point counts in detecting forest birds and verified how many sampling points or occasions are needed to adequately characterize the bird community. We sampled birds in 5 forest stands (conifer and beech forests) from northern to southern Italy in 2012. Sampling (through aural and visual clues) lasted 5 minutes, during which species were recorded. Data were analysed in relation to both the number of sampling points and the number of sampling occasions. Then, estimates of species richness were compared to random resampling of subsets of the original data. Results showed that after 3.8 sampling occasions (out of 19–24 sampling points) or 10.4 sampling points (given points are sampled 5 times), the species coverage of each community approached, or exceeded, the 90% threshold. Also, no difference in the mean values emerged with the subset estimates, but the latter appeared less precise. Our results suggest that the density of 1 sampling point per every 5 ha, each repeated at least 3 times, can represent an adequate optimization of the sampling effort. We provided useful methodological information for planning bird inventories in forest environments (applicable at least for Mediterranean and south-European mountain forests) when personnel and financial resources are limited, leading to a thoughtful fund management whilst providing a method to evaluate the reliability of species coverage for bird surveys.

Key words: sample size, rarefaction, accumulation curve, point count, species richness, inventory

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INTRODUCTION

Forest habitats are strongholds for avian diversity in Europe and investigating the relationships between birds and forests is a key issue for bird conservation and related topics, such as sustainable forestry (Lindenmayer et al. 2000). This is particularly important, given that the birds are often the most numerous group of forest vertebrates in terms of the number of both species and individuals (DeGraaf & Miller 1996). Indeed, changes in forest characteristics due to forestry (including e.g. tree age, canopy cover, stand density, harvest strategy applied, etc.), do profoundly affect the composition of bird communities (Caprio et al. 2008, Gil-Tena et al. 2008, White et al. 2013). A quick disclosure of such changes is essential for a rapid assessment of potential threats and, ultimately for effective bird conservation (Carrillo-Rubio et al. 2014, Balestrieri et al. 2015). An exhaustive bird species survey would be the ideal starting point for a reliable analysis of temporal changes in such a community. Although the actual meaning of "exhaustive" may depend on the research scope, there is a consensus that due to imperfect species detectability, a complete or nearly complete species survey is in most cases unfeasible, if not impossible (Magurran & McGill 2011, Colwell et al. 2012, Iknayan et al. 2014). Furthermore, if anything, an exhaustive sampling

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Habitat geology influences intraspecific variation in the speckling patterns of Blue Tit *Cyanistes caeruleus* and Great Tit *Parus major* eggs

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Abstract. Birds' eggs exhibit a small amount of interspecific diversity in terms of their colors and patterning but considerable variation occurs at the intraspecific level. Here, we examined the contributions of habitat geology, first egg dates, clutch sizes and year in determining intraspecific variation in the intensity of speckling patterns on the eggs of Blue Tits *Cyanistes caeruleus* and Great Tits *Parus major* breeding in deciduous woodlands with underlying calcium-rich limestone and calcium-poor gritstone rock types in northwest England. Eggshell speckling patterns varied significantly in relation to habitat geology, with both species laying more heavily speckled eggs in woodlands with gritstone rock types than in woodlands with limestone rock types, even though the weights of laying females and the availability of aerial invertebrates never differed between the two habitat geology types. Meanwhile, there was no variation in eggshell speckling patterns in both species in relation to first egg dates, clutch sizes or year. The eggs of both species were probably more speckled in the calcium-poor gritstone woodland because laying females were compensating for reduced eggshell strength in those woodland areas where there was low calcium availability by depositing more protoporphyrin-based pigments, that constitute the darker speckles and form at locations on the egg where the shell is thinnest, than conspecifics laying eggs in the calcium-rich limestone woodland. We thus conclude that micro-geographic heterogeneity in habitat geology types significantly influence the eggshell patterning of birds' eggs and more broadly our study confirms that environmental factors strongly influence intraspecific variation in avian eggshell patterning.

Key words: eggs, speckling, *Cyanistes caeruleus*, *Parus major*, habitat geology, limestone, gritstone, eggshell coloration

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INTRODUCTION

Birds are among those taxa that exhibit oviparous reproduction and their eggs exhibit a relatively small amount of variation in terms of their coloration and patterning. The laying of purely white eggs was the ancestral norm and white eggs remain prominent amongst those species that oviposit in comparatively safe nesting sites such as holes in trees (Kilner 2006, Mainwaring et al. 2014, 2015). However, the risk of predation has exerted strong selection pressures on both the coloration and patterning of birds' eggs, which has resulted in the increasing occurrence of both brightly colored and increasingly patterned eggs over evolutionary timescales (Kilner 2006, Hanley et al. 2013, 2015, Fossøy et al. 2016, Torres-Campos et al. 2016). Whilst the evolutionary history of interspecific variation in the coloration and patterning of birds' eggs is fairly well established (Reynolds et al. 2009, Cherry & Gosler 2010), intraspecific variation in the coloration and patterning of eggs remains less understood.

Studies have shown that intraspecific variation in the intensity of the blue-green coloration of eggshells is influenced by a number of environmental variables including the time of egg laying (Honza et al. 2011, Hanley et al. 2016, Hargitai et al. 2016a, c), ambient temperatures during egg laying (Avilés et al. 2007), the availability of food during egg laying (Moreno et al. 2006) and the presence of environmental toxins in the environment (Jagannath et al. 2008, Hanley & Doucet 2010).

Studies examining intraspecific variation in the speckling patterns of birds eggs, which is caused by the pigment protoporphyrin, meanwhile are scarcer despite the eggshells of many species' eggs being speckled (Cassey et al. 2012a,b, Brulez et al. 2014a, 2016, Gosler & Wilkin 2017). Protoporphyrin is produced during the biosynthesis of blood and

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Incubation behaviour of Blue *Cyanistes caeruleus* and Great Tits *Parus major* in a Mediterranean habitat

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Abstract. The incubation stage in avian reproduction could be as costly as the nestling rearing stage. This is particularly true in the case of uniparental incubation, during which both current and future breeding attempts may be compromised. Therefore, the knowledge of the proximate effects that condition the incubation behaviour in free-living bird populations is of great importance in understanding the evolution of avian life history. In this two-year study, we assessed the incubation behaviours of Blue *Cyanistes caeruleus* and Great Tits *Parus major* inhabiting the same Mediterranean area in central Spain through the usage of iButton data loggers. It showed that the incubating behaviour of our tit populations resembles that reported in previous studies, but with peculiarities related to living at lower latitudes, i.e. with a relatively low attentiveness and a shorter active day. Both tit species showed very different incubation strategies, with Blue Tits leaving more frequently the nest (Mean ± SE number of off-bouts, Blue Tit = 27.14 ± 0.63, Great Tit = 16.95 ± 0.58) but for shorter periods than Great Tits (off-bout duration, Blue Tit = 8.76 ± 0.22 min, Great Tit = 14.04 ± 0.56 min; on-bout duration, Blue Tit = 22.63 ± 0.60 min, Great Tit = 36.86 ± 0.86 min). Nonetheless, both species provided a similar nest attentiveness, percentage of time of the active day during which the females were actively incubating (Blue Tit = 70.87 ± 0.57%, Great Tit = 70.75 ± 0.83%). Presumably, differences in the cooling rate of clutches, estimated with the iButtons, could be behind the differences in incubation behaviour between species and the greater capacity of Great Tits to adjust their incubation behaviour.

Key words: incubation rhythm, attentiveness, cooling rate, *Cyanistes caeruleus*, *Parus major*, iButton

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INTRODUCTION

The reproduction of birds has classically been divided into three well-differentiated stages: egg production, incubation and care of nestlings (Nilsson et al. 2008); although it has subsequently been proposed that the stage of nest construction should also be included (Mainwaring & Hartley 2013). Until recently, researchers' attention has been focused almost exclusively on the last stage (care of nestlings), because it has been considered to be the most expensive in terms of energy expenditure (Williams 1996). However, the incubation period could be as expensive as nestling rearing, where the metabolic rates of parents incubating eggs can exceed the metabolic costs of thermoregulation at cool temperatures by 40–50% (reviewed in Tinbergen & Williams 2002). This is particularly true in the case of species with uniparental incubation, usually provided by the female (Conway & Martin 2000a). The high costs of uniparental incubation compromise not only current breeding attempts but also those in the future (Williams 1996, Reid et al. 2000a, Visser & Lessells 2001, Tinbergen & Williams 2002). Optimal embryo-development conditions are also provided by the female through incubation, so this stage is crucial to the hatchability of eggs and the phenotype of nestlings (Cooper et al. 2005, Chalfoun & Martin 2007, Nord & Nilsson 2011).

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Nocturnal hunting by Eleonora's Falcons *Falco eleonorae* on their breeding and non-breeding grounds

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Abstract. We report on nocturnal hunting by Eleonora's Falcons in their breeding range in the Mediterranean region and in their non-breeding range in Madagascar. Hunting activity of Eleonora's Falcons near floodlights during the breeding season in western Morocco peaked 30–60 min after sunset, but continued into the early morning. Hunting activity and prey capture rates near floodlights were highest during nights with little moonlight or overcast conditions. Fifty-one percent of 73 group capture attempts were successful. Of the migratory prey species identified at the Moroccan study site (26 species), 73% belonged to species mainly migrating at night, whereas 57% of all migratory bird prey species of Eleonora's Falcon reported to date (122 species) migrate predominantly at night; suggesting that hunting near artificial light may increase the proportion of nocturnal migrant species in the diet of falcons. *Sylvia* and *Acrocephalus* were the most commonly recorded genera among prey caught after dark. Our direct observations and analysis of satellite transmitter data indicated that Eleonora's Falcons also hunted away from artificial light in Morocco, Italy, and frequently so in Madagascar. Flight activity was detected in 18% of 342 night-time locations of seven satellite-tagged Eleonora's Falcons in Madagascar, at an average moon illumination of 60%. We conclude that nocturnal hunting by Eleonora's Falcons is more common than previously assumed and occurs preferably, but not exclusively, at above-average moon illumination on wintering grounds or near artificial lights during the breeding period.

Key words: Eleonora's Falcon, raptors, night-time hunting, artificial light, light pollution, moonlight, migratory birds

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INTRODUCTION

Diurnal (Falconiformes and Accipitriformes) and nocturnal (Strigiformes) raptors do not differ enough in prey use to justify the view that they reduce exploitative competition by differing in activity period (Jaksic 1982). This is at least partly because some diurnal and nocturnal birds of prey hunt crepuscularly, thus sharing prey of that activity period. Observations of diurnal raptors hunting at night suggest that activity periods between diurnal and nocturnal raptors may overlap more than generally thought. The Letter-winged Kite *Elanus scriptus* is the only truly nocturnal raptor of the order Falconiformes, with a diet comparable to the sympatric and more strictly nocturnal Barn Owl *Tyto alba* (Pavey et al. 2008). However, various other diurnal raptors have been observed to forage at night, including members of the genera *Accipiter*, *Falco*, *Circaetus*, *Elanus*, *Phalcoboenus*, *Haliastur*, *Haliaeetus*, *Gyps* and *Macheiramphus* (Morris 1983, Kaiser 1989, McLaughlin 1989, Svazas 1990, Del Hoyo et al. 1994, Sachslehner 1996, Hernando 1998, van Balen & Rombang 2001, Mebs 2009, Martin 2010). The frequent presence of nocturnal prey in the diets of other diurnal raptors suggests that they may also forage at night (e.g. DeGange & Nelson 1982, Anderson & Maritz 1994, Hyde & Worthy 2010). To date, nocturnal hunting has been most commonly reported for Peregrine Falcons *Falco peregrinus* in urban environments of North America (Cade & Bird 1990, Wendt et al. 1991, Cade et al. 1996, DeCandido & Allen 2006), Europe (Schneider & Wilden 1994, van Geneijgen 2000, Rejt 2001, 2004, Marconot 2003, Drewitt & Dixon 2008, Drewitt 2014, Kettel et al. 2016), Australia (Olsen 1995), and Asia (Huang et al. 2006, Hirata et al. 2014).

It may be profitable for diurnal raptors to extend their hunting after dark in particular when prey activity peaks at night-time, or when artificial light or moonlight attract prey or make it more

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Causes and consequences of nest mass and structure variation in the Bay-capped Wren-spinetail *Spartonoica maluroides*

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Abstract. Bay-capped Wren-Spinetail *Spartonoica maluroides* (Furnariidae) nests very close to the ground in dense clumps of grasses or sedges and builds both open and enclosed nest. We describe a proportion and characteristics of both types of nests and evaluate some causes that could force the construction of one nest architecture or another. In order to study the causes of this variation, we assessed the variability of nest types (architecture and size) and vegetation structure, and examined their consequences for breeding parameters in a population of Bay-capped Wren-Spinetail breeding in *Spartina densiflora* saltmarshes located at a coastal lagoon on Atlantic coast in east Argentina. We found that Bay-capped Wren-Spinetail builds nests enclosed and open with similar frequency within the same population and vegetation type. All nests were built with stems and grass leaves of *S. densiflora*. We found that open nests were built in sites with denser vegetation than enclosed nests. Nesting success and nest survival were not affected by nest architecture and size. The ability to adjust nest structure according to the vegetation density may be a strategy aimed at increasing nest concealment to reduce the temperature inside the nest or to avoid nest depredation. A flexible nest architecture strategy in Bay-capped Wren-spinetail is a possible adaptation to living in simple, yet structurally variable environments such as saltmarshes.

Key words: nest, characteristics of nest, Furnariidae, *Spartonoica maluroides*, *Spartina densiflora*, saltmarsh, breeding success, Argentina

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INTRODUCTION

Breeding is an important period of bird's life cycle. The nest is a key factor of successful breeding, since it provides shelter for eggs and nestlings and, in many cases, helps parents to conserve energy during the incubation and brooding stages (Collias & Collias 1984). Nest construction is energetically expensive for birds (Withers 1977, Lens et al. 1994, Mainwaring & Hartley 2013, Møller et al. 2014), affecting the energy investment during the incubation and nestling period (Moreno et al. 2010). Therefore, nest size may be subject to multiple trade-offs. While some selective factors favour large nests, due to maintenance of a specific nest temperature and humidity (Mainwaring et al. 2012), sexual selection (Palomino et al. 1998, Soler et al. 1998), clutch size (Møller 1982) and thermoregulation (Palomino et al. 1998, Botero-Delgadillo et al. 2017), whereas other factors favour small nests, due to a decrease in the risk of nest predation (Møller 1987), brood-parasitism (Soler et al. 1995), adult predation during nest construction (Slagsvold & Dale 1996) and/or proliferation of pathogens and parasites (Stolp 1988).

Most furnariids breed in enclosed nests, either by building their nest inside a burrow, rock crevice, or tree hole, or by building domed nests (Vaurie 1980, Collias 1997). An exception may be the Bay-capped Wren-spinetail *Spartonoica maluroides*, that nesting very close to the ground amidst dense clumps of cordgrass *Spartina densiflora* and sedges *Scirpus* sp. and its nest vary in the degree of the elaboration of the roof (Narosky et al. 1983, Llambías et al. 2009, Cardoni et al. 2012). Wren-spinetail inhabits freshwater and brackish marshes in the Pampas region in north central Argentina, southeastern Brazil, and Uruguay (Ridgely & Tudor 1994). Its nest architecture (open or enclosed) has been under controversy, since it has been considered as open by some authors

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Differences in the breeding success of Blue Tits *Cyanistes caeruleus* between a forest and an urban area: a long-term study

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Glądalski M., Bańbura M., Kaliński A., Markowski M., Skwarska J., Wawrzyniak J., Zieliński P., Cyżewska I., Bańbura J. 2017. Differences in the breeding success of Blue Tits *Cyanistes caeruleus* between a forest and an urban area: a long-term study. Acta Ornithol. 52: 59–68. DOI 10.3161/00016454AO2017.52.1.006

Abstract. Birds have specific habitat requirements during the breeding period. The Blue Tit *Cyanistes caeruleus* is a species evolutionarily associated with forest areas that prefers deciduous and mixed forests, whilst its breeding in urban areas is a relatively recent phenomenon. Long-term data (2002–2015) on reproductive performance (number of hatchlings, hatching success, number of fledglings and fledging success (fledging success as the number of fledglings in relation to the number of hatchlings)) were quantified for two Blue Tit populations in two, floristically and structurally contrasting areas (a mature deciduous forest and an urban parkland) in central Poland. The principal aim of this study is to see whether the habitat type, year or the food availability affect the breeding success of Blue Tits. Forest Blue Tits produced significantly more hatchlings (9.82 ± 2.64 (SD) in the forest vs.9.17 ± 2.16 in the parkland) and fledglings (9.18 ± 2.84 in the forest vs. 8.14 ± 2.68 in the parkland) than urban Blue Tits. The number of fledglings was positively correlated with the number of hatchlings in both study areas. Both forest and urban Blue Tits shared a similar hatching success (85.9 % in the parkland and 85.5 % in the forest), while the fledging success was significantly higher in the forest (83.4 % in the parkland and 86.1 % in the forest). The amount of caterpillar frassfall was also studied (caterpillars are the optimal food for nestlings) at both study areas and it suggested that caterpillars were more abundant in the forest than in the parkland (the maximum amount of frassfall, averaged 0.21 ± 0.11 g frass/m^2/day in the urban parkland and 0.59 ± 0.50 g frass/m2/day in the forest in 2003–2015). In the forest area, the mean number of fledglings tended to be related to the amount of frassfall but in the parkland, this relation was non-significant. The long-term dynamics of fledging success in our study sites seems to be mutually independent. Thus low fledging success in the forest site does not mean similarly low fledging success in the urban parkland site and vice versa. We suggest that food availability is one of key drivers of differences in the tits breeding success between both studied habitats.

Key words: *Cyanistes caeruleus*, breeding performance, hatching success, natural population, urban population

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INTRODUCTION

Breeding success of birds is a widely-studied and recurring topic in ornithological research and is related to the number of young birds surviving to breed on their own (Rodríguez et al. 2016a). Variation in breeding success within a population is considerable in many bird species and two main causal factors have been proposed to explain such variation (Nager & van Noordwijk 1992, Przybylo et al. 2001). Firstly, parental quality (Slagsvold & Lifjeld 1990, Wolf et al. 1997, Pagani-Núñez & Senar 2014, 2016), health (Gustafsson et al. 1994, Podmokła et al. 2015) or experience (Pärt 1995, Grieco et al. 2002, Janiszewski et al. 2016) may enhance reproductive success. Secondly, variation in breeding success can be due to differences in characteristics of territory quality (Martin 1987, Nager & van Noordwijk 1992, Solonen 2001), such as food abundance (Cresswell & McCleery 2003, Marciniak et al. 2007, Mackenzie et al. 2014), habitat structure (Cowie & Hinsley 1987, Riddington & Gosler 1995), calcium abundance (Bańbura et al. 2010, Reynolds & Perrins 2010) or weather (Bordjan

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Seasonal variation in bird species richness and abundance in riparian galleries in Southern Portugal

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Gomes M., Rabaça J. E., Godinho C., Ramos J. A. 2017. Seasonal variation in bird species richness and abundance in riparian galleries in Southern Portugal. Acta Ornithol. 52: 69–79. DOI 10.3161/00016454AO2017.52.1.007

Abstract. Riparian ecosystems are critical in maintaining biodiversity on a regional scale, which is particularly important for open agroforestry systems. We evaluated bird species richness and abundance in three different distances from the stream (0, 125 and 250 m) in Cork and Holm Oak forest systems (Montado) in southern Portugal. We used 5-minute point-counts to survey birds in two daily periods (morning and afternoon) of three different seasons (breeding season, summer-autumn migration and winter), to describe seasonal and daily variations in the use of riparian galleries and adjacent areas by birds. To assess whether birds move actively from the surrounding matrix into the riparian gallery, we installed mist-nets in mid-summer, autumn migration and winter periods, in two sites adjacent to streams, and recorded flight direction of all passerines trapped in the mist-nets. Both species richness and bird abundance were significantly higher in the riparian gallery than in the adjacent matrix. Species richness was significantly higher during the summer-autumn migration period, and bird abundance significantly lower during the breeding season. Apart from the Short-toed Treecreeper *Certhia brachydactyla*, Nuthatch *Sitta europaea* and Chaffinch *Fringilla coelebs*, all other species (e.g. Blackbird *Turdus merula* and Sardinian Warbler *Sylvia melanocephala*) were generally more abundant closer to the stream than at 250 m away. A significantly higher percentage of birds moved from the surrounding matrix into the riparian gallery in mid-summer, but not during the autumn migration and winter, which suggests that microclimatic conditions are important to explain observed seasonal differences. This study shows the importance of considering seasonal variation for the management of passerine bird populations in riparian galleries of Mediterranean areas. A well conserved riparian gallery appears to be a keystone structure exerting a strong influence on the number of bird species associated with surrounding agro-forestry systems such as the Montado.

Key words: riparian gallery, surrounding matrix, passerines, census, montado, summer, winter, seasonal variation

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INTRODUCTION

Riparian areas are described as the land adjacent to streams, rivers, and nearshore environments that interact with aquatic environments (Naiman & Decamps 1997, Ferreira et al. 2005). Riparian galleries present greater heterogeneity, have relatively high biodiversity, provide critical habitat for rare and threatened species, are refuge and resource areas for prey and predators, and can act as corridors for migrating species (Naiman et al. 1988, Risser 1990). The importance of riparian galleries for the functioning of ecosystems is particularly relevant for relatively dry areas such as savannah-type habitats of the Mediterranean region. In arid regions in particular, riparian ecosystems are critical in maintaining high biodiversity on a regional scale (Johnson et al. 1977, Rottenborn 1999, Godinho et al. 2010). This is noticeable when riparian galleries provide the only breeding and feeding forest habitat in otherwise open landscapes (e.g. Deschęnes et al. 2003, Pereira et al. 2014). Bird species richness in Mediterranean riparian galleries varies throughout the year as a result of seasonal habitat changes, and particularly due to the influx of migrating and wintering birds. For example, during autumn migration both resident and migrant birds are present at higher numbers in the Iberian Peninsula, particularly along riparian galleries (Pereira et al. 2014).

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Sex-specific foraging behaviour of adult Whiskered Terns *Chlidonias hybrida* in response to body mass and offspring age

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Abstract. Understanding foraging strategies remains a central question in behavioural ecology, but studies investigating how foraging of sexes is affected by other individual characteristics, like body size, are still scarce. We investigated how foraging behaviour during chick rearing varies in males and females with brood size, offspring age and individual body mass of parents, in a sexually size-dimorphic waterbird, the Whiskered Tern *Chlidonias hybrida*. Our study took place at the carp fish ponds in southern Poland, where both invertebrates (dragonflies, a typical prey of females — caught by picking) and small vertebrates (fish, tadpoles, frogs, males typical prey — caught by plunge-diving) are plentiful and available for both sexes during chick-rearing period. In total, 1680 attacks of 29 uniquely marked birds (16 males and 13 females) were observed during chick-rearing period. Foraging techniques were affected by sex of the parent and offspring age, interacting with body mass, and brood size. Males foraged mainly by plunge diving, but avoided this foraging technique if their broods were small and when offspring were young, probably because the chicks were too small to consume vertebrate prey caught by diving. In contrast, females foraged mostly by picking prey from the air, water surface or floating leaves, for most of chick-rearing period, but increased frequency of plunge diving as offspring age increased. A significant interaction between body mass and offspring age suggests that birds differing in body mass foraged differently as their offspring grew. We conclude that despite sex-specific differences in foraging behaviour (and prey type delivered to the chicks), both sexes in the Whiskered Tern alter foraging behaviour in response to both brood and individual birds' attributes.

Key words: foraging techniques, parental care, brood size, offspring age, waterbirds

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INTRODUCTION

Sexes of many seabird species differ in foraging behaviours. Females and males can differ in foraging area, foraging behaviour or techniques as well as in size and type of prey (Anderson et al. 2004, Weimerskirch et al. 2006, Mariano-Jelicich et al. 2007). The different foraging patterns of females and males could be a result of sexual size dimorphism (Lewis et al. 2005), intra-specific competition (Lewis et al. 2002) and/or sex-specific foraging abilities (Kato et al. 1999). In terns, sex differences in food provisioning to chicks have been studied mainly by examining food composition at nests (Wiggins & Morris 1987, Quinn 1990, Uttley 1992, Fasola & Saino 1995, Sorokaitė 2005), while sex differences in foraging techniques have rarely been addressed (Gwiazda & Ledwoń 2015). Different foraging techniques have been found in male and female Whiskered Terns *Chlidonias hybrida* (Crawford 1977, Dostine & Morton 1989, Gwiazda & Ledwoń 2015, 2016). In this species, either sex uses a distinctive foraging technique to catch different prey type. Vertebrates (fish, tadpoles, frogs) are caught by shallow plunge diving, while insects (mainly small dragonflies) are caught by picking from water and leaf surfaces. In Whiskered Terns, males forage primarily by plunge diving while females do so by picking prey from water or floating leaf surfaces (Gwiazda & Ledwoń 2015). Male Whiskered Terns are 6–10% larger than females (Ledwoń 2011) and the aforementioned sex-specific differences in foraging techniques can occur due to sexual size dimorphism. The greater male body mass is likely to offer better performance in plunge

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Traffic influence on roadside bird abundance and behaviour

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Abstract. Of the many negative effects roads have on wildlife, vehicle-caused mortality is important, killing several hundred million birds on an annual basis worldwide. Mortality is often the result of sitting on the road and failing to avoid an approaching vehicle, or being hit by a car while flying across the road at too low height. Therefore, one would expect that in areas with very high traffic density, birds would stay away from the road and roadside, and that birds flying over the road would do so at an elevation that minimizes the risk of collision. To test these hypotheses, I observed bird numbers along the roads at approximately 1000 car trips of at least 5 km in Iceland, Norway and the United States, and about 1800 flight heights of birds crossing a road before and after it was opened for car traffic. The bird abundance on roads was significantly lower at higher traffic densities. After start of traffic in a new road situation, birds crossed that road at significantly higher elevations than before. As an example, nearly 40% of Hooded Crows *Corvus cornix* and 70% of Western Jackdaws *Corvus monedula* were observed in the high-risk collision zone 0–5 m height before the road was opened; this was reduced to about 20% and 5% respectively for the two species after the road was opened. Heavy bird species flew higher than small birds. The behavioural adaptations shown here together with other publications provide the foundation of a hypothesis that the relationship between traffic density and the number of bird roadkills is non-linear, with a maximum number of roadkills occurring at a certain traffic density. This implies that fewer roads with high traffic density could reduce the number of roadkilled birds compared to many less trafficked roads.

Key words: collision avoidance, collision rate, flight height, flight distance, landscape, traffic, roadkills, road casualties, road construction, urban planning

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INTRODUCTION

Roads constitute a substantial part of our environment, certainly in Europe and North America. For instance, the Netherlands has 1.5 km and the U.S. 1.2 km of roads per km^2 land area (Forman & Alexander 1998). Many studies demonstrate the negative effects roads have on wildlife are due to habitat loss, population fragmentation, pollution, poisoning, noise, and collisions with cars (Erritzøe et al. 2003, Reijnen & Foppen 2006, Fahrig & Rytwinski 2009, Francis et al. 2009, Goodwin & Shriver 2011, Summers et al. 2011). This also extends beyond the road lanes and verges, and bird densities are in some cases reduced as far away as 1–3.5 km from the road (Reijnen et al. 1995, 1996, Reijnen & Foppen 1995, Reijnen et al. 1996, Forman et al. 2002, Benitez-Lopez et al. 2010).

Roads have influenced the environment in many different ways. Especially road mortality and traffic noise seem to have an important effect on birds (Reijnen & Foppen 2006, Kociolek et al. 2011). Collisions with cars kill several hundred million birds every year with country specific estimates of 13.8 million in Canada (Bishop & Brogan 2013), 80–340 million in the United States (Forman & Alexander 1998, Loss et al. 2014), 27 million in England, 653,000 in the Netherlands, 9.4 million in Germany, 1.1 million in Denmark, 8.5 million in Sweden, and more than 7 million in Bulgaria (Erritzøe et al. 2003).

The risk of collisions with vehicles differs among groups of birds. Birds like raptors, gulls, and corvids are often attracted to roads where they scavenge on food leftovers or roadkills (Forman 2000, Mumme et al. 2000, Dean & Milton 2003, Husby & Husby 2014). Other species, like White Wagtails *Motacilla alba* (Erritzøe et al. 2003, Husby & Husby 2014), forage on insects on or next to roads, and e.g. Red-backed Shrike *Lanius collurio* frequently use shrubs, trees and power

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Diet of Marsh Tit *Poecile palustris* nestlings in a primeval forest in relation to food supply and age of young

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Abstract. Composition of Marsh Tit *Poecile palustris* nestling food was studied in the Białowieża National Park (E Poland). The birds relied exclusively on natural food sources. Repeated visual observations of food brought to young in over 500 broods, during 14 seasons (1993–2007), showed that Marsh Tit used a highly specialised diet in rearing young. Soft-bodied, folivorous caterpillars typically composed > 80% of the nestling diet both in riverine and oak-hornbeam habitat. Spiders formed the second most important prey type (c. 12%). Diet composition fluctuated across years but the proportion of caterpillars in the diet remained high (70–90%) despite more than hundredfold variation in the caterpillars' supply across years. Within years, diet composition changed with nestling age and the broods' synchronisation with the seasonal peak of caterpillars availability. Young that were fed within 15 days before and 10 days after the peak received a high (> 80%) proportion of caterpillars, independent of their age. The share of caterpillars in the diet dropped only outside of that period. In most seasons, Marsh Tit young appeared in nests more than two weeks before the caterpillar peak; consequently, the share of caterpillars fed to small young in the earliest broods was lowest (c. 62% on average). Marsh Tits strove to collect caterpillars even when they were scarce, rather than switch to alternative food types. Spiders were brought in highest numbers (up to 20%) to the youngest (1–7 days old) nestlings. This suggests that spiders contained specific nutritional ingredients required by the small young.

Key words: Białowieża National Park, foliage gleaning birds, folivorous caterpillars, caterpillar peak, nestling diet

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INTRODUCTION

Birds should breed when chances of producing offspring are highest, which — among other things — requires the presence of an adequate supply of nestling food. Thus, adjustment of the birds' breeding time to a seasonal peak of food availability for young has been proposed repeatedly (Lack 1950, Marshall 1951, Perrins 1970, Immelmann 1971, Drent 2006). However, as different types of food resources tend to peak at different times of the year, we have to know the nestling diet composition of a species to test whether it indeed adjusts its breeding time to the availability of that resource. Detailed information on nestling diet composition is thus crucial for understanding the variation in birds breeding seasons both at the ultimate and proximate level (Newton 1998, Durant et al. 2005, review in Cholewa & Wesołowski 2011).

It is difficult to study effects of variation in food supply on nestling diet in contemporary forests, as variation in prey availability there can be substantially modified by human actions. The impacts could be indirect, e.g. changed timing of seasonal food peaks due to climate warming (Visser et al. 2004, Durant et al. 2005, Jones & Cresswell 2010), or could act via altered structure of forest landscapes (reviewed by Niemelä 1997, Wesołowski & Rowiński 2006). They could also be direct, e.g., by application of insecticides or other means of 'pest' control (reviewed by Dajoz 2000).

In the Białowieża Forest (eastern Poland) it is still possible to study avian diets in conditions nearing that of primeval forest (Tomiałojć et al. 1984, Tomiałojć & Wesołowski 2005, Wesołowski 2007a). Here, food in the breeding season is usually superabundant and interspecific competition is generally of minor importance (Wesołowski et al. 2002, Wesołowski 2003, 2007a). Food sources are diverse and are free from control by human management. Outbreaks of both folivorous caterpillars (Wesołowski & Rowiński 2006, 2008), rodents

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Decomposition of nest material in tree holes and nest-boxes occupied by European Starlings *Sturnus vulgaris*: an experimental study

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Abstract. Numerous bird species depend on the availability of tree cavities, and most non-excavators fill their cavities with considerable amounts of nest material. If not removed, this material can accumulate and render cavities unusable, as recorded in some nest-box studies. Data from earlier studies of tree cavities, however, showed that nest material can decrease mostly due to in situ decomposition, but the relative difference between nest decomposition in tree holes and nest-boxes is still unknown. We undertook parallel studies of decay in tree holes and nest-boxes used by European Starlings *Sturnus vulgaris* in oak-hornbeam stands (SW Poland). We inserted into its tree holes and nest-boxes litter-bags filled with cellulose and wool. After 7.5 months of exposure we detected much greater decomposition in tree holes than in nest-boxes. In tree holes a median 75% of cellulose and 26% of wool disappeared, whilst in nest-boxes a median of only 2% of cellulose and 14% of wool. These results are the first to document the relative difference between natural and artificial breeding cavities in the extent of nest decomposition. We also discuss the effect of nest material accumulation in tree holes and nest-boxes on the different nesting conditions available for hole-nesting birds. Taken together with: microclimate, nest safety, competition with social insects and presence of ectoparasites, the physical accumulation of nest material appear to be distinctive feature that differentiates the natural and artificial sites of tree-hole-nesting birds.

Key words: bird nests, nest material decomposition, nest site choice, nest-site cleaning, cavity nesting birds, litter-bags

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Between 10–40% of forest bird and mammal species are hole dwellers (Cockle et al. 2011), and as many as half of the representatives of the avian orders rely on cavities for nesting or roosting (Gill 2007). Some of these species, especially non-excavators, freely occupy artificial cavities for breeding, i.e. nest-boxes, provided by humans for scientific studies or nature protection purposes (Perrins 1979, Korpimäki 1987, Newton 1994). Conditions of breeding or roosting in natural holes differ in many aspects from those found in nest-boxes (Møller 1989, Lambrechts et al. 2010). Among them, presence of old nest material may affect the breeding biology of hole-nesting birds in several important aspects such as the pressures of ectoparasites, predators, issues of time saving during nest building and informative cues for breeding birds (review in: Mazgajski 2007a). For these reasons old nests are routinely removed from nest-boxes before studies begin and information about their presence/absence should be a mandatory provision by authors (see "List of recommendations" in Lambrechts et al. 2010).

Secondary hole-nesting birds use various nest materials to build their nests. Most often used are: dry leaves (e.g. flycatchers *Ficedula*, Robin *Erithacus rubecula*, Starling *Sturnus vulgaris*, Tree Sparrow *Passer montanus*), moss (tits Paridae, Robin, flycatchers), animal hairs or wool (Robin, flycatchers, tits) and feathers (Starling, Tree Sparrow) (Hansell 2000). Such diversity in the organic components of birds' nests facilitates the presence of diverse decomposer assemblages, both cellulolitic and keratinolitic, which may