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Bird and plant companion species predict breeding and migrant habitats of the genus *Oenanthe*

Stefan Pentzold[1,3,*], Constanze Pentzold[1,4] and Christoph Randler[2]

[1]University of Leipzig, Institute of Biology II, Talstraße 33, D-04103 Leipzig, Germany
[2] University of Education Heidelberg, INF 561-2, D-69120 Heidelberg, Germany
[3]Present address: University of Copenhagen, Faculty of Life Sciences, Department of Plant Biology and Biotechnology, Thorvaldsensvej 40, DK-1871 Frederiksberg, Copenhagen, Denmark
[4]Present address: University of Copenhagen, Faculty of Science, Department of Biology, Ole Maaløes Vej 5, 2200 Copenhagen, Denmark

Abstract

Analysing companion species from unrelated taxa concentrated so far mainly on identifying biosurrogacy in terms of conservation biology. No study has investigated companion bird and plant species to predict breeding and migrant habitats of a bird genus. In this study we recorded and analysed companion bird and plant species of the breeding bird Cyprus Wheatear *Oenanthe cypriaca* and four migranting *Oenanthe* species on Cyprus. We found characteristic companion species in Cyprus Wheatear's, Wheatear migrant's and in control habitats where no Wheatears were present. We show that plant and bird companion species can be used as discriminating factors to predict breeding and migrant habitats of the genus *Oenanthe* on Cyprus. Furthermore, habitat preferences of Cyprus Wheatear's companion species indicate bushy and vegetation rich habitats avoiding woodland on the one hand and managed farmland on the other hand. In comparison, migrant Wheatear and control habitats were characterised by companion species pointing to a high openness. These results support former habitat descriptions of Cyprus Wheatear and migrant Wheatears. In more general, this study shows that companion species from unrelated taxa can be used to predict breeding and migrant habitats of a bird genus.

Key words: breeding and migrant birds, companion species, habitat, Wheatears *Oenanthe*

INTRODUCTION

A central pattern in ecology is the interaction of species in many different ways with each other; they can compete, be mutual exclusive or can occur together and often depend on each other (Begon et al. 1996). Since decades co-occurrence has been used to identify indicator species which are applied in terms of conservation biology (Pearson and Cassola 1992, "umbrella species"), habitat descriptions (Aydin and Kazak 2010) and in biodiversity surrogacy. Several studies showed that unrelated taxa can act as surrogates for one another to predict biodiversity. Using different taxa of plants, insects and vertebrates, Leal et al. (2010) showed that this is true for different biomes. In a similar approach Schulze et al. (2004) revealed certain taxa as good predictors for species richness of other taxa, for example trees for fruit- and nectar-feeding birds. In concordance with this, Ricketts et al. (2002) found that phylogenetic relatedness is no reliable criterion for selection of suitable indicator taxa since butter-

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***Corresponding Author**
E-mail: stp@life.ku.dk
Tel: +45-3533-2354

flies were found to be poor indicators of moth diversity at a local scale. Instead, using unrelated taxa in terms of biosurrogacy seems to be more convenient. For instance, Blair (1999) demonstrated that birds and butterflies can be used as surrogates for one another in assessing biodiversity at the community level within a single habitat of a former oak wood.

Birds and plants provide an interesting example for studying biosurrogacy and indicator groups for one another since both taxa often rely on each other. Many bird species feed on plants and build their nests in trees, shrubs or grassy vegetation. In turn, plants can profit since their seeds are dispersed by migrating birds (Howe and Smallwood 1982). The co-occurrence between these two unrelated taxa can be very tight as demonstrated by Howe (1977) who showed that the extinction of a certain tree species led to the disappearance of the bird species feeding on it. Bird species assemblages were also used as ecological indicators of forest condition showing that certain bird species were typical for disturbed habitat or undisturbed habitat in a pine forest in northern America (Canterbury et al. 2000). Further examples from Martin and Possingham (2005), Barry et al. (2006) or Lehmkuhl et al. (2007) showed that studies focused so far only on forest types with certain dominating tree species inhabiting characteristic bird species in few cases. However, to our knowledge no study has ever before revealed certain bird and plant species predicting the presence and absence of a given bird species.

In this study we recorded the companion bird and plant species of the endemic breeding bird Cyprus Wheatear (*Oenanthe cypriaca)* and four migrating Wheatear species (Northern Wheatear *O. oenanthe*, Isabelline Wheatear *O. isabellina*, Desert Wheatear *O. desertii* and Eastern Black-Eared Wheatear *O. melanoleuca*) on Cyprus. We tested if the companion bird and plant species are suitable as discriminating factors for the presence or absence of the Cyprus Wheatear as well as migrating Wheatears in a certain habitat. The Cyprus Wheatear *Oenanthe cypriaca* is a vegetation tolerant bird species (Kaboli et al. 2007) and the most arboreal living species in comparison with migrating *Oenanthe* species on Cyprus (Randler et al. 2010). Thus, our working hypothesis is that in addition to companion bird species plant species should serve as predictors for the presence and absence of the Cyprus Wheatear in a certain habitat.

MATERIALS AND METHODS

Field work was carried out on the Mediterranean island Cyprus from 22 March 2008 to 21 April 2008 during spring bird migration and totalled > 300 h. Despite its relatively small size of approximately 9,250 km² the island has a high diversity of natural vegetation and nearly 20% of Cyprus is covered with woodland (Stagg and Hearl 1998, Jones 2006). When performing field observations, we walked around randomly and searched for individuals of the target species (see Salewski et al. 2003). We assessed the habitats within a radius of 100 m for the target species Cyprus Wheatear using the main location of a singing male. Control habitats were also measured with 100 m radius. They were assigned when there was no Wheatear present. Here, playback experiments were used to ascertain the absence of a Cyprus Wheatear because it responds strongly to conspecific playbacks. In migrant wheatear habitats, we chose a radius of 25 m because migrants often used only a very small area, and extending the 25 m radius would have included vegetation structure that was not used by the migrants. Furthermore, preliminary observations in 2005 (by CR) indicated that 100 m for breeding habitat and 25 m for migrant *Oenanthe* seem a good approximation. In every habitat type we noted all other bird species that were present in the area visually and acoustically, defined as companion bird species. Furthermore, we recorded and identified the most dominating plant species in all habitats down to the species level, defined as companion plant species. To compare the companion bird species, we chose species that are common breeders on Cyprus. Therefore, Whaley and Dawes (2003) and Flint and Stewart (1992) were used as a basis. However, as the field work took place in March/April, migrant breeders that arrive late, such as *Hippolais pallida* could not be used. For statistical analyses companion plant and bird species from the different habitats were compared by using Fisher's exact test.

RESULTS

We sampled a total of 192 habitats, 129 *O. cypriaca* breeding habitats, 17 control habitats (*Oenanthe* species absent), and 46 habitats of migrants (*O. oenanthe*, $N = 14$; *O. hispanica melanoleuca*, $N = 20$; *O. isabellina*, $N = 7$; *O. desertii*, $N = 1$; and 4 habitats with two or three species simultaneously present). We recorded 81 companion bird species in the different habitats, shown in Table 1. The five most common bird species in Cyprus Wheatear habitats were Sardinian Warbler *Sylvia melanocephala*, Great Tit *Parus major*, Cetti's Warbler *Cettia cetti*, Magpie *Pica pica*

Table 1. Companion bird species (*N* = 81) in Cyprus Wheatear breeding habitats (*N* = 129), control habitats (*N* = 17), and in Wheatear migrant habitats (*N* = 46)

Scientific name	Vernacular name	*	Breeding habitat	Control habitat	Fisher's exact	Migrant habitat	Fisher's exact
Sylvia melanocephala	Sardinian Warbler	*	75	6		7	$P < 0.001$
Parus major	Great Tit	*	74	6		7	$P < 0.001$
Cettia cetti	Cetti's Warbler	*	41	5		3	$P < 0.001$
Pica pica	Magpie	*	38	7		5	$P = 0.016$
Carduelis carduelis	Goldfinch	*	37	1	$P = 0.073$	4	$P = 0.008$
Passer domesticus	House Sparrow	*	33	2		6	
Hirundo rustica	Barn Swallow	*	27	5		4	
Alectoris chukar	Chukar	*	26	0	$P = 0.043$	4	
Carduelis cannabina	Linnet	*	22	1		6	
Sylvia atricapilla	Blackcap		20	1		2	
Corvus monedula	Jackdaw	*	17	2		5	
Carduelis chloris	Greenfinch	*	16	0		0	$P = 0.007$
Clamator glandarius	Great Spotted Cuckoo	*	16	1		2	
Emberiza hortulana	Ortolan Bunting		15	0		4	
Sylvia melanothorax	Cyprus Warbler	*	14	0		5	
Cisticola juncidis	Fan-tailed Warbler	*	13	9	$P < 0.001$	1	
Luscinia megarhynchos	Nightingale	*	12	0		1	
Falco tinnunculus	Kestrel	*	12	4		0	$P = 0.038$
Anthus trivialis	Tree Pipit		10	1		1	
Miliaria calandra	Corn Bunting	*	9	4	$P = 0.047$	4	
Francolinus francolinus	Black Francolin	*	9	4	$P = 0.047$	0	
Sylvia curruca	Lesser Whitethroat		9	0		2	
Columba palumbus	Woodpigeon	*	9	2		0	
Columba liviadomestica	Domestic Dove	*	9	2		0	
Upupa epops	Hoopoe	*	9	0		2	
Troglodytes troglodytes	Wren		7	2		0	
Serinus serinus	Serin	*	6	0		1	
Emberiza caesia	Cretzschmar's Bunting	*	5	0		0	
Oenanthe melanoleuca	Black-eared Wheatear		5	0		1	
Passer hispaniolensis	Spanish Sparrow	*	5	0		0	
Coracias garrulus	Roller	*	4	0		1	
Ficedula albicollis	Collared Flycatcher		4	0		1	
Corvus cornix	Hooded Crow	*	4	1		3	
Oenanthe oenanthe	Northern Wheatear		4	0		1	
Parus ater	Coal Tit		4	2		0	
Streptopelia tutur	Turtle Dove	*	4	0		0	
Phylloscopus bonelli	Bonelli's Warbler		3	0		1	
Phoenicurus phoenicurus	Redstart		3	0		0	
Apus apus	Swift	(*)	3	0		0	
Columba livia	Rock Dove	(*)	2	0		0	
Loxia curvirostra	Crossbill		2	0		0	

Table 1. Contiuned

Scientific name	Vernacular name	*	Breeding habitat	Control habitat	Fisher's exact	Migrant habitat	Fisher's exact
Certhia brachydactyla	Short-toed Treecreeper		2	2	$P = 0.067$	0	
Muscicapa striata	Spotted Flycatcher		2	0		1	
Ficedula semitorquata	Semi-collared Flycatcher		2	0		0	
Galerida cristata	Crested Lark	*	2	3	$P = 0.011$	10	$P < 0.001$
Delichon urbica	House Martin	*	2	1		0	
Hirundo daurica	Red-rumped Swallow	*	2	0		0	
Lanius senator	Woodchat Shrike		2	0		0	
Apus melba	Alpine Swift	(*)	1	0		0	
Monticola solitarius	Blue Rock Thrush		1	0		0	
Hippolais pallida	Olivaceous Warbler	*	1	0		0	
Anthus campestris	Tawny Pipit		1	0		5	$P = 0.005$
Saxicola rubetra	Whinchat		1	0		1	
Sylvia conspicillata	Spectacled Warbler		1	0		0	
Fringilla coelebs	Chaffinch		1	2	$P = 0.036$	0	
Sylvia communis	Whitethroat		1	0		1	
Acrocephalus arundinaceus	Great Reed Warbler		1	0		0	
Phylloscopus trochilus	Willow Warbler		1	0		0	
Hieraaetus fasciatus	Bonelli's Eagle		1	0		0	
Lullula arborea	Woodlark		1	0		0	
Oenanthe isabellina	Isabelline Wheatear		1	0		1	
Calandrella brachydactyla	Short-toed Lark		1	0		2	
Lanius nubicus	Masked Shrike		1	0		0	
Oriolus oriolus	Golden Oriole		1	0		0	
Acrocephalus schoenobaenus	Segde Warbler		1	0		0	
Athene noctua	Little Owl		1	0		1	
Ficedula hypoleuca	Pied Flycatcher		1	0		0	
Streptopelia decaocto	Collared Dove	*	1	0		0	
Phylloscopus collybita	Chiffchaff		1	0		1	
Otus scops	Scops Owl		1	0		0	
Turdus merula	Blackbird		0	2	$P = 0.013$	0	
Motacilla alba	Wagtail		0	0		1	
Merops persicus	Blue-cheeked Bee-eater		0	0		1	
Charadrius dubius	Little Ringed Plover		0	0		1	
Motacilla feldegg	Black-headed Wagtail		0	0		2	
Falco naumanni	Lesser Kestrel		0	1		0	
Anthus cervinus	Red-throated Pipit		0	0		1	
Motacilla flava	Yellow Wagtail		0	0		2	
Motacilla flava superciliaris	Yellow Wagtail		0	0		1	
Larus michahellis	Mediterranean Gull		0	1		0	

Statistical significance was calculated with Fisher's exact test. Values are given only if $P < 0.05$ at least.
*in column 3 indicates a common breeding bird species on Cyprus.

and Goldfinch *Carduelis carduelis*. These companion bird species were all significantly more present in Cyprus Wheatear habitats than in control or migrant habitats. This was also true for the Chukar *Alectoris chukar* and the Greenfinch *Carduelis chloris*. Control habitats where no Wheatear was present were dominated by the Black Francolin *Francolinus francolinus*, the Blackbird *Turdus merula*, the Chaffinch *Fringilla coelebs*, the Fan-tailed Warbler *Cisticola juncidis* and the Corn Bunting *Miliaria calandra*. In Wheatear migrant habitats Tawny Pipit *Anthus campestris* and Crested Lark *Galerida cristata* were significantly more common than in the other habitats. We sampled a total of 19 companion plant species within the different habitats, displayed in Table 2. The dominating plant species within Cyprus Wheatear habitats were *Calicotome villosa*, *Sarcopoterium spinosum* (syn. *Poterium spinosum*), *Ceratonia siliqua*, *Juniperus phoenicea* and *Pinus halepensis*. These plant species were all significantly more abundant in Cyprus Wheatear habitats than in control or migrant habitats. In control habitats cereals were found to be the dominating plant taxa which occurred significantly more often in these habitats than in Cyprus Wheatear breeding or Wheatear migrant habitats.

DISCUSSION

Co-existence of species is a basic pattern of ecosystems. The degree of their phylogenetic relationships may vary. Analysing co-occurrence of unrelated taxa in a certain area has been applied to questions in biosurrogacy and conservation biology mostly with a focus on insects, vertebrates and plants. For example it was shown that insect species can be used as bioindicators for habitats like afforested *Eucalyptus* forest, salty meadow, mud or dune in the Mediterranean (Aydin and Kazak 2010). As a vertebrate model system, certain bird species of woodpeckers, owls or kingfishers have been shown to be characteristic for forest types like Riparian forest in northern Texas, USA or Australia (Martin and Possingham 2005, Barry et al. 2006). However, specific species of birds and plants have only been analysed in the study of Lehmkuhl et al. (2007) from the Cascade Ranges in Northern America. There, different types of forest like upland dry forest, upland mesic forest or Riparian forest were each strongly characterised by certain plant species (*Pinus ponderosa, Abies grandis, Populus trichocarpa* respectively) and certain bird species (Mountain chickadee *Poecile gambeli,*

Table 2. Companion plant species ($N = 19$) in Cyprus Wheatear habitats ($N = 129$), control habitats ($N = 17$), and in Wheatear migrant habitats ($N = 46$)

Species	Breeding habitat	Control habitat	Fisher's exact	Migrant habitat	Fisher's exact
Calicotome villosa[*]	38	1	$P = 0.042$	3	$P = 0.001$
Sarcopoterium spinosum (syn. *Poterium spinosum*)	36	3		4	$P = 0.007$
Ceratonia siliqua	26	1		2	$P = 0.010$
Poaceae	24	4		3	
Juniperus phoenicea	17	1		1	$P = 0.045$
Asphodelus aestivus (syn. *A. microcarpus*)	17	0		5	
Bunias erucago	15	0		1	
Pistacia lentiscus	14	0		1	
Pinus halepensis	13	0		0	$P = 0.022$
Olea europaea	12	1		1	
Cereals	12	6	$P < 0.008$	3	
Trifolium stellatum	9	0		1	
Pistacia terebinthus	5	0		0	
Glebionis coronaria (syn. *Chrysanthemum coronarium*)	5	1		2	
Phagnalon rupestre	5	0		1	
Cupressus sempervirens	4	0		0	
Acacia retinodes	2	0		0	
Sinapis arvensis	2	0		0	
Calendula arvensis	2	0		0	

Statistical significance was calculated with Fisher's exact test. Values are given only if $P < 0.05$ at least.
[*]Note that all were assigned to Calicotome villosa which flowers February to April while Genista sphacelata is flowering from June onwards.

Hermit thrush *Catharus guttatus* or Song sparrow *Melospiza melodia,* respectively). Nevertheless, the data was not used to predict the presence or absence of these bird species in the according forest type. However, this was done by Venier et al. (2004) in the Great Lakes Basin in Northern America, although only abiotic factors like climate and land cover were used to predict the distribution of forest birds. To our knowledge no study has hitherto used an assemblage of bird and plant species as discriminating factors for the presence and absence of a given bird species in a certain area.

In this study we used birds and plants as the experimental system. In the field, both taxa have the advantage that they are relatively easy to detect and to identify and their taxonomy is well resolved (Diekmann 2003, Gregory et al. 2005). We found that the habitat preferences of the companion bird species of the Cyprus Wheatear indicate a habitat dominated by bush land vegetation and low distances to settlements. Likewise the dominating plant species indicate a preference for bush and tree vegetation. Control habitats were clearly separated from the habitats of Cyprus Wheatear by their companion bird species. There was also a difference in the dominating plant species between these two habitats. Cereals were typical for control habitats as indicator species in contrast to Cyprus Wheatear habitats. This indicates that the Cyprus Wheatear avoids woodlands on the one side and intensively managed and even farmland on the other. The habitats of migrating Wheatear species could also be distinguished from habitats of Cyprus Wheatear by their companion species. For example Tawny Pipit *Anthus campestris* and Crested Lark *Galerida cristata* were more common in migrant habitats. Together with the companion plant species they point to a high openness of migrant habitats in comparison to bush land species in Cyprus Wheatear territories. Summarizing, the habitat preferences of the bird and plant companion species reflect the habitat preferences of the Cyprus Wheatear and Wheatear migrants. Randler et al. (2010) described the habitat preferences of the Cyprus Wheatear as vegetation bound and more arboreal in comparison to Wheatear migrants which were found to be more ground-dwelling. The habitat preferences of the companion species we found here are furthermore in concordance with Kaboli et al. (2007) who showed – based on morphometric data – that the Cyprus Wheatear is a vegetation-tolerant species in contrast to Wheatear migrants which are morphologically more adapted to open ground.

Thus, we provide evidence that the presence or absence of a bird species in a given habitat can be determined by its bird and plant companion species. We showed that companion species – birds as well as plants – can be used as predictors for the presence or absence of the Cyprus Wheatear in a certain area. Furthermore, it was possible to identify control habitats and habitats of migrating Wheatears based on their bird and plant companion species.

In a more general context, it might be useful to determine the presence or absence of a species based on its companion species especially when the target species is difficult to localize due to camouflage or rare performance of bioacoustics. In addition, this approach shown here obviates the need for a time-consuming habitat analysis.

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