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Assessing woodland ecological characters through a new objective bird community index, the WBCI

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Abstract – Defining a bird species as a 'forest' one is often troublesome, owing to the lack of overall ecological knowledge and to differences among regions. In spite of this, in a lot of studies the set of 'forest' species is empirically chosen. The authors present an objective measure of the relationship existing, at the Italian national scale, between bird species and woods. Using data of the MITO2000 project (>17000 point-counts), 138 species were scored according to the alpha coefficient of the logistic function linking species-presence and wood-cover. A community index (WBCI), obtained simply as the arithmetic mean of the scores of all present species, has proven (trying it with independent samples) to be strictly linked with the actual degree of wood cover, either at small (e.g. point-count) or large (i.e. 20 km grid Atlas) scale. The WBCI was tested also for its response to various sampling-effort levels, showing stability also with very incomplete data-sets (2/3 the actual species richness). Owing to its stability, specificity, ease, and sensitiveness (allowing to detect also fine temporal habitat change trends), WBCI seems an useful and concise indicator of the complex relationships existing between woodland and birds.

INTRODUCTION

In the last decades many European countries have developed own bird population monitoring projects (Van Strien *et al.* 2001). Such kind of projects are basic knowledge tools to identify priority actions in biodiversity preservation policy and allow, at the same time, to verify effects of actions implemented (Gregory *et al.* 2005). The use of ecological indicators, particularly those related with bird population trends, does not concern biodiversity or nature conservation only, or such activities that are close to them, like agriculture (e.g. De la Concha 2005). Ecological indicators also provide useful knowledge basis to evaluate social welfare and life style level (Wilson and Fuller 2001, Huby *et al.* 2005). The growing importance that ecological indicator use has recently shown on different social issues, has led to consider with growing attention the procedures to choose right species selection (Gregory *et al.* 2005), promoting, in many instances, those based on objective methodologies, as well as the use of community indices rather than single-species data (Canterbury *et al.* 2000, Gregory *et al.* 2005).

It is just using community indices that, though indirectly, it is possible to evaluate, through changes registered the composition and structure of bird communities, the modifications occurred in the environment, especially those related with landscape structure (e.g. Preiss *et al.* 1997, Berthold 2003, Tellini Florenzano 2004).

In the recent past, two main phenomena have interested the European landscapes: the recovery of forested areas and the crisis of farming systems, especially those traditionally managed (Anon. 1995, Onrubia and Andrés 2005). Both phenomena are evidently linked each-other and can be explained mainly by changes in socio-economical conditions occurred at the European scale (Preiss *et al.* 1997, Chamberalain *et al.* 2000).

In the last 50 years, forests in Italy have doubled their surface, especially on mountain and hilly areas, jumping from a percent cover by approx. 18% to more than 32% (Falcucci *et al.* 2007). This process, still in action, has brought to an increase of many animal species (Boitani *et al.* 2003), and among them some birds (Laiolo *et al.* 2004, Tellini Florenzano 2004); this result, even with differences, can be generalised to many other European countries (Burfield and Van Bommel 2004).

The overall improvement in European forest conditions, and consequently in animal communities living therein, cannot be merely related to an increase in forest surface, but also in its quality. In the last years in fact, an increased attention towards naturalistic and sustainable management practices, with a revaluation of the traditional ones, has lead to an increase in the diversity of forested landscapes (Angelstam 1991, Angelstam *et al.* 2005, Angelstam and Elbakidze 2006). The capacity, and thus, the possibility, to detect such modifications has particular significance since organisms, and birds in particular, are sensitive to many environmental characteristics, and therefore to modifications occurring at different spatial scales (Lee *et al.* 2002, Lichstein *et al.* 2002, Crozier and Niemi 2003). Widespread phenomena, like forest expansion, are able in fact to influence, either positively or negatively, entire populations, even those living in areas marginally concerned by such events (Newton 1998).

The purpose of this paper is to present the results in defining a concise index (called WBCI) describing the bird community response to woodland at various spatial scales. We give also evidence for the usefulness of this index as a tool to detect important attributes of bird communities, allowing in turn to monitor structural changes in the woodland and in the landscape.

STUDY AREA AND METHODS

One of the main difficulties in elaborating indices for monitoring purposes, starting from living communiy data, is to define which species have to be considered, especially when working with specific habitat indices (e.g. for farmland birds). Very often the set of species is chosen starting from non-standardized ecological knowledge and/or from anectodal information. Other problems involve differences in species' habitat selection among different regions, that therefore reduce the usefulness of indices developed over wide geographical areas. To give an example, in the list of farmland species proposed by Gregory *et al.* (2005) for Europe, are comprised the Song Thrush and Dunnock. These two species do not breed in Mediterranean farmland at all (e.g. Meschini and Frugis 1993, Handrinos and Akriotis 1997, Martì and Del Moral 2003). It seems therefore necessary to build indices at the local scale (e.g. national), or at least to adapt the existing ones to the local conditions.

Our index is built starting from the data gathered in the MITO2000 project (Italian Breeding Bird Monitoring Scheme; see Fornasari *et al.* 2003, 2004), that consists in random chosen 10' point-counts, distributed in the whole Italian mainland. All birds contacted are reported, and also a corresponding habitat description is done by bird-observers, in terms of percent cover of third level Corine Land-cover categories (Büttner *et al.* 1998). First of all, starting from the 2000-2003 data-set, we have selected the 17903 points that were complete of bird- and habitat-data. Then, to obtain reliable species-scores, we have selected only the 138 species found in at least 50 poits.

The first step of our procedure is to define a score, for each species, representing the corresponding response to woodland, at the national scale. The score is the alpha coefficient of the simple logistic function linking species-presence with woodland cover (3.1 Corine Land Cover codes, see Büttner *et al.* 1998). Regression functions, for every species, were built using all presence points, comparing them with an equal number of non-presence points, randomly selected from the whole data-set (Manel *et al.* 2001). Because the alpha coefficients obtained have very small values, we have standardised them.

In the logistic regression the alpha coefficient can be considered as a concise indicator of the 'slope' of the relationship curve relating the dependent variable (in our case the presence of the species) and the independent one, woodland-cover (Hosmer and Lemeshow 1989). The coefficient can be positive or negative, indicating, respectively, a positive or negative relationship. Higher values (either positive or negative) indicate a stronger response (preference or avoidance) of the species to the wood-cover variable.

For a bird community, and in general for a given species-list, we define the WBCI ('Woodiness' Bird Community Index) as the arithmetic mean of the scores of all present species. To test the effectivennes and reliability of the WBCI, we have conducted a series of check-controls:

1 to test for the effectivenness of the index through different studies and scale levels, we have chosen seven different data-sets, spanning from point-counts to different grid-size breeding bird atlases (Tab. 1). For each set we have computed the correlation (Spearman) between wood-cover and WBCI;

2 we have also tested the index over multi-year data, verifying the possibility to apply it in detecting environmental changes. For this purpose we have used the data from the Foreste Casentinesi monitoring programme of breeding birds, spanning over 15 years (12-year sampling), that has already proven as a good data-set to monitor environmental change (Tellini Florenzano 2004). In this case the correlation was computed on the annual means of the point-count (N=174) WBCI values;

3 finally, we have checked the sensitivity of the WBCI to the sampling-effort level using a resampling procedure (Crowley 1992, Magurran 2004). To do that, we have taken species contact vectors, still from the Foreste Casentinesi data-set, collected in three different habitats: beech-fir continuous forest, mosaic-landscape (woods, shrub and pastures), and pastures. Through resampling (100 permutations each), we have estimated the WBCI at different species richness (i.e. species number) levels, obtaining index values (and confidence intervals) at all the possible richness levels resulting from underestimation of actual richness.

All the above calculations were made only considering the 138 species ranked in Appendix 1, rarer species, when present in the samples, were simply excluded.

RESULTS

The alpha logistic regression coefficients of the 138 evaluated species span from -0.0828 (Short-toed Lark) to 0.0448 (Eurasian Treecreeper), having a mean of -0.00727 (SD 0.0245). After standardization (i.e. putting SD=1 and mean=0), the range of the species scores spans from -3.08 to 2.12. The list of the scores is given in Appendix 1.

Tab. 2 shows the results of the Spearman correlation analyses conducted on the seven data-sets listed in Tab. 1, and on the multi-year Foreste Casentinesi data-set (see methods, point 2). Rho values are always highly significant, and the differences among values seem to be not linked with the scale-level of sampling. The WBCI seems therefore to work in similar ways both at the point-level and at wider areas-level. Considering the multi-year example (last row in Tab. 2) it seems that the WBCI can work well also over slight multi-temporal changes, being able to simply summarize a general trend, otherwise difficult to detect on the whole (Tellini Florenzano 2004).

Fig. 1 shows the results of the resamplings conducted on selected vectors of species. In all the three habitats chosen, the WBCI seems to reach reliable values at low richness-levels, i.e. it seems that the index can be used also with sampling-levels well below the actual bird community total richness. Some tendencies to overestimate (subset B) or underestimate (C) the actual WBCI value seem confined only at very low richness values (<1/3 of the actual value), this behaviour contributes to make usable the index also at low-sampling rates.

DISCUSSION

The WBCI seems to act as an useful indicator for describing multi-scale response of bird species communities or

Table 1. List of the data-sets used for testing the WBCI.

data-set	Scale level	source
Bibbiena municipality (Tuscany)	point-count	G. Londi *umpubl*.
Val di Cecina (Pisa, Tuscany)	point-count	Tellini Florenzano 1996
Foreste Casentinesi (Arezzo, Tuscany)	point-count	Tellini Florenzano 2004
Campania region	point-count	Courtesy M. F. Caliendo
Province of Bologna breeding bird atlas	square-grid of 5 km	Tinarelli *et al.* 2002
Tuscany region atlas of breeding birds	square-grid of ~10 km	Tellini Florenzano *et al.* 1997
Italian breeding bird atlas	square-grid of ~20 km	Meschini and Frugis 1993

Table 2. Spearman rho correlation coefficients between the WBCI and wood-cover, computed for the data-sets listed in Tab. 1, and for multi-year Foreste Casentinesi analysis (see methods).

data-set	N	Spearman rho	P
Bibbiena municipality (Tuscany)	214	0.721	< 0.01
Val di Cecina (Pisa, Tuscany)	403	0.835	< 0.01
Foreste Casentinesi (Arezzo, Tuscany)	174	0.729	< 0.01
Campania region	1319	0.617	< 0.01
province of Bologna breeding bird atlas	482	0.837	< 0.01
Tuscany region atlas of breeding birds	289	0.623	< 0.01
Italian breeding bird atlas	845	0.746	< 0.01
Foreste Casentinesi, multi-year analysis	12	0.855	< 0.01

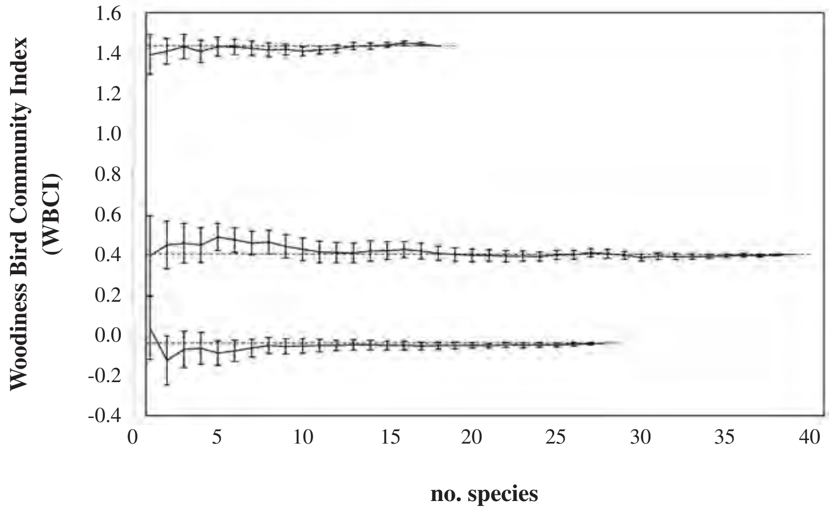

Figure 1. WBCI values (± 95% c.i.) at increasing levels of species number, obtained from random resampling the three data-subsets of the Foreste Casentinesi database (see methods): A, beech-fir continuous forest (total 18 bird species); B, mosaic landscape (wood, shrub, pastures, 39 species), C, pastures (28 species); dashed lines represent the WBCI obtained at the complete species set.

lists, to the wood-cover. This index derives directly from scores that describe the response of common species to local wood-cover, at the Italian scale. Species scores (Appendix 1), though not being directly judged in their reliability, owing to the lack of other independent classifications (at least at the same scale), seem to correctly arrange well known species-groups. Taking a look at Appendix 1, we note that, for example, the tit-group (genus *Parus*) is arranged from strictly forest-linked species (Crested and Coal Tits), through more ecotonal and generalist ones (Blue tit), reaching the lowest score with the Great Tit, whose breeding outside forests is well known (e.g. Farina 1983).

The WBCI itself, being computed from simple species lists (not taking into account abundance values), can be obtained from a lot of survey data, spanning from plot censuses to large-scale atlases. The only condition for its use is that all 'common' (i.e. listed in Appendix 1) breeding species have to be considered. Other properties of the index can be summarized as follows:

- the WBCI seems to give a stable measure also with variable sampling effort, and in particular it seems to give reliable values also when the actual bird-species assemblage is not completely known. Half the total species present (to give a rough picture) seem enough to obtain the 'true' value. The stability of the WBCI allows a wide range of comparison-opportunities among samples, in spite of different sampling efforts and methods;
- being a 'community' index, taking therefore into account almost the whole spectrum of bird species present, the use of the WBCI avoids completely the problems linked with species selection (e.g. 'umbrella' or 'flagship' species, Andelman and Fagan 2000, Linnell *et al.* 2000, Ozaki *et al.* 2006);
- as stated above, the WBCI seems to work indifferently at very variable spatial scale-levels, giving a syntethic picture of quite complex patterns (landscape structure) and processes (landscape change).

We are aware that our testing of the WBCI is only a first step in the validation of this index. Further applications can confirm its usefulness, perhaps revealing application limits not directly arguable from our data and analyses. To practically apply the WBCI we provisionally suggest some simple rules: a) when trying to evaluate communities, it is necessary to take all common species (i.e listed in Appendix 1) into account; b) the more complex is the studied landscape, the more sampled has to be, because the index is more variable in the case of communities composed by species having very variable scores.

Finally, we suggest that the species scores given in Appendix 1 can be used to objectively define the 'true forest species'; i.e. to select, within a species list, only those actually linked with woodland. A tentative threshold score-value of 1 or more seems to work well with actual data.

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Appendix 1. List of the species' standardized 'woodiness' scores. N is the respective number of presence-points.

	species	**woodiness score**	**N**
1	Eurasian Treecreeper (*Certhia familiaris*)	2.1216	103
2	Wood Warbler (*Phylloscopus sibilatrix*)	2.0190	91
3	Goldcrest (*Regulus regulus*)	1.8498	397
4	European Robin (*Erithacus rubecula*)	1.8279	3343
5	Firecrest (*Regulus ignicapilla*)	1.6989	590
6	Crested Tit (*Parus cristatus*)	1.6871	233
7	Coal Tit (*Parus ater*)	1.6460	1557
8	Eurasian Nuthatch (*Sitta europaea*)	1.6457	751
9	Eurasian Bullfinch (*Pyrrhula pyrrhula*)	1.6261	450
10	Black Woodpecker (*Dryocopus martius*)	1.5645	94
11	Marsh Tit (*Parus palustris*)	1.5355	461
12	Willow Tit (*Parus montanus*)	1.4949	221
13	Common Chiffchaff (*Phylloscopus collybita*)	1.4841	2653
14	Song Thrush (*Turdus philomelos*)	1.4658	846
15	Winter Wren (*Troglodytes troglodytes*)	1.4018	3488
16	Spotted Nutcracker (*Nucifraga caryocatactes*)	1.3148	265
17	Western Bonelli's Warbler (*Phylloscopus bonelli*)	1.3142	496
18	Short-toed Treecreeper (*Certhia brachydactyla*)	1.2310	584
19	Common Crossbill (*Loxia curvirostra*)	1.2239	140
20	White-throated Dipper (*Cinclus cinclus*)	1.2017	58
21	Mistle Thrush (*Turdus viscivorus*)	1.1763	542
22	Chaffinch (*Fringilla coelebs*)	1.1389	4009
23	European Blue Tit (*Parus caeruleus*)	1.0776	2875
24	Eurasian Jay (*Garrulus glandarius*)	1.0743	2640
25	Long-tailed Tit (*Aegithalos caudatus*)	1.0296	879
26	Great Spotted Woodpecker (*Dendrocopos major*)	1.0191	1277
27	Eurasian Sparrowhawk (*Accipiter nisus*)	0.9926	173
28	Grey Wagtail (*Motacilla cinerea*)	0.9585	382
29	Rock Bunting (*Emberiza cia*)	0.9089	219
30	Garden Warbler (*Sylvia borin*)	0.8454	142
31	Dunnock (*Prunella modularis*)	0.8259	390
32	Eurasian Green Woodpecker (*Picus viridis*)	0.7574	1688
33	Common Wood-Pigeon (*Columba palumbus*)	0.7531	1731
34	Great Tit (*Parus major*)	0.6893	5308
35	Blackcap (*Sylvia atricapilla*)	0.6759	4064
36	Ring Ouzel (*Turdus torquatus*)	0.6565	121
37	Eurasian Cuckoo (*Cuculus canorus*)	0.5986	3759
38	Short-toed Eagle (*Circaetus gallicus*)	0.5694	67
39	Fieldfare (*Turdus pilaris*)	0.5469	195
40	Carrion Crow (*Corvus corone*)	0.5314	334
41	Eurasian Crag Martin (*Ptyonoprogne rupestris*)	0.5277	284
42	Eurasian Blackbird (*Turdus merula*)	0.5197	4024
43	Tree Pipit (*Anthus trivialis*)	0.4922	561
44	European Honey-Buzzard (*Pernis apivorus*)	0.4896	199

continued

	species	woodiness score	N
45	Common Raven (*Corvus corax*)	0.4667	329
46	Subalpine Warbler (*Sylvia cantillans*)	0.4644	942
47	Lesser Whitethroat (*Sylvia curruca*)	0.4419	140
48	Golden Eagle (*Aquila chrysaetos*)	0.4327	67
49	Common Buzzard (*Buteo buteo*)	0.4033	1278
50	Yellowhammer (*Emberiza citrinella*)	0.3851	327
51	Eurasian Golden Oriole (*Oriolus oriolus*)	0.3632	1556
52	Spotted Flycatcher (*Muscicapa striata*)	0.3297	694
53	Cirl Bunting (*Emberiza cirlus*)	0.3243	2878
54	Common Redstart (*Phoenicurus phoenicurus*)	0.2932	842
55	European Turtle-Dove (*Streptopelia turtur*)	0.2468	3347
56	Black Kite (*Milvus migrans*)	0.2389	214
57	Peregrine Falcon (*Falco peregrinus*)	0.2138	78
58	Rock Sparrow (*Petronia petronia*)	0.2088	54
59	Eurasian Wryneck (*Jynx torquilla*)	0.1988	605
60	Woodlark (*Lullula arborea*)	0.1691	735
61	Alpine Swift (*Apus melba*)	0.1586	98
62	Common Kingfisher (*Alcedo atthis*)	0.1277	123
63	White Wagtail (*Motacilla alba*)	0.1075	1529
64	Eurasian Hoopoe (*Upupa epops*)	0.0248	1165
65	Dartford Warbler (*Sylvia undata*)	0.0139	58
66	Common Nightingale (*Luscinia megarhynchos*)	0.0111	4473
67	Melodious Warbler (*Hippolais polyglotta*)	-0.0015	698
68	Red-backed Shrike (*Lanius collurio*)	-0.0026	1069
69	Black Redstart (*Phoenicurus ochruros*)	-0.0339	878
70	Hooded Crow (*Corvus cornix*)	-0.0650	6457
71	Common Redpoll (*Carduelis flammea*)	-0.0759	145
72	Common Whitethroat (*Sylvia communis*)	-0.0806	726
73	Eurasian Hobby (*Falco subbuteo*)	-0.0841	85
74	Common Pheasant (*Phasianus colchicus*)	-0.1032	1623
75	European Greenfinch (*Carduelis chloris*)	-0.1550	3945
76	Whinchat (*Saxicola rubetra*)	-0.1758	138
77	Cetti's Warbler (*Cettia cetti*)	-0.2213	1246
78	Eurasian Penduline-Tit (*Remiz pendulinus*)	-0.2229	128
79	European Bee-eater (*Merops apiaster*)	-0.2379	745
80	European Serin (*Serinus serinus*)	-0.2500	4708
81	Sardinian Warbler (*Sylvia melanocephala*)	-0.2650	2363
82	Northern House Martin (*Delichon urbicum*)	-0.2885	3218
83	European Goldfinch (*Carduelis carduelis*)	-0.3127	5681
84	Sand Martin (*Riparia riparia*)	-0.3146	53
85	Eurasian Jackdaw (*Corvus monedula*)	-0.3173	494
86	Eurasian Linnet (*Carduelis cannabina*)	-0.3402	1070
87	Common Swift (*Apus apus*)	-0.3852	5084
88	Blue Rock-Thrush (*Monticola solitarius*)	-0.4176	125
89	Common Kestrel (*Falco tinnunculus*)	-0.4404	1222
90	Marsh Warbler (*Acrocephalus palustris*)	-0.4945	168
91	Great Crested Grebe (*Podiceps cristatus*)	-0.5226	116
92	Little Ringed Plover (*Charadrius dubius*)	-0.5233	95
93	Mallard (*Anas platyrhynchos*)	-0.5694	502
94	Grey Heron (*Ardea cinerea*)	-0.6125	753
95	Red-billed Chough (*Pyrrhocorax pyrrhocorax*)	-0.6442	93
96	Ortolan Bunting (*Emberiza hortulana*)	-0.6517	111

continued

	species	woodiness score	N
97	Montagu's Harrier (*Circus pygargus*)	-0.6536	61
98	Common Coot (*Fulica atra*)	-0.6669	215
99	Common Moorhen (*Gallinula chloropus*)	-0.6703	548
100	Rufous-tailed Rock-Thrush (*Monticola saxatilis*)	-0.6726	54
101	Common Tern (*Sterna hirundo*)	-0.6996	123
102	Common Starling (*Sturnus vulgaris*)	-0.7052	3983
103	Great Cormorant (*Phalacrocorax carbo*)	-0.7106	93
104	Barn Swallow (*Hirundo rustica*)	-0.7180	5551
105	Little Grebe (*Tachybaptus ruficollis*)	-0.7230	128
106	Common Quail (*Coturnix coturnix*)	-0.7329	518
107	Alpine Chough (*Pyrrhocorax graculus*)	-0.7353	162
108	Little Egret (*Egretta garzetta*)	-0.7425	494
109	Common Stonechat (*Saxicola torquatus*)	-0.7523	1870
110	Woodchat Shrike (*Lanius senator*)	-0.7648	271
111	House Sparrow (*Passer* (*domesticus*) *italiae*)	-0.7651	4024
112	Tawny Pipit (*Anthus campestris*)	-0.7655	278
113	Eurasian Collared-Dove (*Streptopelia decaocto*)	-0.7888	2591
114	Corn Bunting (*Emberiza calandra*)	-0.8013	2013
115	Yellow-legged Gull (*Larus michahellis*)	-0.8244	990
116	Spotless Starling (*Sturnus unicolor*)	-0.8318	439
117	Black-billed Magpie (*Pica pica*)	-0.8379	3826
118	Black-crowned Night-Heron (*Nycticorax nycticorax*)	-0.8475	259
119	Eurasian Tree-Sparrow (*Passer montanus*)	-0.8962	2606
120	Eurasian Reed-Warbler (*Acrocephalus scirpaceus*)	-0.9405	278
121	Black-headed Gull (*Larus ridibundus*)	-0.9975	163
122	Great Reed Warbler (*Acrocephalus arundinaceus*)	-1.0129	373
123	Little Owl (*Athene noctua*)	-1.1104	246
124	Zitting Cisticola (*Cisticola juncidis*)	-1.1426	1898
125	Water Pipit (*Anthus spinoletta*)	-1.1640	403
126	Spanish Sparrow (*Passer hispaniolensis*)	-1.1794	1188
127	Skylark (*Alauda arvensis*)	-1.2456	2419
128	Western Marsh Harrier (*Circus aeruginosus*)	-1.3234	157
129	Northern Wheatear (*Oenanthe oenanthe*)	-1.4217	352
130	Northern Lapwing (*Vanellus vanellus*)	-1.6240	99
131	Black-winged Stilt (*Himantopus himantopus*)	-1.6339	118
132	Crested Lark (*Galerida cristata*)	-1.7166	1571
133	Little Tern (*Sterna albifrons*)	-1.8883	51
134	Purple Heron (*Ardea purpurea*)	-1.9300	241
135	Calandra Lark (*Melanocorypha calandra*)	-1.9774	74
136	Yellow Wagtail (*Motacilla flava*)	-2.0640	934
137	Alpine Accentor (*Prunella collaris*)	-2.2630	113
138	Greater Short-toed Lark (*Calandrella brachydactyla*)	-3.0825	155