Oikos

o20008

Reif, J. and Flousek, J. 201**2.** The role of species' ecological traits in climatically driven altitudinal range shifts of central European birds. – Oikos 121: 1053–1060.

Appendix 1

Figure A1. Location of transects in the Giant Mountains, the Czech Republic, central Europe, along which birds were recorded at 201 census points during the breeding seasons of 1986–1988, 1996–1998 and 2006–2008, respectively. Numbers of transects correspond to their codes in the Table A4.

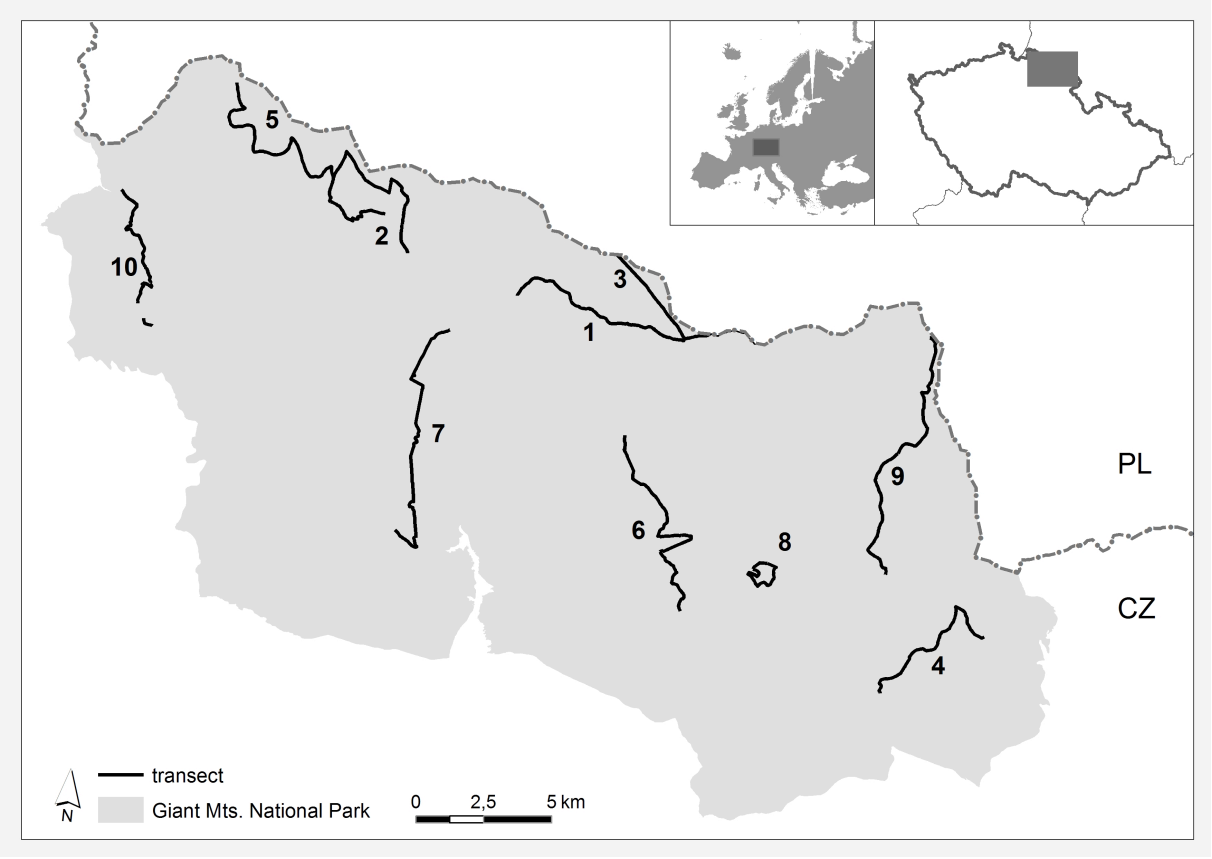

Table A1. Estimates of shifts in the altitudinal ranges of 51 bird species recorded in the Giant Mountains in 1986–1988, 1996–1998 and 2006–2008, respectively. The altitudinal range shift of a given species was computed by a generalized linear mixed effects model on its presence/absence at census points at different altitudes in the times periods studied. See the Methods section for more details on model specifics.

Species	Shift between 1986-1988 and 1996-1998		Shift between 1996-1998 and 2006-2008	
	estimate	SE	estimate	SE
Tetrao tetrix	0.00197	0.00672	-0.00785	0.00522
Columba palumbus	0.00389	0.00218	-0.00118	0.00168
Streptopelia turtur	0.00658	0.00547	0.00396	0.00529
Cuculus canorus	0.00065	0.00168	0.00194	0.00181
Dryocopus martius	-0.01064	0.00780	0.00619	0.00797
Dendrocopos major	-0.00355	0.00446	0.00156	0.00413
Alauda arvensis	-0.00389	0.00573	0.00123	0.00915
Anthus trivialis	0.00034	0.00154	0.00196	0.00179
Anthus pratensis	0.00173	0.00481	0.00902	0.00637
Anthus spinoletta	0.00061	0.01892	-0.00110	0.02190
Motacilla cinerea	-0.00025	0.00215	0.00225	0.00212
Motacilla alba	0.01247	0.00623	0.00882	0.01050
Troglodytes troglodytes	0.00003	0.00176	-0.00401	0.00190
Prunella modularis	0.00261	0.00191	0.00362	0.00221
Erithacus rubecula	-0.00663	0.00297	0.00162	0.00330
Luscinia svecica	0.07236	0.04744	-0.02955	0.14653
Phoenicurus ochruros	-0.00503	0.00323	0.00058	0.00372
Phoenicurus phoenicurus	0.01131	0.00746	-0.00428	0.00501
Saxicola rubetra	-0.00274	0.00372	0.01098	0.00536
Turdus torquatus	0.00087	0.00381	0.00344	0.00292
Turdus merula	0.00167	0.00277	0.00243	0.00232
Turdus philomelos	-0.00106	0.00224	0.00267	0.00214
Turdus viscirorus	-0.00185	0.00171	0.00104	0.00174
Sylvia curruca	0.01218	0.00615	-0.00087	0.00556
Sylvia communis	-0.00269	0.00506	0.00315	0.00401
Sylvia borin	0.01606	0.00714	-0.00365	0.00563
Sylvia atricapilla	0.00438	0.00243	0.00233	0.00222
Phylloscopus sibilatrix	-0.00485	0.00439	0.00199	0.00488
Phylloscopus collybita	0.00006	0.00148	0.00116	0.00144
Phylloscopus trochilus	0.00122	0.00151	0.00617	0.00174
Regulus regulus	-0.00598	0.00294	0.00010	0.00352
Regulus ignicapilla	-0.00064	0.00246	0.00225	0.00225
Ficedula hypoleuca	-0.00271	0.00592	0.00313	0.00508
Lophophanes cristatus	0.00011	0.00174	-0.00194	0.00175
Periparus ater	-0.00908	0.00310	0.00736	0.00313
Cyanistes caeruleus	0.00947	0.01645	0.00346	0.00737
Parus major	-0.01321	0.00910	0.01315	0.00908
Sitta europaea	-0.02379	0.01652	0.01342	0.00840

Certhia familiaris	-0.00329	0.00261	0.00197	0.00238
Lanius collurio	-0.00394	0.00741	0.00447	0.00696
Garrulus glandarius	-0.00048	0.00255	0.00173	0.00207
Nucifraga caryocatactes	-0.00176	0.01137	0.00578	0.01116
Fringilla coelebs	0.01680	0.01572	-0.00881	0.00599
Carduelis spinus	-0.00183	0.00152	0.00343	0.00140
Carduelis cannabina	-0.00788	0.00953	0.02409	0.00990
Carduelis flammea	-0.00238	0.00344	0.00813	0.00408
Loxia curvirostra	-0.00308	0.00155	0.00180	0.00151
Carpodacus erythrinus	-0.00619	0.00674	0.00745	0.00599
Pyrrhula pyrrhula	0.00032	0.00151	0.00053	0.00134
C. coccothraustes	-0.01848	0.00701	-0.00737	0.00852
Emberiza citrinella	0.00354	0.00768	0.01489	0.00829

Table A2. Characteristics of species recorded in the Giant Mountains used for the analyses of altitudinal range shifts. See the Methods section for detailed explanations of particular variables.

Species	Climatic niche breadth (°C)	Habitat niche position	Habitat niche breadth	Dietary niche	Original altitude of occurrence (m)
Tetrao tetrix	21.3	4.0	4	2	1171
Columba palumbus	25.8	2.5	3	1	875
Streptopelia turtur	23.9	4.0	4	1	780
Cuculus canorus	26.2	4.0	4	3	1030
Dryocopus martius	26.6	1.0	0	3	942
Dendrocopos major	25.4	2.5	3	2	790
Alauda arvensis	27.9	7.0	0	2	1300
Anthus trivialis	24.2	4.5	3	3	1049
Anthus pratensis	26.2	6.5	1	3	1240
Anthus spinoletta	22.0	7.0	0	3	1324
Motacilla cinerea	28.8	4.0	4	3	1041
Motacilla alba	28.8	5.0	2	3	1093
Troglodytes troglodytes	25.5	3.7	5	3	950
Prunella modularis	28.1	3.7	3	3	1034
Erithacus rubecula	28.8	2.5	3	3	974
Luscinia svecica	27.0	5.5	1	3	1376
Phoenicurus ochruros	24.4	5.7	3	3	1185
Phoenicurus phoenicurus	25.6	3.0	2	3	1041
Saxicola rubetra	24.7	6.5	1	3	1227
Turdus torquatus	22.8	3.3	3	2	1212
Turdus merula	27.9	2.3	3	2	868
Turdus philomelos	28.4	2.3	3	2	940
Turdus viscivorus	30.0	2.0	2	2	962
Sylvia curruca	22.5	4.5	1	3	946
Sylvia communis	23.6	5.5	1	3	1006
Sylvia borin	26.2	3.3	3	3	839
Sylvia atricapilla	24.6	3.3	3	3	932
Phylloscopus sibilatrix	22.6	2.0	0	3	857
Phylloscopus collybita	26.7	3.3	3	3	994
Phylloscopus trochilus	26.6	3.3	3	3	1057
Regulus regulus	26.6	1.0	0	3	960
Regulus ignicapilla	22.3	1.0	0	3	883
Ficedula hypoleuca	24.3	3.0	2	3	892
Lophophanes cristatus	26.4	1.0	0	2	942
Periparus ater	26.3	2.0	2	2	961
Cyanistes caeruleus	25.6	3.0	2	2	627
Parus major	28.4	3.0	2	2	780
Sitta europaea	25.6	2.3	3	2	826
Certhia familiaris	24.4	2.0	2	3	904
Lanius collurio	21.8	6.0	0	3	893
Garrulus glandarius	28.4	2.3	3	2	902
Nucifraga caryocatactes	23.7	1.0	0	2	998
Fringilla coelebs	28.4	3.3	4	2	1014
Carduelis spinus	23.9	2.3	3	1	975
Carduelis cannabina	24.4	5.0	2	1	1213

Carduelis flammea	21.8	4.0	2	1	1250
Loxia curvirostra	29.7	1.0	0	1	1008
Carpodacus erythrinus	10.9	5.0	2	1	1159
Pyrrhula pyrrhula	27.7	2.3	3	1	944
C. coccothraustes	24.5	3.0	2	1	1085
Emberiza citrinella	27.7	4.7	3	1	842

Table A3. Mean spring temperatures during the local breeding season (April–July) measured at three meteorological stations in the Giant Mountains in the time periods when the bird counts were carried out.

Year	Time period	Temperature (°C)		
		First station (650 m a.s.l.)	Second station (816 m a.s.l.)	Third station (1315 m a.s.l.)
1986	first	11.98	10.50	7.13
1987	first	10.63	9.10	5.80
1988	first	11.55	9.65	6.83
1996	second	10.08	9.30	6.70
1997	second	10.15	9.38	6.10
1998	second	11.60	10.73	7.63
2006	third	12.20	11.50	8.28
2007	third	12.55	11.50	8.65
2008	third	12.13	10.68	8.48

Table A4. Characteristics (altitude above sea level and relative forest cover within the radius of 100 m) of 201 census points in the Giant Mountains where the birds were recorded in 1986–1988, 1996–1998 and 2006–2008. Points were located along ten transects (Fig. A1; numbers of transects in this table correspond to their codes in Fig. A1).

Point	Transect	Altitude (m)	Relative forest cover (%)		
			1986-1988	1996-1998	2006-2008
1	1	792	70	70	70
2	1	802	50	40	40
3	1	826	70	70	70
4	1	859	40	30	30
5	1	874	65	65	65
6	1	906	90	90	90
7	1	923	70	70	70
8	1	967	25	25	25
9	1	1011	5	5	5
10	1	1053	60	60	60
11	1	1071	80	80	80
12	1	1139	40	40	40
13	1	1163	25	25	25
14	1	1196	20	20	20
15	1	1266	0	0	0
16	1	1339	0	0	0
17	1	1380	0	0	0
18	1	1421	0	0	0
19	1	1426	0	0	0
20	1	1428	0	0	0
21	2	1397	0	0	0
22	2	1384	0	0	0
23	2	1329	0	0	0
24	2	1307	0	0	0
25	2	1313	0	0	0
26	2	1339	0	0	0
27	2	1360	0	0	0
28	2	1371	0	0	0
29	2	1370	0	0	0
30	2	1359	0	0	0
31	2	1324	5	5	5
32	2	1253	10	10	10
33	2	1182	75	75	75
34	2	1126	80	60	60
35	2	1040	50	50	50
36	2	1091	95	95	95
37	2	1148	60	60	60
38	2	1219	55	55	55
39	2	1281	1	1	1
40	2	1339	0	0	0
41	2	1086	0	0	0

42	3	1346	0	0	0
43	3	1393	0	0	0
44	3	1458	0	0	0
45	3	1462	0	0	0
46	3	1397	0	0	0
47	3	1429	0	0	0
48	4	575	60	60	60
49	4	609	85	85	85
50	4	636	65	65	65
51	4	642	0	0	0
52	4	651	55	35	35
53	4	679	100	90	90
54	4	739	100	100	100
55	4	783	90	85	85
56	4	800	95	90	90
57	4	814	95	90	90
58	4	830	95	95	95
59	4	860	100	95	95
60	4	888	85	85	85
61	4	908	95	95	95
62	4	931	100	100	100
63	4	957	100	100	100
64	4	976	100	100	100
65	4	996	80	80	80
66	4	1005	95	95	95
67	4	1007	90	90	90
68	4	1017	55	55	55
69	4	1025	85	85	85
70	4	1033	100	100	100
71	4	1014	100	100	100
72	4	979	95	95	95
73	5	1063	0	0	0
74	5	1049	0	0	0
75	5	1023	0	0	0
76	5	1006	5	5	5
77	5	1010	50	45	45
78	5	1023	10	10	10
79	5	1036	90	45	45
80	5	1057	80	20	20
81	5	1058	70	0	0
82	5	1073	100	85	85
83	5	1073	50	0	0
84	5	1068	10	5	5
85	5	1063	0	0	0
86	5	1079	50	40	40
87	5	1099	90	90	90
88	5	1117	90	50	50
89	5	1133	80	0	0
90	5	1135	5	5	5
91	5	1129	5	5	5
92	5	1115	70	70	70
93	5	1100	80	55	50
94	5	1084	50	0	0

95	5	1114	30	30	30
96	5	1126	90	20	20
97	5	1126	85	45	45
98	5	1122	50	50	50
99	6	702	85	75	75
100	6	742	70	70	70
101	6	760	90	90	90
102	6	797	100	100	100
103	6	856	95	95	95
104	6	889	100	100	100
105	6	934	95	95	95
106	6	948	95	95	95
107	6	982	95	95	95
108	6	997	80	80	80
109	6	1018	100	100	100
110	6	1035	75	75	75
111	6	1043	40	30	5
112	6	1034	100	80	65
113	6	1053	65	0	0
114	6	1050	45	45	45
115	6	1055	40	40	40
116	6	1076	0	0	0
117	6	1119	15	0	0
118	6	1136	80	25	0
119	6	1150	80	30	15
120	6	1141	85	50	30
121	6	1142	80	40	5
122	6	1146	80	25	5
123	6	1175	90	90	90
124	6	1172	90	90	90
125	6	1191	90	60	60
126	7	932	85	80	80
127	7	1011	85	85	85
128	7	1013	100	80	80
129	7	1023	50	5	5
130	7	925	95	95	95
131	7	889	95	95	95
132	7	924	90	90	90
133	7	853	85	85	85
134	7	870	95	95	95
135	7	954	85	85	85
136	7	995	75	75	75
137	7	1025	80	35	35
138	7	971	75	70	70
139	7	996	90	30	30
140	7	1033	100	100	100
141	7	1018	100	100	100
142	7	983	100	100	100
143	7	938	100	100	100
144	7	952	100	100	100
145	7	1018	30	30	30
146	7	1071	0	0	0
147	7	1015	100	20	20

148	8	1203	100	100	100
149	8	1191	95	95	95
150	8	1186	95	95	20
151	8	1204	95	95	95
152	8	1186	95	95	95
153	8	1176	100	100	100
154	8	1110	0	0	0
155	8	1100	0	0	0
156	8	1080	0	0	0
157	9	712	85	85	85
158	9	749	100	100	100
159	9	793	85	85	85
160	9	815	45	45	45
161	9	820	80	80	80
162	9	836	100	100	100
163	9	851	100	100	70
164	9	873	100	100	100
165	9	863	100	100	100
166	9	845	95	95	95
167	9	829	100	100	100
168	9	855	95	95	95
169	9	870	90	85	60
170	9	910	95	95	95
171	9	944	85	65	65
172	9	966	0	0	0
173	9	1004	90	30	30
174	9	1065	45	45	45
175	9	1123	10	0	0
176	9	1120	40	40	40
177	9	1120	0	0	0
178	9	1136	0	0	0
179	9	1142	0	0	0
180	9	1096	0	0	0
181	9	1067	0	0	0
182	10	579	20	20	20
183	10	579	70	70	70
184	10	587	90	90	90
185	10	599	95	95	85
186	10	601	100	100	100
187	10	592	100	100	100
188	10	592	100	100	80
189	10	597	95	95	95
190	10	586	95	95	95
191	10	579	80	80	80
192	10	575	95	80	80
193	10	585	100	100	100
194	10	573	60	60	60
195	10	531	55	55	55
196	10	499	35	35	35
197	10	543	60	60	60
198	10	511	90	90	90
199	10	490	75	75	65
200	10	473	70	70	70

201	10	472	55	55	55