

Migratory connectivity analysis

by EURING Migration Atlas

Passer montanus (EURING code 15980)

1.1 Connectivity between individuals

The analysis evaluated 7008 individuals (14016 encounters) filtered from a total of 181786 records in the EURING databank which were considered for the Atlas. The species shows a significant connectivity from clustering, with a number of first-level clusters = 7 (Table 15980-1; Figure 15980-1).

Table 15980-1. Results from the migratory connectivity analysis. For each cluster, the degree of connectivity (r_M), its statistical significance (p-value) and 95% confidence interval limits are shown. When the p-value is less than or equal to 0.1, the degree of clustering structure (oasw) and the best number of clusters identified are reported.

Cluster name	Level of clustering	N individuals	Migratory connectivity (r_M)	p-value	Lower 95% confidence limit	Upper 95% confidence limit	Best number of clusters	oasw
0	0	7008	0.996	0.001	0.994	0.998	7	0.594
1	1	724	0.986	0.001	0.973	0.996	6	0.586
2	1	935	0.988	0.001	0.979	0.994	9	0.496
3	1	1448	0.809	0.001	0.760	0.859	3	0.504
4	1	2852	0.993	0.001	0.989	0.996	9	0.611
5	1	435	0.957	0.001	0.902	1.000	6	0.855
6	1	412	0.999	0.001	0.996	1.000	9	0.641
7	1	202	0.999	0.001	0.997	1.000	9	0.676
11	2	36	1.000	0.001	1.000	1.000	2	0.998
12	2	124	0.981	0.001	0.961	0.996	9	0.758
13	2	226	0.863	0.001	0.817	0.953	9	0.687
14	2	35	1.000	0.001	1.000	1.000	6	0.898
15	2	176	0.972	0.001	0.926	1.000	9	0.864
16	2	127	0.849	0.001	0.728	0.971	9	0.679
31	2	681	0.442	0.001	0.357	0.544	2	0.474
32	2	577	0.909	0.001	0.838	0.964	9	0.586
33	2	190	0.922	0.001	0.864	0.967	9	0.606
41	2	288	0.593	0.001	0.425	0.800	8	0.759
42	2	326	0.919	0.001	0.855	0.975	6	0.698
43	2	432	0.863	0.001	0.780	0.940	9	0.829
44	2	257	0.972	0.001	0.935	0.999	9	0.800
45	2	115	0.983	0.001	0.952	0.997	9	0.637
46	2	676	0.807	0.001	0.736	0.862	7	0.685
47	2	422	0.949	0.001	0.897	0.996	9	0.861
48	2	150	0.968	0.001	0.931	0.992	5	0.856
49	2	186	0.990	0.001	0.971	1.000	9	0.754
51	2	13	-	-	-	-	-	-

Cluster name	Level of clustering	N individuals	Migratory connectivity (r_M)	p-value	Lower 95% confidence limit	Upper 95% confidence limit	Best number of clusters	oasw
52	2	22	0.987	0.001	0.956	1.000	9	0.755
53	2	21	1.000	0.001	1.000	1.000	3	0.934
54	2	343	0.995	0.001	0.986	0.999	4	0.818
55	2	8	-	-	-	-	-	-
56	2	28	1.000	0.001	1.000	1.000	5	0.982
61	2	54	0.998	0.001	0.993	1.000	8	0.809
62	2	32	0.997	0.001	0.993	1.000	8	0.749
63	2	53	0.917	0.001	0.784	0.999	9	0.774
64	2	69	0.989	0.001	0.962	1.000	2	0.774
65	2	51	0.999	0.001	0.999	1.000	9	0.811
66	2	25	0.997	0.005	0.133	1.000	2	0.948
67	2	84	0.977	0.001	0.898	1.000	3	0.905
68	2	23	0.997	0.001	0.989	1.000	7	0.678
69	2	21	0.993	0.001	0.989	1.000	5	0.728
71	2	43	1.000	0.001	0.999	1.000	9	0.661
72	2	15	-	-	-	-	-	-
73	2	22	0.993	0.001	0.982	1.000	2	0.736
74	2	8	-	-	-	-	-	-
75	2	23	0.986	0.001	0.924	1.000	3	0.847
76	2	54	0.991	0.001	0.972	1.000	7	0.924
77	2	27	0.982	0.001	0.927	0.995	2	0.840
78	2	1	-	-	-	-	-	-
79	2	9	-	-	-	-	-	-
111	3	3	-	-	-	-	-	-
112	3	33	1.000	0.001	1.000	1.000	2	0.948
121	3	17	-	-	-	-	-	-
122	3	51	0.991	0.001	0.984	0.999	4	0.906
123	3	9	-	-	-	-	-	-
124	3	1	-	-	-	-	-	-
125	3	6	-	-	-	-	-	-
126	3	5	-	-	-	-	-	-
127	3	3	-	-	-	-	-	-
128	3	27	0.389	0.058	0.013	0.995	6	0.889
129	3	5	-	-	-	-	-	-
131	3	14	-	-	-	-	-	-
132	3	1	-	-	-	-	-	-
133	3	12	-	-	-	-	-	-
134	3	32	0.974	0.001	0.969	1.000	2	0.945
135	3	51	0.818	0.001	0.744	0.999	2	0.914
136	3	17	-	-	-	-	-	-
137	3	20	0.692	0.002	0.386	0.999	5	0.857
138	3	14	-	-	-	-	-	-
139	3	65	1.000	0.001	1.000	1.000	4	0.985
141	3	8	-	-	-	-	-	-
142	3	9	-	-	-	-	-	-
143	3	1	-	-	-	-	-	-
144	3	1	-	-	-	-	-	-
145	3	9	-	-	-	-	-	-
146	3	7	-	-	-	-	-	-
151	3	29	0.999	0.001	0.961	1.000	2	0.952

Cluster name	Level of clustering	N individuals	Migratory connectivity (r_M)	p-value	Lower 95% confidence limit	Upper 95% confidence limit	Best number of clusters	oasw
152	3	42	1.000	0.001	0.443	1.000	2	0.965
153	3	8	-	-	-	-	-	-
154	3	2	-	-	-	-	-	-
155	3	69	1.000	0.001	1.000	1.000	4	1.000
156	3	1	-	-	-	-	-	-
157	3	17	-	-	-	-	-	-
158	3	6	-	-	-	-	-	-
159	3	2	-	-	-	-	-	-
161	3	10	-	-	-	-	-	-
162	3	32	1.000	0.001	1.000	1.000	7	0.903
163	3	20	0.870	0.001	0.810	1.000	5	0.776
164	3	8	-	-	-	-	-	-
165	3	4	-	-	-	-	-	-
166	3	24	1.000	0.042	0.999	1.000	2	0.957
167	3	11	-	-	-	-	-	-
168	3	5	-	-	-	-	-	-
169	3	13	-	-	-	-	-	-
321	3	88	0.831	0.001	0.731	0.922	6	0.742
322	3	16	-	-	-	-	-	-
323	3	27	0.707	0.001	0.587	1.000	6	0.858
324	3	53	1.000	0.001	1.000	1.000	4	1.000
325	3	46	0.906	0.001	0.788	0.990	9	0.789
326	3	38	0.847	0.001	0.757	1.000	9	0.893
327	3	96	0.914	0.001	0.881	0.992	5	0.833
328	3	132	0.983	0.001	0.962	0.995	5	0.843
329	3	81	0.856	0.001	0.777	1.000	5	0.971
331	3	3	-	-	-	-	-	-
332	3	25	0.764	0.001	0.510	1.000	7	0.823
333	3	35	0.544	0.001	0.310	0.757	9	0.572
334	3	33	1.000	0.035	1.000	1.000	2	0.970
335	3	21	0.337	0.030	0.114	0.857	9	0.559
336	3	5	-	-	-	-	-	-
337	3	51	0.926	0.001	0.867	0.999	9	0.830
338	3	8	-	-	-	-	-	-
339	3	9	-	-	-	-	-	-
411	3	3	-	-	-	-	-	-
412	3	30	0.614	0.001	0.502	0.767	2	0.618
413	3	14	-	-	-	-	-	-
414	3	13	-	-	-	-	-	-
415	3	130	0.871	0.001	0.713	0.959	4	0.833
416	3	74	0.820	0.001	0.357	1.000	2	0.951
417	3	2	-	-	-	-	-	-
418	3	22	-	-	-	-	-	-
421	3	21	0.858	0.001	0.740	0.973	2	0.712
422	3	123	0.848	0.001	0.703	0.961	7	0.767
423	3	28	0.971	0.001	0.904	1.000	3	0.932
424	3	70	0.989	0.001	0.958	1.000	9	0.943
425	3	53	0.998	0.001	0.343	1.000	2	0.975
426	3	31	0.943	0.001	0.899	0.995	5	0.850
431	3	8	-	-	-	-	-	-

Cluster name	Level of clustering	N individuals	Migratory connectivity (r_M)	p-value	Lower 95% confidence limit	Upper 95% confidence limit	Best number of clusters	oasw
432	3	38	0.767	0.001	0.678	0.906	6	0.887
433	3	5	-	-	-	-	-	-
434	3	7	-	-	-	-	-	-
435	3	183	-0.008	0.507	-0.019	-0.005	-	-
436	3	20	0.553	0.027	0.352	1.000	5	0.850
437	3	105	0.588	0.001	0.357	0.875	9	0.903
438	3	5	-	-	-	-	-	-
439	3	61	0.250	0.060	-0.083	0.683	2	0.844
441	3	96	0.867	0.001	0.254	0.983	9	0.934
442	3	26	1.000	0.002	1.000	1.000	2	0.948
443	3	8	-	-	-	-	-	-
444	3	22	0.969	0.001	0.939	0.992	8	0.949
445	3	19	-	-	-	-	-	-
446	3	15	-	-	-	-	-	-
447	3	39	1.000	0.001	1.000	1.000	3	1.000
448	3	12	-	-	-	-	-	-
449	3	20	0.739	0.001	0.346	0.997	4	0.819
451	3	4	-	-	-	-	-	-
452	3	13	-	-	-	-	-	-
453	3	6	-	-	-	-	-	-
454	3	37	0.313	0.052	0.046	0.892	2	0.813
455	3	13	-	-	-	-	-	-
456	3	2	-	-	-	-	-	-
457	3	24	0.982	0.001	0.476	1.000	6	0.875
458	3	12	-	-	-	-	-	-
459	3	4	-	-	-	-	-	-
461	3	5	-	-	-	-	-	-
462	3	176	0.381	0.001	0.134	0.583	9	0.840
463	3	227	0.255	0.001	0.143	0.377	9	0.922
464	3	140	0.852	0.001	0.153	0.977	2	0.956
465	3	25	-	-	-	-	-	-
466	3	74	-0.009	0.551	-0.081	0.159	-	-
467	3	29	-0.096	1.000	-0.127	-0.049	-	-
471	3	8	-	-	-	-	-	-
472	3	52	1.000	0.001	1.000	1.000	3	0.990
473	3	11	-	-	-	-	-	-
474	3	15	-	-	-	-	-	-
475	3	109	0.586	0.006	0.046	0.935	7	0.963
476	3	158	0.836	0.001	0.591	0.997	6	0.985
477	3	7	-	-	-	-	-	-
478	3	39	0.994	0.001	0.989	1.000	2	0.947
479	3	23	0.947	0.038	0.879	1.000	2	0.938
481	3	24	0.700	0.001	0.464	0.996	6	0.792
482	3	110	0.756	0.001	0.611	0.982	8	0.907
483	3	6	-	-	-	-	-	-
484	3	8	-	-	-	-	-	-
485	3	2	-	-	-	-	-	-
491	3	51	1.000	0.001	1.000	1.000	6	1.000
492	3	14	-	-	-	-	-	-
493	3	27	0.970	0.001	0.947	0.999	6	0.776

Cluster name	Level of clustering	N individuals	Migratory connectivity (r_M)	p-value	Lower 95% confidence limit	Upper 95% confidence limit	Best number of clusters	oasw
494	3	39	0.987	0.001	0.981	1.000	2	0.950
495	3	6	-	-	-	-	-	-
496	3	11	-	-	-	-	-	-
497	3	25	0.992	0.004	0.835	1.000	2	0.940
498	3	9	-	-	-	-	-	-
499	3	4	-	-	-	-	-	-
521	3	1	-	-	-	-	-	-
522	3	2	-	-	-	-	-	-
523	3	6	-	-	-	-	-	-
524	3	3	-	-	-	-	-	-
525	3	2	-	-	-	-	-	-
526	3	2	-	-	-	-	-	-
527	3	3	-	-	-	-	-	-
528	3	2	-	-	-	-	-	-
529	3	1	-	-	-	-	-	-
531	3	6	-	-	-	-	-	-
532	3	14	-	-	-	-	-	-
533	3	1	-	-	-	-	-	-
541	3	8	-	-	-	-	-	-
542	3	8	-	-	-	-	-	-
543	3	54	0.955	0.001	0.863	1.000	6	0.965
544	3	273	0.977	0.001	0.946	0.993	9	0.955
561	3	3	-	-	-	-	-	-
562	3	14	-	-	-	-	-	-
563	3	6	-	-	-	-	-	-
564	3	3	-	-	-	-	-	-
565	3	2	-	-	-	-	-	-
611	3	3	-	-	-	-	-	-
612	3	15	-	-	-	-	-	-
613	3	11	-	-	-	-	-	-
614	3	5	-	-	-	-	-	-
615	3	3	-	-	-	-	-	-
616	3	5	-	-	-	-	-	-
617	3	1	-	-	-	-	-	-
618	3	11	-	-	-	-	-	-
621	3	4	-	-	-	-	-	-
622	3	11	-	-	-	-	-	-
623	3	3	-	-	-	-	-	-
624	3	5	-	-	-	-	-	-
625	3	3	-	-	-	-	-	-
626	3	3	-	-	-	-	-	-
627	3	1	-	-	-	-	-	-
628	3	2	-	-	-	-	-	-
631	3	4	-	-	-	-	-	-
632	3	1	-	-	-	-	-	-
633	3	2	-	-	-	-	-	-
634	3	4	-	-	-	-	-	-
635	3	6	-	-	-	-	-	-
636	3	5	-	-	-	-	-	-
637	3	10	-	-	-	-	-	-

Cluster name	Level of clustering	N individuals	Migratory connectivity (r_M)	p-value	Lower 95% confidence limit	Upper 95% confidence limit	Best number of clusters	oasw
638	3	20	0.785	0.053	0.580	1.000	3	0.900
639	3	1	-	-	-	-	-	-
641	3	61	0.935	0.001	0.852	0.999	9	0.679
642	3	8	-	-	-	-	-	-
651	3	8	-	-	-	-	-	-
652	3	6	-	-	-	-	-	-
653	3	8	-	-	-	-	-	-
654	3	8	-	-	-	-	-	-
655	3	5	-	-	-	-	-	-
656	3	2	-	-	-	-	-	-
657	3	4	-	-	-	-	-	-
658	3	8	-	-	-	-	-	-
659	3	2	-	-	-	-	-	-
661	3	24	0.295	0.078	0.046	0.719	7	0.820
662	3	1	-	-	-	-	-	-
671	3	7	-	-	-	-	-	-
672	3	76	0.583	0.001	0.379	0.947	4	1.000
673	3	1	-	-	-	-	-	-
681	3	1	-	-	-	-	-	-
682	3	6	-	-	-	-	-	-
683	3	7	-	-	-	-	-	-
684	3	2	-	-	-	-	-	-
685	3	4	-	-	-	-	-	-
686	3	2	-	-	-	-	-	-
687	3	1	-	-	-	-	-	-
691	3	6	-	-	-	-	-	-
692	3	7	-	-	-	-	-	-
693	3	4	-	-	-	-	-	-
694	3	2	-	-	-	-	-	-
695	3	2	-	-	-	-	-	-
711	3	3	-	-	-	-	-	-
712	3	1	-	-	-	-	-	-
713	3	8	-	-	-	-	-	-
714	3	4	-	-	-	-	-	-
715	3	1	-	-	-	-	-	-
716	3	1	-	-	-	-	-	-
717	3	14	-	-	-	-	-	-
718	3	10	-	-	-	-	-	-
719	3	1	-	-	-	-	-	-
731	3	16	-	-	-	-	-	-
732	3	6	-	-	-	-	-	-
751	3	4	-	-	-	-	-	-
752	3	18	-	-	-	-	-	-
753	3	1	-	-	-	-	-	-
761	3	44	0.060	0.166	-0.060	0.288	-	-
762	3	2	-	-	-	-	-	-
763	3	2	-	-	-	-	-	-
764	3	1	-	-	-	-	-	-
765	3	1	-	-	-	-	-	-
766	3	1	-	-	-	-	-	-

Cluster name	Level of clustering	N individuals	Migratory connectivity (r_M)	p-value	Lower 95% confidence limit	Upper 95% confidence limit	Best number of clusters	oasw
767	3	3	-	-	-	-	-	-
771	3	24	0.935	0.001	0.162	0.988	2	0.843
772	3	3	-	-	-	-	-	-

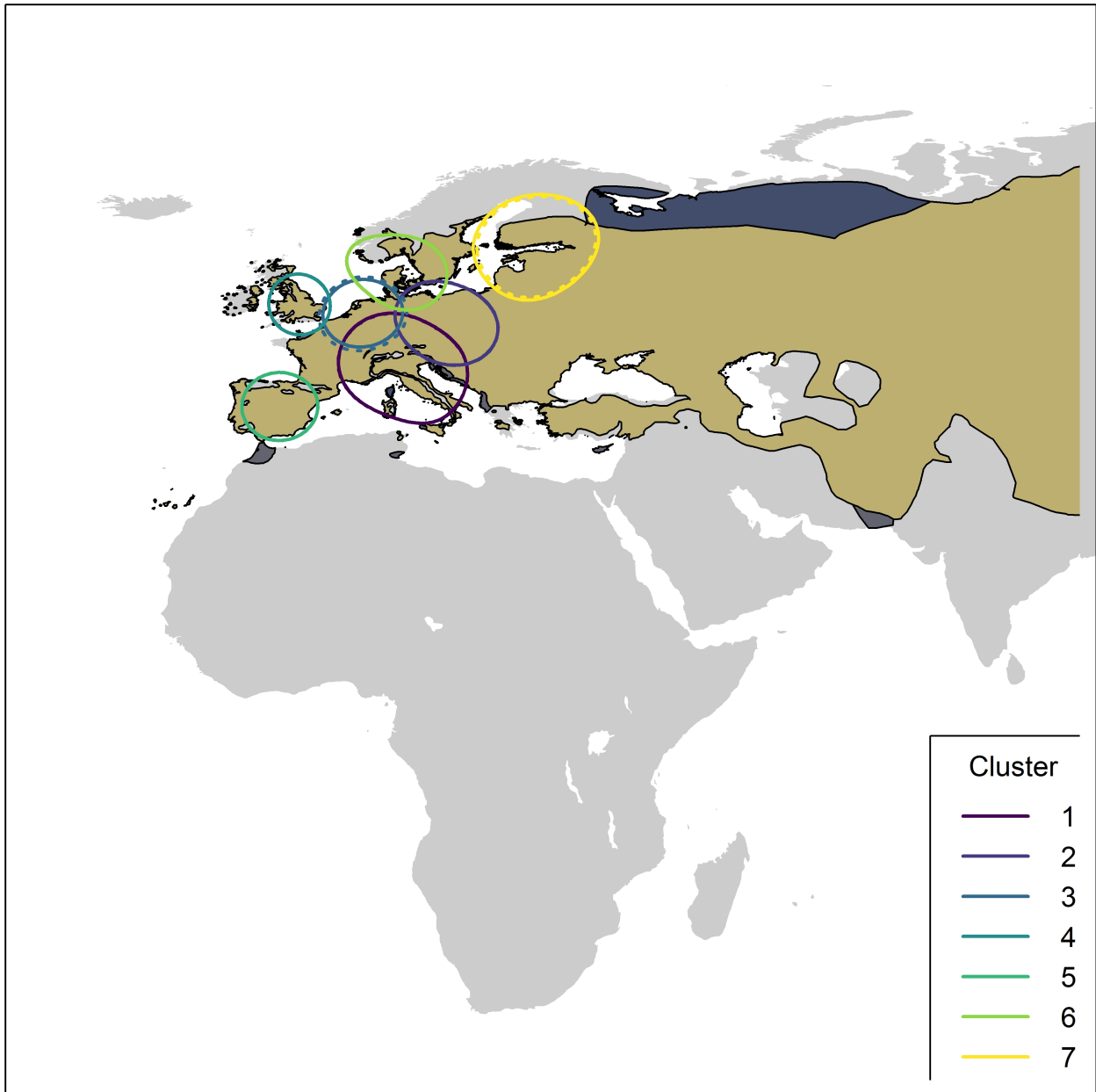


Figure 15980-1. Map showing 95% kernel contours of of first-level clusters identified by the migratory connectivity analysis, if any, or 95% kernel contours of all encounters, in case of no clustering structure. Solid lines indicate the clusters in the breeding range, dotted lines those in the non-breeding range. Different contour colours correspond to different clusters, as reported in legend. The species distribution range is also shown (breeding range: blue; non-breeding range: dark grey; resident range: beige; from BirdLife

International, 2019).

1.2 Sensitivity analysis

Results of power analysis and validation. Analyses at the species level were re-run on subsamples of individuals of decreasing size (100 repetitions per subsample size), according to simple random sampling of individuals (Figure 15980-2) and stratified sampling of individuals within the breeding range (Figure 15980-3) and the non breeding range (Figure 15980-4). For stratified sampling, we selected individuals with a probability inversely proportional to the number of observation in each country. Figures below report the results of the procedure.

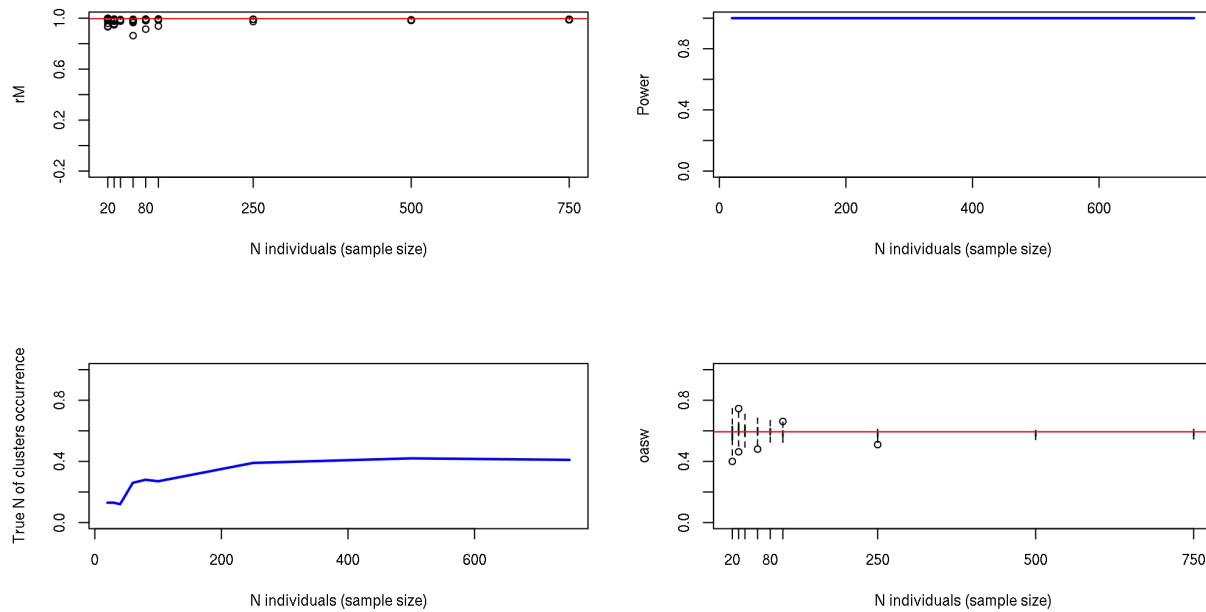


Figure 15980-2. Top left: simulated distribution (boxplots) and observed value (red line) of connectivity. Top right: Simulated power of the analysis (i.e. proportion of times the analyses on the subset of individuals was significant). Bottom left: Proportion of times the analysis provides the observed best number of cluster. Bottom right: simulated distribution (boxplots) and observed value (red line) of clustering intensity.

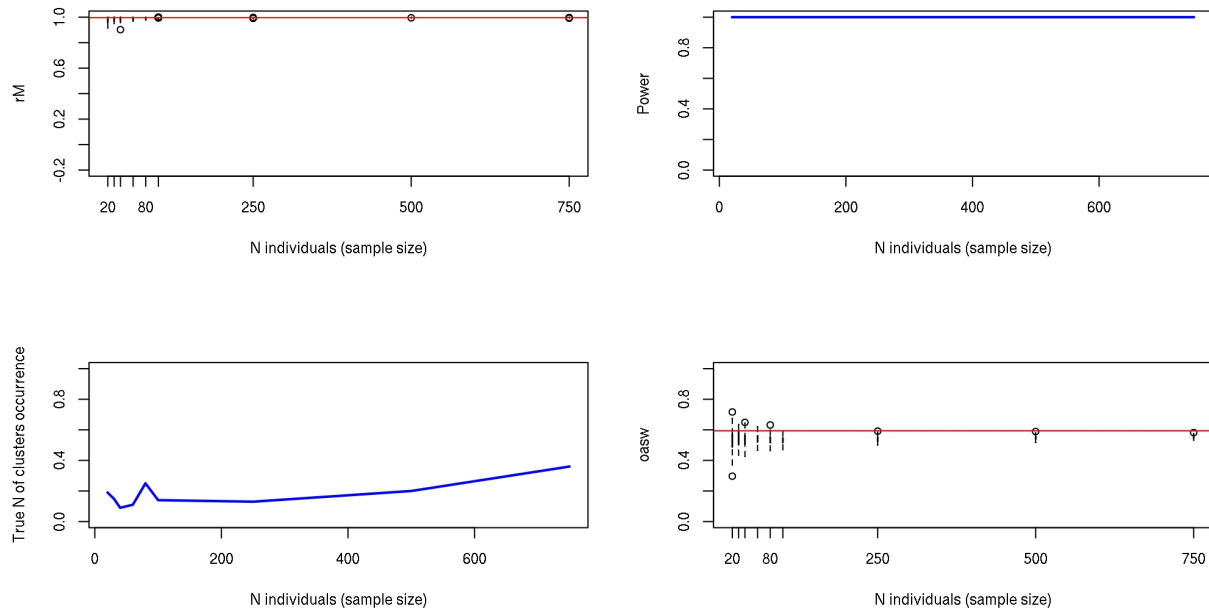


Figure 15980-3. Top left: simulated distribution (boxplots) and observed value (red line) of connectivity. Top right: Simulated power of the analysis. Bottom left: Proportion of times the analysis provides the observed best number of cluster. Bottom right: simulated distribution (boxplots) and observed value (red line) of clustering intensity.

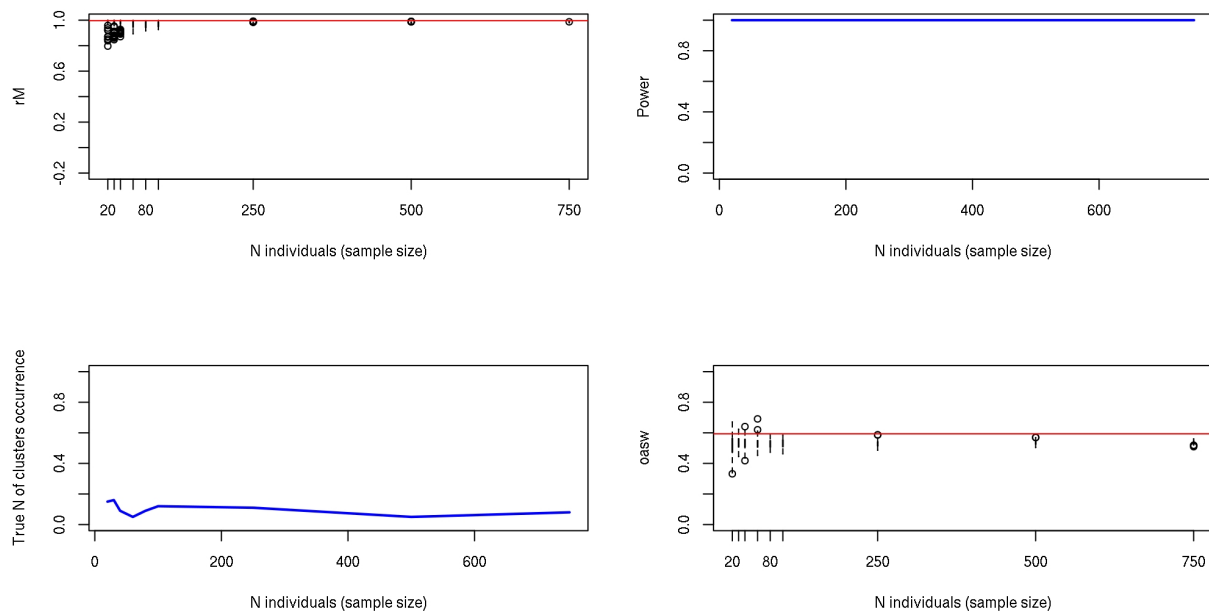


Figure 15980-4. Top left: simulated distribution (boxplots) and observed value (red line) of connectivity. Top right: Simulated power of the analysis. Bottom left: Proportion of times the analysis provides the observed best number of cluster. Bottom right: simulated distribution (boxplots) and observed value (red line) of clustering intensity.

The comparison between the bootstrapped distribution of r_M values from live recaptures and dead recoveries is not significant ($p = 0.853$); Figure 15980-5).

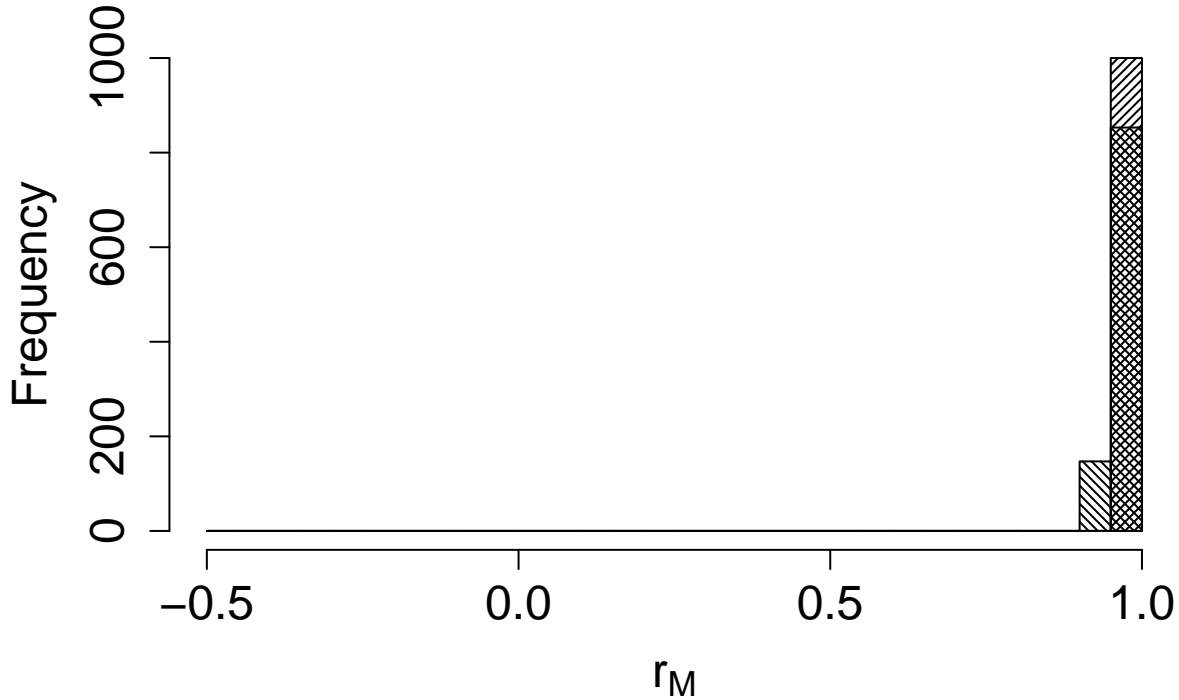


Figure 15980-5. Comparison between the bootstrapped distributions of connectivity value for alive recaptures (filling lines with angle=45°) and dead recoveries (filling lines with angle=37°).

2. Connectivity between pre-defined regions

The species shows high connectivity ($MC = 0.999$; $MC = 0.999$ when adjusted for absolute abundance) between 8 breeding regions and 8 non breeding regions (Table 15980-2; Figure 15980-6).

Table 15980-2. Transition probabilities between pre-defined regions. Estimated abundance (number of individuals) in each breeding region is also reported.

Breeding region	Abundance	Non breeding region	Transition probability
Central Europe	10384800	Central Europe	0.993
Central Europe	10384800	East Europe	0.001
Central Europe	10384800	South-central Europe	0.001
Central Europe	10384800	South-east Europe	0.001
Central Europe	10384800	West Europe	0.004
East Europe	30205192	East Europe	1.000
North Europe	2219000	North Europe	1.000
North-west Europe	404000	North-west Europe	0.999
North-west Europe	404000	West Europe	0.001
South-central Europe	3576629	South-central Europe	0.998

Breeding region	Abundance	Non breeding region	Transition probability
South-central Europe	3576629	South-west Europe	0.002
South-east Europe	9025000	South-east Europe	1.000
South-west Europe	5178734	South-west Europe	1.000
West Europe	479489	Central Europe	0.010
West Europe	479489	North-west Europe	0.003
West Europe	479489	South-central Europe	0.001
West Europe	479489	South-west Europe	0.004
West Europe	479489	West Europe	0.982

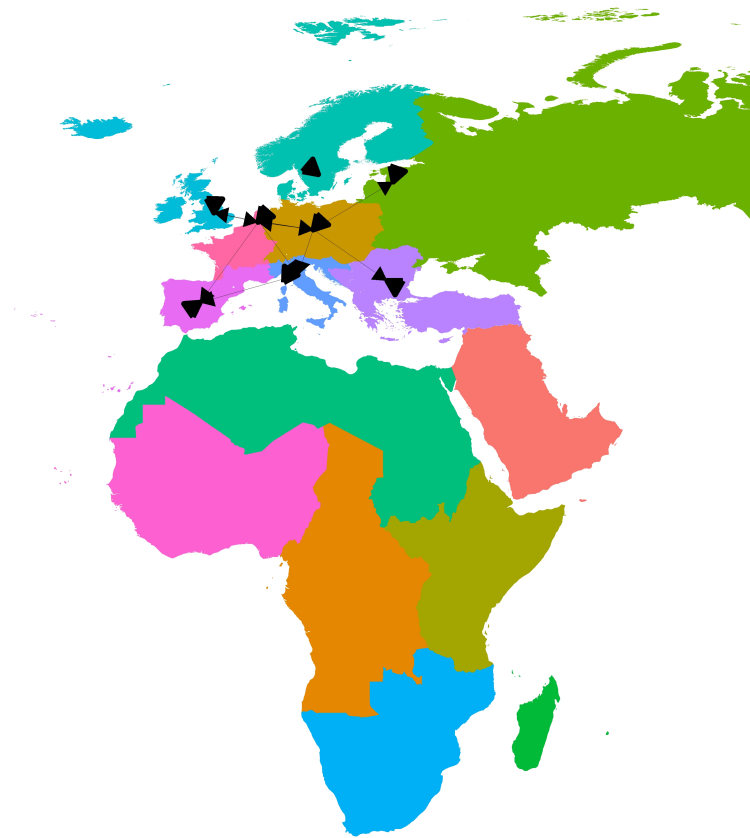


Figure 15980-6. Map showing pre-defined regions in different colours, with black arrows linking centroids of individual encounters in different regions. Arrow width is proportional to transition probability.

Reference

BirdLife International and Handbook of the Birds of the World (2019). Bird species distribution maps of the world. Version 2019.1. Available at <http://datazone.birdlife.org/species/requestdis>.