

# Migratory connectivity analysis

by EURING Migration Atlas

*Parus ater* (EURING code 14610)

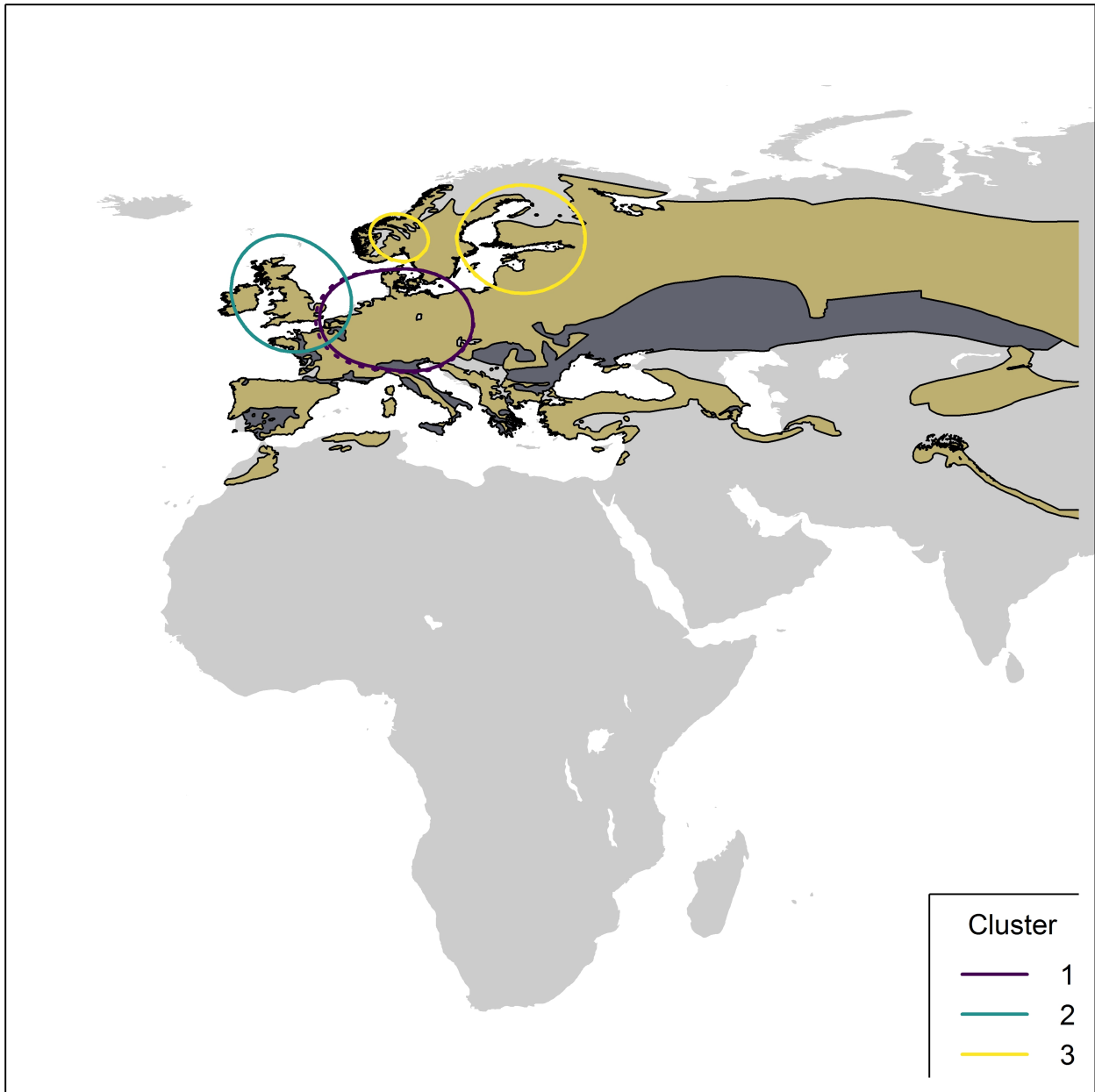
## 1.1 Connectivity between individuals

The analysis evaluated 5211 individuals (10422 encounters) filtered from a total of 292208 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 = 3 (Table 14610-1; Figure 14610-1).

**Table 14610-1.** 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	5211	0.992	0.001	0.990	0.995	3	0.601
1	1	1471	0.930	0.001	0.898	0.956	4	0.549
2	1	3343	0.999	0.001	0.998	1.000	9	0.482
3	1	397	0.989	0.001	0.980	0.996	2	0.774
11	2	332	0.606	0.001	0.436	0.751	6	0.665
12	2	844	0.923	0.001	0.882	0.958	3	0.632
13	2	200	0.860	0.001	0.766	0.920	2	0.803
14	2	95	0.924	0.001	0.832	0.992	3	0.728
31	2	327	0.973	0.001	0.949	0.989	5	0.500
32	2	70	0.763	0.001	0.559	0.994	8	0.607
111	3	82	0.599	0.001	0.482	0.751	5	0.455
112	3	21	0.431	0.047	0.350	0.999	2	0.841
113	3	193	0.445	0.002	0.196	0.756	6	0.331
114	3	10	-	-	-	-	-	-
115	3	6	-	-	-	-	-	-
116	3	20	0.845	0.001	0.551	0.991	2	0.550
121	3	80	0.800	0.001	0.725	0.905	2	0.789
122	3	90	0.781	0.001	0.533	1.000	8	0.537
123	3	674	0.879	0.001	0.761	0.957	7	0.622
131	3	189	0.603	0.001	0.485	0.715	2	0.705
132	3	11	-	-	-	-	-	-
141	3	42	0.774	0.001	0.491	0.913	9	0.536
142	3	24	1.000	0.001	1.000	1.000	5	0.799
143	3	29	1.000	0.001	1.000	1.000	3	0.964
321	3	19	-	-	-	-	-	-
322	3	18	-	-	-	-	-	-
323	3	3	-	-	-	-	-	-

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
324	3	6	-	-	-	-	-	-
325	3	6	-	-	-	-	-	-
326	3	16	-	-	-	-	-	-
327	3	1	-	-	-	-	-	-
328	3	1	-	-	-	-	-	-

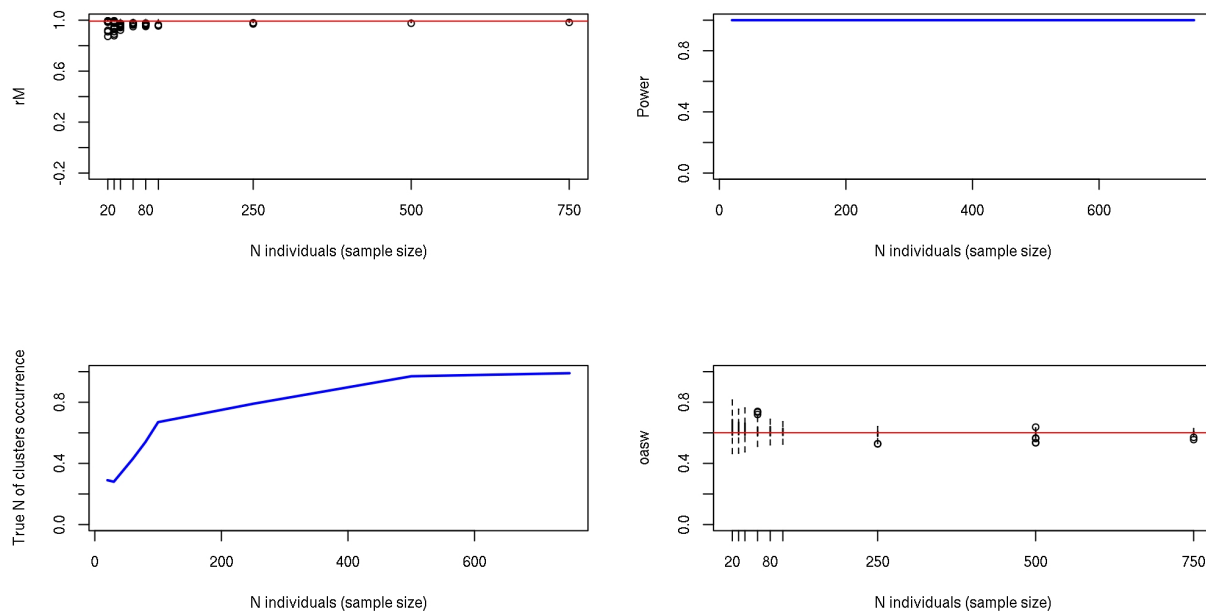


**Figure 14610-1.** Map showing 95% kernel contours of of first-level clusters identified by the migratory connectivity analysis, if any, or 95% kernel contours of all encounters, in case of no clustering structure. Solid lines indicate the clusters in the breeding range, dotted lines those in the non-breeding range. Different

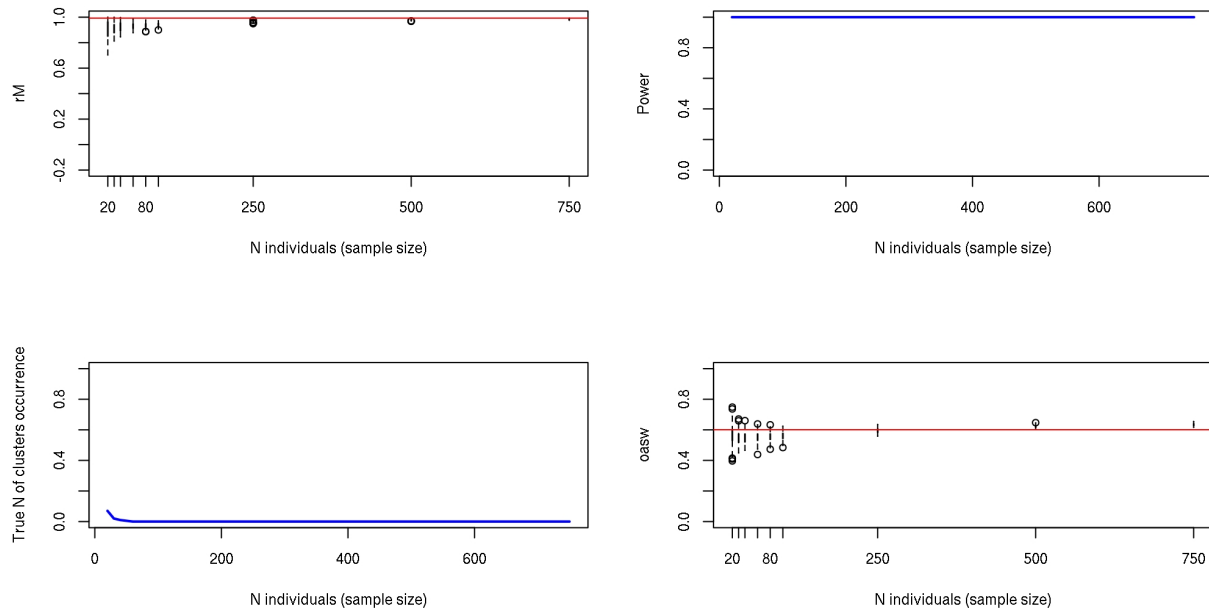
contour colours correspond to different clusters, as reported in legend. The species distribution range is also shown (breeding range: blue; non-breeding range: dark grey; resident range: beige; from BirdLife International, 2019).

## 1.2 Sensitivity analysis

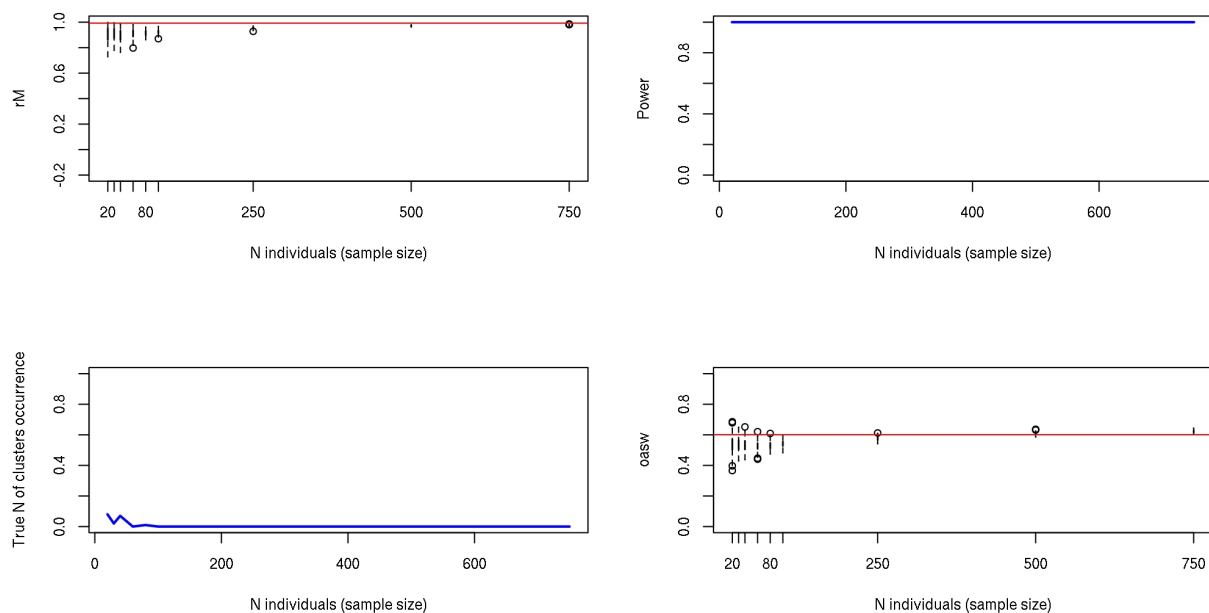
Results of power analysis and validation. Analyses at the species level were re-run on subsamples of individuals of decreasing size (100 repetitions per subsample size), according to simple random sampling of individuals (Figure 14610-2) and stratified sampling of individuals within the breeding range (Figure 14610-3) and the non breeding range (Figure 14610-4). 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 14610-2.** 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.

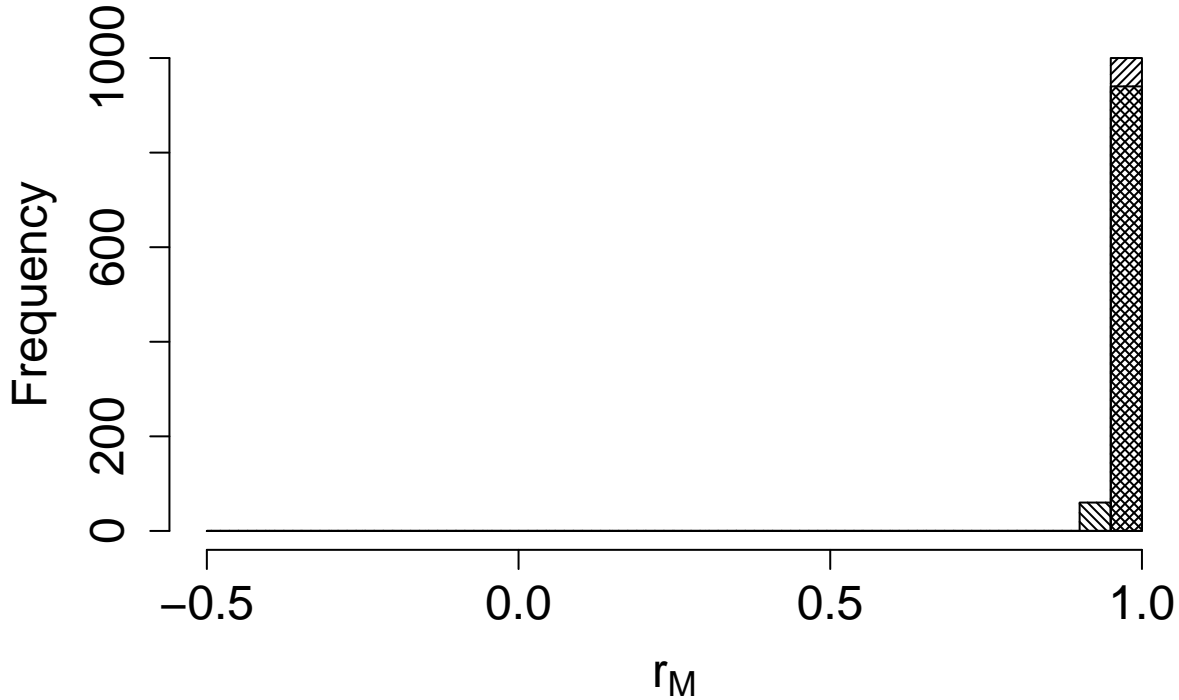


**Figure 14610-3.** Top left: simulated distribution (boxplots) and observed value (red line) of connectivity. Top right: Simulated power of the analysis. Bottom left: Proportion of times the analysis provides the observed best number of cluster. Bottom right: simulated distribution (boxplots) and observed value (red line) of clustering intensity.



**Figure 14610-4.** 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 ( $p = 0.94$ ); Figure 14610-5).



**Figure 14610-5.** Comparison between the bootstrapped distributions of connectivity value for alive recaptures (filling lines with angle=45°) and dead recoveries (filling lines with angle=375°).

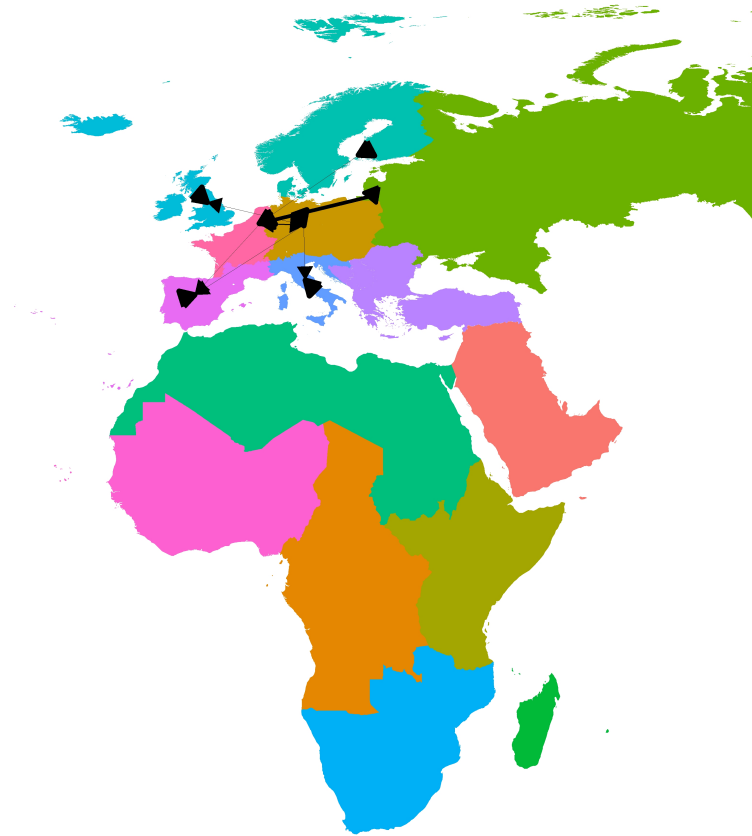
## 2. Connectivity between pre-defined regions

The species shows high connectivity ( $MC = 0.879$ ;  $MC = 0.879$  when adjusted for absolute abundance) between 7 breeding regions and 7 non breeding regions (Table 14610-2; Figure 14610-6).

**Table 14610-2.** 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	10460300	Central Europe	0.948
Central Europe	10460300	North-west Europe	0.001
Central Europe	10460300	South-central Europe	0.004
Central Europe	10460300	South-west Europe	0.003
Central Europe	10460300	West Europe	0.043
East Europe	6500426	East Europe	0.500
East Europe	6500426	West Europe	0.500
North Europe	1408000	North Europe	0.995
North Europe	1408000	West Europe	0.005
North-west Europe	4073790	North-west Europe	1.000

Breeding region	Abundance	Non breeding region	Transition probability
South-central Europe	4852572	South-central Europe	1.000
South-west Europe	7342151	South-west Europe	1.000
West Europe	1054390	Central Europe	0.007
West Europe	1054390	South-west Europe	0.002
West Europe	1054390	West Europe	0.991



**Figure 14610-6.** 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>.