**Supporting Information: DATA and CODE.** Coline Canonne1,2, Ariane Bernard-Laurent3, Guillaume Souchay4, Charlotte Perrot2, Aurélien Besnard1. Contrasted impacts of weather conditions in species sensitive to both survival and fecundity: a montane bird case study. Ecology.

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**ABSTRACT**

This folder contains the R code (file “Rock\_partridge\_IPM.r “) of the integrated population model (IPM) used to study the population dynamics of the rock partridge in the French Alps, along with associated data (file “jags.data”). The integrated population model allowed us to model survival and breeding success (split in several steps) simultaneously. Data were collected by the French Office for Biodiversity (OFB) and the Observatory of mountain galliformes (OGM: <https://www.observatoire-galliformes-montagne.com/>). The “Read.me” file provides a detailed description of the different datasets. We also included values of the covariates used to study the influence of weather variation on survival and breeding success (files “covariates\_survival”, “covariates\_brood\_size” and “covariates\_brood\_size\_per\_site”).

**METHODS**

The “jags.data.r” file contains data used in the integrated population model composed of three modelling parts: survival, breeding success and population trend. The column “Y” contains the number of monitored year (21 years), shared by all 3 parts. “jags.data.r” is an R object that can be loaded using the following code: load(“jags.data.r”)

**Survival: Radio-tracking in the Dévoluy massif**

Components of the jags.data associated with survival:

* z: CMR Capture history of the 212 rock partridges equipped with a VHF necklace
* nch: number of capture history = 212
* n.occasions: number of occasions considered in the CMR model = 120 months
* f = first and l = last capture occasion for each bird
* age\_tr = occasions corresponding to March: when birds move from juveniles to adults
* year = the year at each occasion

From 2011 to 2020, a total of 212 rock partridges were captured in the Dévoluy massif (44°41′N, 5°56′E, 149 sq km; Bernard-Laurent et al., 2017 and Appendix S1&S2). Birds were fitted with 9–14-g necklace radio transmitters (Holohil system Ltd., <3% of body mass, expected lifespan of 18–36 months) and tracked until their death or the failure of the tag. Our sample was male-biased (104 adult males, 61 adult females, 28 juvenile males and 19 juvenile females). Birds were weighed and aged based on the moult of outer wing primaries. For birds older than eight months, sex was determined by the presence or absence of spurs on the tarsus, while for young birds we used DNA sexing from feathers. Throughout the year, birds were located two to three times per month by approaching the bird on the ground, using a portable receiver (ICOM R20 or AOR AR-8200MK3). Monitoring during the breeding season was more intensive, with remote controls three to five times per week. This intensive monitoring allowed us to get information about clutch size, hatching date and the fate of chicks until September, when it became impossible to distinguish juveniles from adults in flight. No bird was lost during the monitoring and almost all the devices were found when the mortality signal occurred (with the exception of devices located in cliffs), hence we had no permanent emigration.

**Breeding success**

Components of the jags.data associated with breeding success:

* R\_dog : number of monitored sites in summer = 17
* data\_bp1: outcome (0 = failure, 1 = success) of birds that laid at least one clutch
* nb\_bp1: number of birds that laid at least one clutch considered = 24
* data\_bp2: outcome (0 = 1 clutch, 1 = 2 clutches) of birds that laid two clutches
* nb\_bp2: number of birds that laid two clutches considered = 20
* data\_ns: outcome at the end of August (0 = failure, 1 = success) of initiated clutches
* nb\_ns: number of birds with an initiated clutch = 74
* CperF: young/adult ratio during summer counts with pointing dogs (per site)
* fc\_dog and lc\_dog : years of first and last counts respectively on each site

Counts of both adult and juvenile birds using pointing dogs were conducted by the OGM in August each year during the study period to establish a fledging/adult ratio that we used as a proxy of brood size (mean number of chicks per successful adult at the end of August). The absence of dimorphism did not allow distinction between sexes. The pointing-dog counts were conducted on a network of 30 legacy sites, from which we selected 16 with counts available from 2000 onwards and with few missing values. In August, chicks are five weeks old on average; they are already able to fly, but remain with their parent. We completed this dataset with opportunistic observations of adults with broods in the Dévoluy massif from 2011 to 2020 (last line in the column CperF).

**Population** **trend**

Components of the jags.data associated with populations trends:

* R\_sing: number of monitored sites in spring = 10
* logy\_sing: log of the number of males counted in spring per site each year
* fc\_sing and lc\_sing : years of first and last counts respectively on each site

The spring counts of singing males were conducted on a network of 32 legacy sites scattered through the French Alps (non-randomly selected sites to meet logistical constraints). Of these sites, we retained only 10 that had been surveyed since 2000 and had few missing values for the analysis.

**Environmental covariates**

Covariates associated with survival are in the file “ covariates\_survival.csv”. As for covariates associated with brood sizes, we distinguished the ones with values per site (“covariates\_brood\_size\_per\_site.r”) from the ones shared among sites (covariates\_brood\_size.csv).

Environmental covariates were selected to represent both local and large-scale weather variations experienced by the rock partridge over its annual cycle. Covariates measured during winter (Dec, Jan, Feb, Mar) were expected to directly influence overwinter survival in a given year, and to indirectly influence subsequent breeding success through carry-over effects. Covariates measured during the breeding season (May, Jun, Jul, Aug) were expected to directly influence breeding success the same year, and to indirectly influence breeding success through carry-over effects the following year.

All variables were scaled prior to analysis. When we suspected a potential non-linear response or optimal value, we tested for both a linear and a quadratic effect.

Local weather indices were based on meteorological conditions estimated by SAFRAN (Système d’Analyse Fournissant des Renseignements Atmosphériques à la Neige: https://www.umr-cnrm.fr/spip.php?article788), a mesoscale atmospheric analysis system for surface variables using ground data observations from Météo France. We calculated a mean value per site, weighted by the proportion each 8-km grid cell overlapped study site areas.

We extracted snowmelt dates from the Moderate Resolution Imaging Spectroradiometer (MODIS: https://modis.gsfc.nasa.gov/data/dataprod/mod10.php), defining the date of snowmelt as the end of the period of continuous snow cover. Date\_100 corresponded to total snowmelt at the counting sites (100% of pixels of the site with bare ground), and Date\_50 to 50% bare ground.

Covariates built from SAFRAN and MODIS data were calculated for the Dévoluy area for the survival analysis (as all birds were caught in this area), and on the summer counting sites for the analysis of fecundity.

To explore the impact of large-scale weather conditions, we collected both winter (Dec–Feb) and summer (Jun–Aug) North Atlantic Oscillation indexes, which summarize weather variations in a single index encompassing both precipitation and temperature.

Finally, as hunting of this species of rock partridge is allowed, though very limited (depending on the year, hunting bags ranged from 55 to 407 birds at the national scale during the study period), we tested for an influence of the number of harvested birds on annual survival.