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Victor Chauveau, Mathieu Garel, Carole Toïgo, Pia Anderwald, Bruno Bassano, Mathieu Beurier, Yoann Bunz, Michel Bouche, Alice Brambilla, Francesca Cagnacci, et al.

### ► **To cite this version:**

Victor Chauveau, Mathieu Garel, Carole Toïgo, Pia Anderwald, Bruno Bassano, et al.. It's time to go: drivers of migration phenology in a mountain ungulate, the Alpine ibex *Capra ibex*. *Movement Ecology of Animals* 2023, May 2023, Lucca, Italy. hal-04452373

**HAL Id: hal-04452373**

**<https://ofb.hal.science/hal-04452373>**

Submitted on 12 Feb 2024

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# It's time to go: drivers of migration phenology in a mountain ungulate, the Alpine ibex *Capra ibex*

V Chauveau, M Garel, C Toïgo, P Anderwald, B Bassano, M Beurier, Y Bunz, M Bouche, A Brambilla, F Cagnacci, M Canut, J Cavailles, I Champly, F Filli, A Frey-Roos, G Gressmann, I Herfindal, F Jurgeit, L Martinelli, L Maurino, R Papet, E Petit, M Ramanzin, P Semenzato, E Vannard, A Coulon, A Loison, P Marchand

## CONTEXT & OBJECTIVES

- Climate change affects the phenology of biological events such as migrations<sup>(1)</sup>.
- These effects are expected to be **amplified** in highly seasonal environments such as **mountains**<sup>(2)</sup> but remain **less documented** for **short-distance migratory species** like the Alpine ibex, an emblematic species of the Alps.
- Understanding the **drivers of phenology** (environmental and individual) is therefore crucial to understand how individuals can respond to such rapid changes.

### Our goals:

- To identify individual and environmental drivers of migration phenology in spring and autumn
- To assess behavioral plasticity in the timing of migration



## METHODS

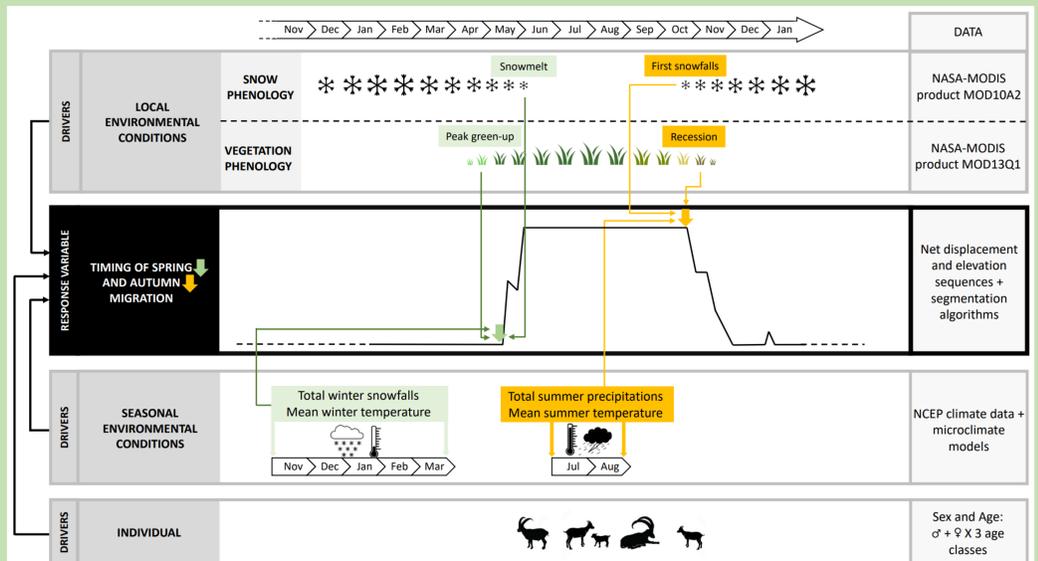
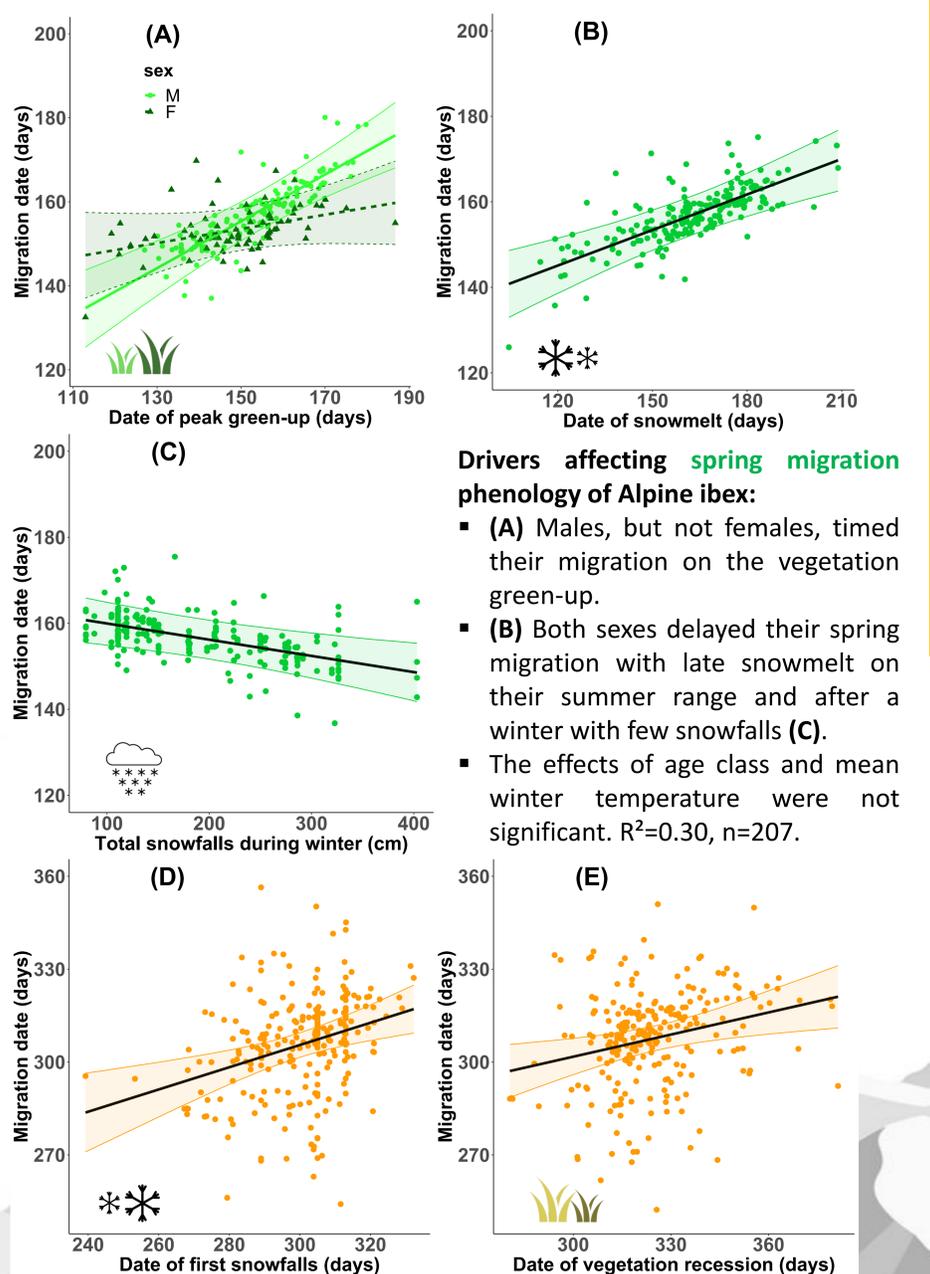


Illustration of possible environmental and individual drivers affecting the timing of ibex migration

## RESULTS

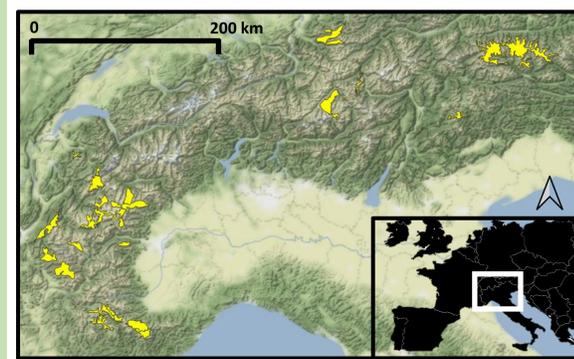


### Drivers affecting spring migration phenology of Alpine ibex:

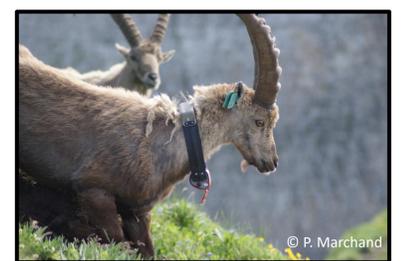
- (A) Males, but not females, timed their migration on the vegetation green-up.
- (B) Both sexes delayed their spring migration with late snowmelt on their summer range and after a winter with few snowfalls (C).
- The effects of age class and mean winter temperature were not significant.  $R^2=0.30$ ,  $n=207$ .

### Drivers affecting autumn migration phenology of Alpine ibex:

- (D) Migration date was positively correlated with the date of first snowfalls as well as the date of vegetation recession (E). These effects were similar for both sexes.
- The effects of age class and seasonal drivers were not significant.  $R^2=0.11$ ,  $n=247$ .

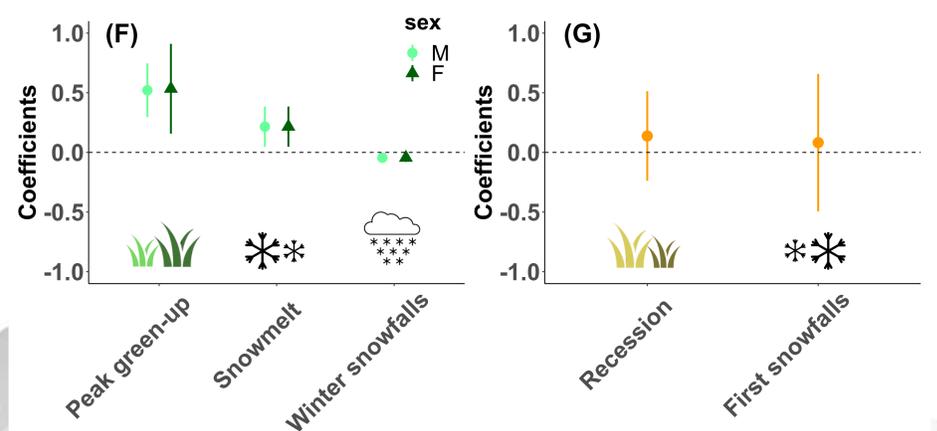


Study extent: The Alps



407 ibex (218 M/189 F) tracked by GPS-collars from 17 populations (in yellow on the map, study period: 2003-2022)

- Linear mixed-effects models:** Drivers (Fixed effects) + Population/animal id (Random effects) -> Model selection based on AICc
- Assessing behavioral plasticity:** Animals migrating multiple years + interannual differences in drivers ->  $\Delta$ migration dates  $\sim \Delta$ drivers selected in best models



### Behavioral plasticity is limited

- In spring (F,  $n=49$ ), both males and females displayed behavioral plasticity in response to interannual differences in date of peak green-up, snowmelt and winter snowfalls.
- However, this plasticity appeared limited with a shift of 5.2 and 2.2 days in migration dates for a shift of 10 days in vegetation growth peak and snowmelt, respectively. A difference of 1 meter in winter snowfalls led to a shift of 4.5 days in migration dates.
- In autumn (G,  $n=38$ ), no behavioral plasticity in response to changes in phenological events was observed.

## CONCLUSIONS

- Vegetation and snow phenology affects the timing of migration** in Alpine ibex but **differently between sexes in spring** (females constrained by parturition?).
- Individuals display behavioral plasticity, but its extent appears limited** (other important events such as the parturition and rut, possibly less plastic and potentially driven by other parameters, could constrain plasticity in migration timing).
- Onset of spring will be advanced by 30 days in 2100<sup>(3)</sup>. Ibex could possibly respond with a shift in migration timing but a mismatch of 15 days with the peak of green-up could be expected.
- Understanding how this trophic mismatch could change the benefits of migration and lead to demographic consequences is therefore crucial<sup>(4, 5)</sup>.