

## Competition in the Alps under global warming: Alpine mountain hares, European hares, and their hybrids in focus

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### Initial situation and competition

European hares and Alpine mountain hares are in close competition with each other in the Alps, as both species use similar ecological resources. The more competitive European hare appears to be increasingly displacing the specialised Alpine mountain hare. In addition, hybridisation occurs between the two species, typically involving a male European hare and a female Alpine mountain hare. For the Alpine mountain hare population, this results in a loss of species-specific litters. This process may therefore contribute to the observed decline of Alpine mountain hares.

### Shift in habitats along the elevational gradient

Long-term data from hunting statistics show that the habitats of both species are shifting as a result of climatic changes. Along the elevational gradient of the Alps, both European hares and Alpine mountain hares are moving to higher elevations. However, it is striking that the European hare is advancing upslope more rapidly than the Alpine mountain hare. This suggests that the European hare is increasingly pushing the Alpine mountain hare into higher, more restricted habitats. As the available area decreases with increasing elevation, the situation for the Alpine mountain hare worsens further.

### Genetic analyses and new insights from faecal samples

To investigate these processes in greater detail, a research project was launched in the Lower Engadine in 2019. Since then, faecal samples have been collected annually along seven transects between Susch and Ramosch. These samples serve as an important source of information, as they allow for genetic analyses. Over seven years, several thousand samples have been collected, most recently an additional 599 in July and August 2025. Using nuclear DNA and mitochondrial DNA, the samples can be clearly assigned to European hares, Alpine mountain hares, or hybrids. It is also possible to determine whether the mother was a Alpine mountain hare or a European hare. To date, a total of 246 individuals have been identified, including 106 European hares, 88 Alpine mountain hares, and 52 hybrids. An important finding is that the vast majority of hybrids originate from female Alpine mountain hares: 50 out of 52 individuals had a Alpine mountain hare mother (Fig. 1a). This confirms that hybridisation is particularly problematic for the Alpine mountain hare population. In addition, 119 individuals were repeatedly detected over several years (Fig. 2a), providing valuable insights into population dynamics. Among these were also eleven hybrids (Fig. 2b).

### Spatial distribution and significance of hybrids

The spatial distribution of the species in the study area is more complex than originally assumed (Fig. 1b). On one transect (Guarda), European hares were even detected at high elevations, and the elevational ranges of both species overlapped considerably. On the other transects, however, habitats were largely separated along the elevational gradient. Interestingly, hybrids were found primarily at lower elevations, often together with European hares, even though they mostly originate from female Alpine mountain hares. This suggests that hybridisation does not occur only in clearly overlapping habitats. Genetic analyses also show that most hybrids do not result from recent hybridisation events. Rather, they are predominantly later-generation individuals whose origin lies further in the past. Throughout the entire study period, only one individual was identified as resulting from a recent hybridisation event. Hybrids can significantly influence evolutionary processes by contributing both to species loss and to the emergence

of new adaptations. However, little is currently known about their ecological role in the interaction between European and Alpine mountain hares.

### Outlook in the context of climate change

In light of ongoing climate change, these questions are of particular importance. Alpine ecosystems are highly sensitive to temperature changes, and specialised species such as the Alpine mountain hare are especially at risk. Therefore, monitoring will continue in the coming years. The aim is to better understand competition dynamics, the role of hybridisation, and the future distribution of the two species. Ultimately, the findings will be incorporated into models of the distribution of European hares, Alpine mountain hares, and their hybrids across the entire Alpine region. Based on this, concrete conservation measures can be developed to ensure the long-term survival of the Alpine mountain hare.

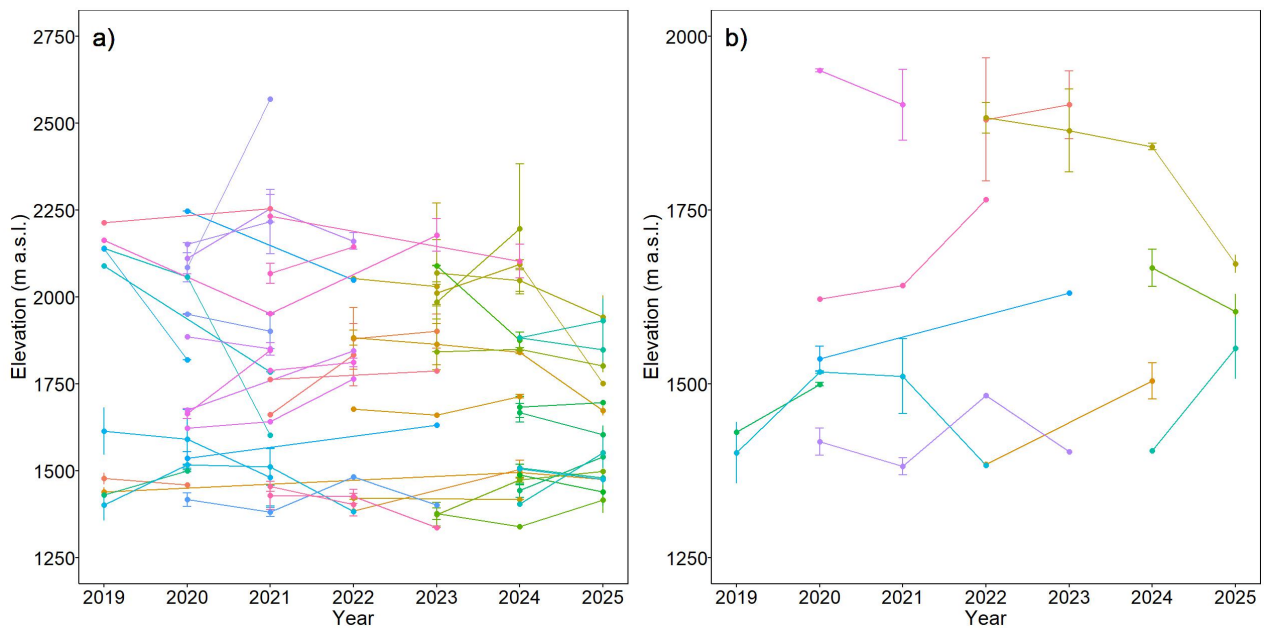


Fig. 1: a) Individual hares that were “recaptured” over the seven-year period, b) including eleven hybrids. The mean elevation of the faecal sample locations, along with site variation, is given when multiple “recaptures” occurred within the same year.

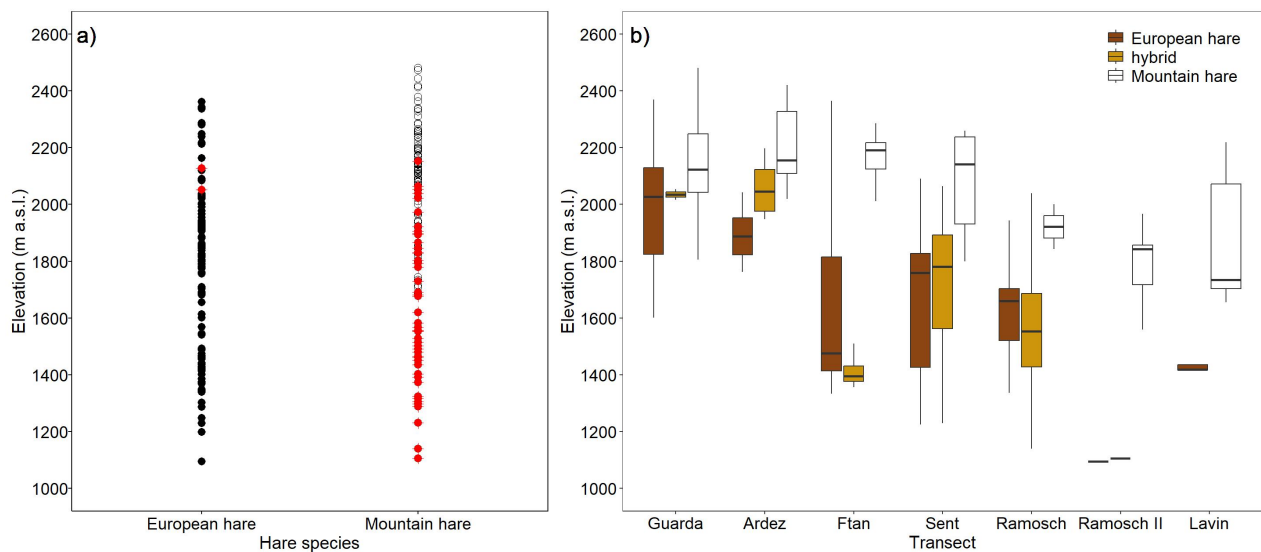


Fig. 2: a) European hares (black dots), Alpine mountain hares (white dots), and hybrids (red dots). Almost all hybrids in our study had Alpine mountain hare mothers at the time of hybridisation, as their mtDNA shows genetic material from Alpine mountain hares. b) European hares occupy high elevations in Guarda, whereas hybrids were predominantly detected at lower elevations.

## **Acknowledgment**

We gratefully acknowledge the financial support of the Basler Stiftung für biologische Forschung, Swiss Delegation of the International Council for Game and Wildlife Conservation CIC, German Society for Mammalian Biology, International Rotary Fellowship of Hunters, Stiftung Temperatio, Graf Fabrice, von Gundlach und Payne Smith-Stiftung, Verein Grünes Kreuz, Legat Dr. Joachim de Giacomo, Amt für Jagd und Fischerei Graubünden, Swiss National Park, Institute for Wildlife Biology and Game Management, BOKU University, and thank the German Wildlife Foundation for a grant to Stéphanie Schai-Braun.