Prey size affects reproductive success and global distribution of the Golden Eagle *Aquila chrysaetos* L.

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Background

Several proximal causes are known to limit species distribution and, thus, cause species distribution borders. Whereas abiotic environmental factors like climate are well known to affect global species distribution, effects of biotic factors such as resource (food) availability are sparsely investigated so far on continental scale.

The effect of resource availability on species performance is empirically and theoretically well-founded (optimal foraging theory). Optimal prey availability is reported from local scale studies to affect foraging behavior and reproductive success of predators. However, knowledge is lacking on continental scale, even for prominent predators such as the Golden Eagle.

Fig. 1: Juvenile Golden Eagle feeding on optimal-sized prey (mountain hares and marmots) which were brought by the adult birds to the nest (Bavarian Alps, Photo: H.-J. Fünfstück) .

Hypothesis

Availability of optimal prey will affect foraging behavior and breeding success and, thus, distribution patterns of the Golden Eagle on a continental scale.

Methods

For the Golden Eagle, medium-sized prey species between 0.5 and 5 kg are considered optimal (Fig. 1), whereas smaller and larger species are deemed as energetically sub-optimal.

We combined biogeographical information on Golden Eagle's range margins with information about the foraging behavior and reproductive success of Golden Eagles from the entire Northern Hemisphere (Fig. 2).

We correlated diet breadth (Levin's niche breadth) as a measure of foraging generalism, breeding success and proportions of optimal and sub-optimal sized prey in the diet with the minimum distance of the examined eagles to the actual species distribution boundary.
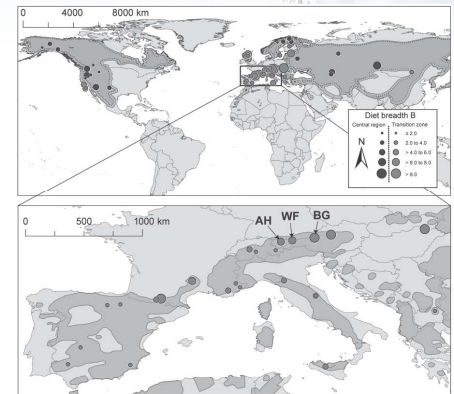

Fig. 2: Locations of the examined Golden Eagle populations. Enlargement shows Golden Eagle's distribution and examined study sites in Central Europe. Diet breadth is depicted by point size. Populations within the outer transition zone of the distribution area with high variability in diet breadth (grey points) are separated by central populations with low variability in B (black points). Source distribution area: BirdLife International 2012.
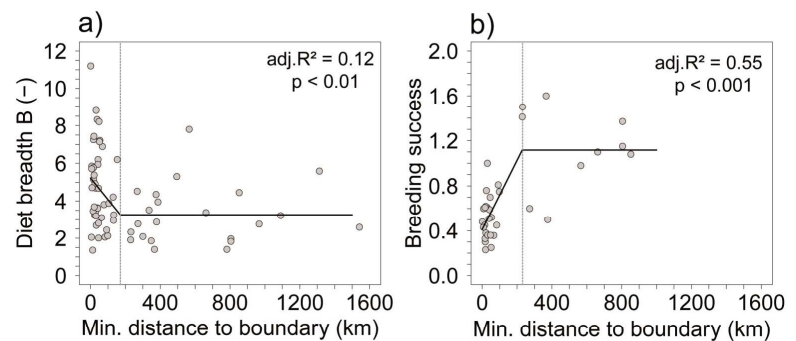
Results

- Diet breadth B increased towards the distribution boundary within the first few hundred kilometers but stayed constantly low with increasing distance above this threshold (dashed line in Fig. 3a).

- Breeding success was constantly high in the central zones of the global distribution area but decreased in the outer transition zones towards the distribution boundary (Fig. 3b).

- Proportions of optimal (medium-sized) prey in the diet decreased whereas proportions of sub-optimal (small and large) prey increased towards the distribution boundary (Fig. 4).

- In the central zones of the Golden Eagle's distribution area proportions of optimal prey were constantly high but consistently low for sub-optimal prey.

- Breeding success increased with increasing proportions of optimal prey but decreased with increasing proportions of sub-optimal (small) prey.

- Golden Eagles from the Nearctic were more specialized than the examined eagles from the Palearctic.

Discussion & Conclusions

Our study shows that Golden Eagles' diet becomes more generalist whereas breeding success markedly decreases close to distributional limits.

Central European Golden Eagles (including the Pyrenees, the Apennines, the Alps as well as Scotland) are exclusively located in the sub-optimal transition zone of species distribution whereas optimal central zones only occur in the eastern Palearctic as well as in the center of North America.

Decrease in net energy gain seems to cause the observed increase in foraging generalism and significantly affects the foraging behavior and breeding success of Golden Eagles close to the distribution edge with a spatial threshold of about 200 km from the boundary.

These results stress the profound role of optimal prey availability in affecting breeding success and distribution patterns of the Golden Eagle on a continental scale.

Fig. 3: Diet breadth and breeding success of Golden Eagles dependent on the minimum distance to the species distribution boundary. (a) diet breadth, (b) breeding success (fledged young per territorial pair and year). Solid lines represent significant relationships not affected by spatial autocorrelation or the co-variables latitude and elevation. The spatial threshold which separates populations located in the transition zones from the populations in the central regions of the distribution area is depicted as a dashed grey, vertical line.
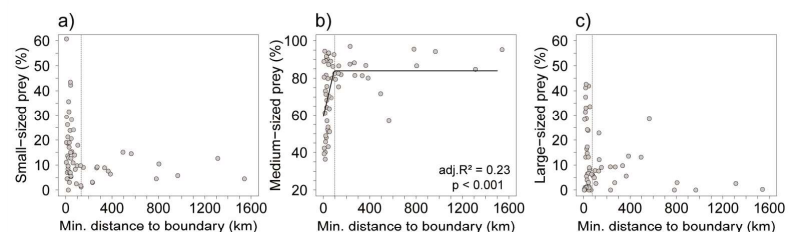

Fig. 4: Proportion of optimal (b) and sub-optimal sized (a and c) prey within the diet of Golden Eagles dependent on the minimum distance to the species distribution boundary. (a) small-sized prey species (> 0.5 kg), (b) medium-sized prey species (0.5 to 5 kg), (c) large-sized prey species (> 5 kg).

Further References

Schweiger, Fünfstück & Beierkuhnlein (2015). Availability of optimal-sized prey affects global distribution patterns of the golden eagle *Aquila chrysaetos*. Journal of Avian Biology 46: 81-88.

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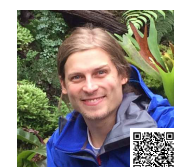
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