

# 5th Biology of the Vipers

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## Parapatric species and the use of fuzzy logic to study biotic interactions: a case study on vipers in the Iberian Peninsula


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The Iberian Peninsula is inhabited by three viper species (genus *Vipera*) that show parapatric distributions: the Euro-Siberian *V. seoanei* in the North, and the two Mediterranean, *V. aspis* in the North-east, and *V. latastei* in most of Iberia. Environmental factors have strong influence in their distribution; however, interactions between species may be also an important driver of species distributions at contact zones. The aim of this work is to identify the favourability of the Iberian Peninsula for the three vipers, giving special importance to those regions simultaneously high favourable for two or the three species (coexistence), simultaneously unfavourable for them (autoecologic segregation), and also those areas where one of the vipers has high favourability whereas the other has intermediate values (likely caused by competition). The favourability models were built under the fuzzy logic as this method may help to understand the species' relationship taking into account coexistence and competition processes. We used a presence/absence dataset in UTM 10x10km grid cells and a set of spatial and environmental variables (topographic, climatic, human activity and land uses) to develop models of current favorability for the three species. Then we used fuzzy logic to compare species-specific favourabilities with the shared two by two favourabilities. The results suggested that the environment has a strong predictive power in the distribution of the vipers, but the potential interactions between them may be also decisive for their presence or absence in specific areas of the Iberian Peninsula. It is remarkable that *V. aspis* and *V. seoanei* seemed better competitors than *V. latastei*, probably as they were better adapted to northern humid conditions. Although we identified some areas of coexistence, the contact zones are exclusion areas where one species may affect the others. More research is necessary to understand these parapatric distributions by including interactions with other snakes and their prey, as well as their potential evolution under the present-future situation of climate change.

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