

Species shift due to climate change in south-west Germany

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KEYWORDS: *Coenagrion mercuriale*, *Ophiogomphus cecilia*, *Sympetrum flaveolum*, decline

The federal state of Baden-Württemberg in south-west Germany is a mountainous region with a wide variety of climatic conditions and different types of water bodies. With 76 recorded species, the Odonata fauna is rich and includes southern European species as well as boreoalpine species. The species composition has changed considerably over the last 20 years. While the bog specialists in particular have declined, thermophilic species such as *Coenagrion scitulum* have greatly expanded their range. Species such as *Anax imperator* now reproduce in peat bogs and mountain lakes above 800 m a.s.l., while *Coenagrion hastulatum* has disappeared from former habitats below 500 m a.s.l. Using the example of *Coenagrion mercuriale*, *Ophiogomphus cecilia* and *Sympetrum flaveolum*, we demonstrate species shifts. All three species are affected by the climate crisis in different ways. Between 2020 and 2023, many rivulets and ditches in which *C. mercuriale* reproduced dried up completely. Locally in the Upper Rhine Plain, some populations survived the drought in larger flowing waters rich in aquatic plants, a habitat type that has not long been used by *C. mercuriale* for reproduction in Germany. We suppose that the species will be able to recolonize the currently lost, small flowing waters from there. In the southern Upper Rhine plain, the High Rhine valley and the Alpine foothills, the population density of the species is much lower and future recolonisation of the lost habitats is likely to take a long time or even be impossible due to the species' low dispersal ability. As a result of the improved water quality in creeks and rivers in Germany in the 1990s, *O. cecilia* appeared to spread and populations of the species increased at least until 2010. Since then, however, the species was only detected at 14 of 63 monitoring plots (22%), and the number of exuviae detected in optimal habitats fell to less than 10% of previous surveys. None of the larger watercourse sections monitored have dried up in recent years. The reasons for this important decline are multifactorial, with climate change playing a central role. Until 2006, *S. flaveolum* was a widespread species in south-west Germany. Of more than 200 sites where the species was recorded in the past, only two remain today. One effect of climate change is the increasing stability of high pressure from February to April, when vernal ponds used to fill up. Today, they dry out too early and even specialists such as *S. flaveolum* can no longer develop successfully. The species has regularly migrated in the past and has subsequently colonized other suitable water bodies regionally. Presumably as a result of accelerating climate change with a loss of habitats in the source regions, the last documented influx dates back more than 20 years.