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Strangers in Paradise: The biogeographic range expansion of the foraminifera Amphistegina in the Mediterranean Sea

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Species distribution models (SDMs) have become important tools in biogeography and biodiversity research over the last decades. They are mainly based on the fundamental niche concept and allow the correlative prediction of species' potential distributional ranges by combining occurrence records with information on environmental (e.g. climatic) conditions. The generated environmental envelope of a species is projected into geographic space, thus defining areas of adequate habitat suitability. Here we apply a species distribution model (SDM) to assess potential range expansions of *Amphistegina* spp. in the Mediterranean Sea under current und future climate conditions. The model uses an environmental envelope of information from localities where amphisteginids are currently known to occur.

Amphisteginid foraminifers are a group of circumtropically distributed, larger symbiont-bearing, calcareous foraminifera that have a well-documented record as detectors of historical climate change. They are currently expanding their biogeographic range in the Mediterranean Sea and rapidly progressing northwestward, closely approaching the Adriatic and the Tyrrhenian Sea. The shift in range locally leads to profound ecological changes where amphisteginids have become the dominant species along entire stretches of coastline. Mass deposits of amphisteginids reflect an increased carbonate production and reduced assemblage diversity, and these are likely to trigger major changes in ecosystem functioning. It is anticipated that the ongoing warming trend will convey the northwestward migration of amphisteginid foraminifers. Our model indicates that further warming is likely to cause a northwestward range extension and predicts dispersal through the straits of Sicily, Messina and Otranto into the Tyrrhenian and Adriatic Sea. Rapid proliferation and the extreme abundances of amphisteginid foraminifera affect the dynamic equilibrium of established foraminiferal biotas. In the eastern Mediterranean, diverse assemblages of shallow-water foraminifera are being replaced by monocultures of rapidly spreading amphisteginids. Climate change, through long-term temperature increase, will continue to promote the homogenization of foraminiferal fauna, ultimately leading to a meridionalization of the Mediterranean Sea.