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Medfly in a warming world: using models to understand shifting range dynamics

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Background: Climate is the principal factor defining the potential distribution of poikilotherms, and hence climatic changes are expected to influence the ranges of a range of pests, including insects, vector-borne diseases, and weeds. As these organisms spread beyond their native ranges, they may threaten natural and productive ecosystems, often triggering substantial expensive management responses.
Methods: We explore the apparent range expansion of Medfly, *Ceratitis capitata,* into areas that were hitherto too cold to support persistent populations, with a focus on Europe and California. We reviewed and refined a published CLIMEX model for *C. capitata*. We used the refined model to assess the climatic suitability of a range of recent occurrence locations spanning the previously modelled range limits in Europe. To assess the meaning of the new European distribution records for *C. capitata* we used the CRU TS4 climate time series dataset to explore the temporal patterns of climate suitability from 1970 to 2019.
Results: At selected indicator sites in Europe, we found statistically significant trends in increasing climate suitability, as well as a substantial northward expansion in the modelled potential range for persistent populations. Recent geographical records in Italy and France appear to represent a mixture of established and ephemeral populations, which is consistent with reports of the seasonal range dynamics of *C. capitata* in Europe. Over the same period in California, we also found a statistically significant trend of northward and altitudinal expansion of areas suitable for *C. capitata* persistence, and a general trend toward improved conditions for population growth.
Conclusion: These statistically significant trends in suitability for *C. capitata* are attributable to a warming climate. These findings have implications for both pest risk analyses and pest management of invasive fruit flies and other mobile pests. The modelling revealed the need to use a climatology that is temporally concordant with species distribution data.

Keywords: CLIMEX, Ceratitis capitata, medfly, niche modelling, pest risk analysis, distribution, climate change, seasonal phenology, invasion