

The propagation of exotic insect-borne diseases in Bavaria as a consequence of global warming

By Dominik Fischer, Stephanie Thomas, Reinhold Stahlmann and Carl Beierkuhnlein, Bayreuth

Background

Global warming is directly impacting human health. For example, extreme weather events (such as heat waves) are reaching new dimensions. In addition to such direct meteorologically induced stress situations, organisms can respond to shifts in climatic conditions in a variety of ways (e.g. activity, phenology, reproduction, productivity, pollen production) (Beierkuhnlein & Foken 2008).

This project focuses on the potential climate-induced spread of insects as disease vectors that formerly confined themselves to tropical and subtropical regions. As a consequence, insect-borne diseases such as West Nile fever, Chikungunya virus, Dengue fever or Leishmaniasis could begin to spread in new areas at higher latitudes (Ebert & Fleischer 2005). The following key questions should be taken into consideration:

1. Could global warming lead to a spread of formerly tropical or subtropical disease vectors in Bavaria, and if so, which areas of the state will have a higher probability of such vector occurrences?
2. What are the thermic constraints for pathogen survival outside of the human body? Will these levels be exceeded within the following decades?
3. What ecological interactions exist between insect vectors, the pathogens they carry, and additional animals possibly acting as alternate hosts?

This study is conducted as part of the interdisciplinary Bavarian VICCI (Vector-borne infectious diseases in climate change investigations) research consortium, funded by the Bavarian Ministry of Environment and Health. In addition to studying insect-borne diseases, the VICCI focuses on diseases carried through Bavaria by ticks and rodents.

Relevant insect vectors with high climatic sensitivity

The Asian Tiger Mosquito (*Aedes albopictus*) is a potential carrier of Dengue fever, Chikungunya virus and West Nile virus. This formerly South-East Asian mosquito now flourishes over large areas on various continents due to the worldwide movement of goods and global warming (Enserink 2008). In 2007 significant population masses of the mosquito crossed the most important climatic barrier between Southern and Central Europe and, for the first time, appeared in Aargau, Swit-

zerland on the northern side of the Alps (Wymann *et al.* 2008). The insect is expected to extend its distribution further on.

Sandflies (*Phlebotomus* species) are vectors of Leishmaniasis, a Mediterranean infectious disease (**Figure 1**). It should be stressed that Leishmaniasis, like Malaria, was previously endemic in Germany. The +10° C mean annual temperature is generally assumed to represent the northern limit of the sandflies habitat. Autochthonous cases in a German child and in horses as well as sandfly catches in the Upper Rhine Valley and southern Rhineland-Palatinate point to the potential re-emergence of Leishmaniasis in Germany (Bogdan *et al.* 2001, Naucke & Pesson 2000).

Bioclimatic envelopes of vectors

The current climatic restrictions of species are identified by correlating occurrence data with climatic data. Supported by geostatistical methods we selected those variables that correlate best with the distribution. These variables contribute to the detection of climatic envelopes. The multidimensional climatic envelopes are related to the expected future climate in Bavaria and contribute to the model of the probability of vector occurrences under future scenarios.

Expected future conditions in Bavaria

Based on regional climate models the present climatic restrictions and

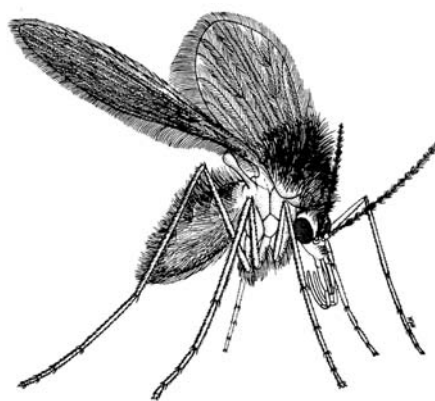


Fig. 1: Ink drawing of a female phlebotomine sandfly. Sandflies are very small insects (2mm long). Hence they cannot fly during windy periods. Source: Young & Perkins (1984), Illustrator: Munoz

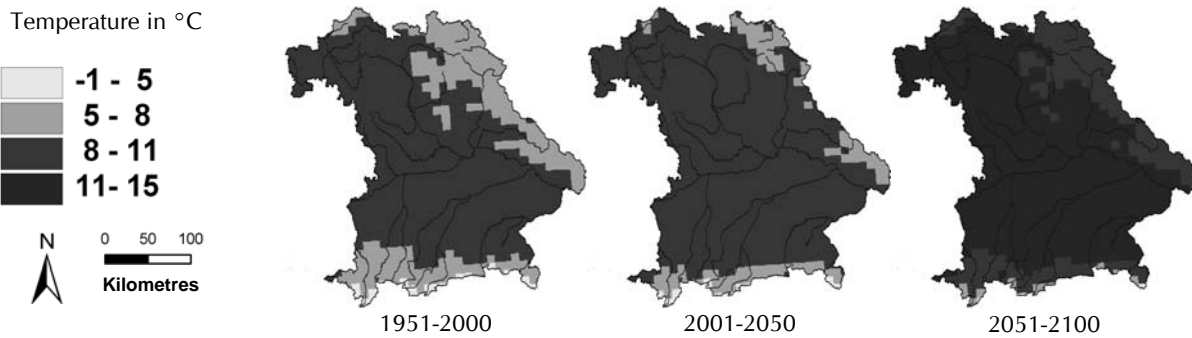


Fig. 2: Annual mean temperature in Bavaria. The period 1951-2000 reflects historical data. Future prognoses result from model calculations (UBA 2006) based on the A1B emission scenario for the periods 2001-2050 and 2051-2100 (IPCC 2007). Note the warming during the second half of the 21st century. Raster data exhibits a resolution of 10-10 km and is averaged over 50 years. (Own modelling of REMO-data)

requirements of the vectors will be assigned to future conditions. Models are driven by anthropogenic emission scenarios. Due to deviant expectations, the model outputs differ according to the magnitude of warming, thus ensemble comparisons are required. These have to include and test different models and scenarios. As a result we find that future temperature and precipitation regimes may offer adequate living conditions for the mentioned insects in Bavaria (**Figures 2 and 3**).

Further project plans include the discussion of the effects of various global scenarios, the comparison of sets of regional climate models, the highlighting of uncertainties, and the simulation of occurrence probabilities.

Scale-dependent significance of environmental variables

We have to keep in mind that idealised relations are overlaid by several specifics that should be included in the analysis. Theories suggest that the global spread of disease vectors is primarily caused by global warming with additional support from the global transport of goods and introductions via animals that serve as hosts (particularly migratory birds), and by travelling humans (Knobloch 2008). But whether a vector can establish itself in a conquered area (regarding a local scale) depends on the local environmental specifics such as land use and biotic interactions (Pearson & Dawson 2003). However, knowing the climatic approaches enables us to detect spreading tendencies of the species. Additionally, remote sensing tech-

niques can become a useful tool for monitoring potential breeding sites within that area.

The need of interdisciplinary research

In some cases vector and pathogen are not as closely connected as assumed. For instance, the Northern biting midge (*Culex pipiens*), a component vector of the West Nile virus, has been endemic in Germany for a long time. Indeed, the pathogen is found in Southern Europe but has not yet established itself in Central Europe. A substantial knowledge of these vectors, pathogens and diseases is required in order to open the door to an interdisciplinary research approach.

The whole and complex chain of human infections as well as the infectious ecological behaviour of the single components (pathogen, reser-

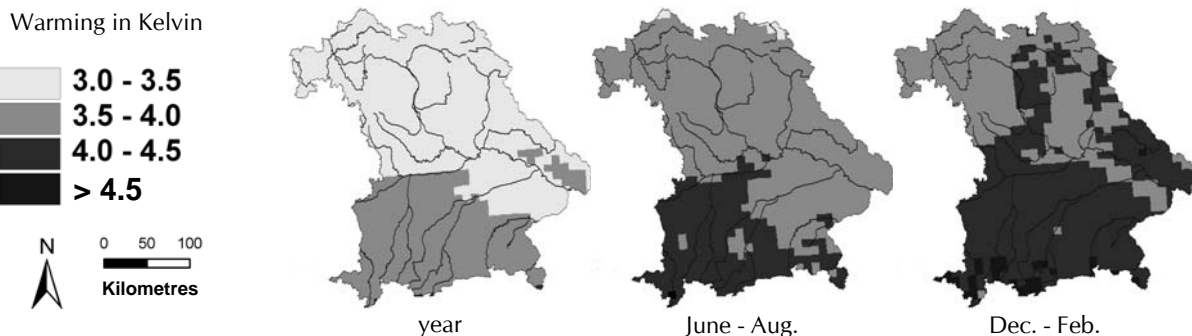


Fig. 3: Change of the mean temperature in 2m height above ground in Bavaria between the periods 1961-1990 and 2071-2100 separated into annual and seasonal periods, based on the A1B scenario. Note the significant warming during winter. Raster data exhibit a resolution of 10-10 km and are averaged over 30 years. (Own modelling of REMO-data)

voir host, and vector) cannot be approached by merely one scientific discipline (Beierkuhnlein & Thomas 2008, Moore 2008). Medicinal modelling and experiments are either not established or are incompatible with ethical rules. Ecological approaches do not take the contagiousness and severity of diseases into account.

An early localisation of potentially exposed regions is urgently needed in order to identify and evaluate regional risk. Based on this, development and implementation strategies can be developed. If the establishment of vector-borne infectious diseases cannot be avoided, feasible adaptation activities are required.

References

- Beierkuhnlein, C., Foken, T. (Eds.) (2008): Klimawandel in Bayern – Auswirkungen und Anpassungsmöglichkeiten. BayCEER, Bayreuth. 501 P.
- Beierkuhnlein, C., Thomas, S. (2008): Regionale Aspekte des Klimawandels – Entwicklungen und Konsequenzen in Bayern. In: Gostomzyk, J.G, Enke, M. (Eds.): Globaler Klimawandel und Gesundheit. Schriftenreihe der Landeszentrale für Gesundheit in Bayern 19, München: 35-46.
- Bogdan, C., Schonian, G., Banuls, A.L., Hide, M., Pralong, F., Lorenz, E., Rollinghoff, M., Mertens, R. (2001): *Visceral leishmaniasis* in a german child who had never entered a known endemic area: Case report and review of the literature. *Clinical Infectious Diseases* 32 (2): 302-306.
- Ebert, B., Fleischer, B. (2005): Globale Erwärmung und Ausbreitung von Infektionskrankheiten. *Bundesgesundheitsblatt* 42: 55-62.
- Enserink, M. (2008): A mosquito goes global. *Science* 320 (5878): 864-866.
- IPCC (2007): Climate Change 2007: Synthesis Report. www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf
- Knobloch, J. (2008): Globale Zunahme von Tropenkrankheiten. In: Lozán *et al.* (Eds.): Warnsignal Klima: Gesundheitsrisiken. Hamburg: 159-164.
- Moore, C.G. (2008): Interdisciplinary research in the ecology of vector-borne diseases: Opportunities and needs. *Journal of Vector Ecology* 33 (2): 218-224.
- Naucke, T., Pesson, B. (2000): Presence of *Phlebotomus (Transphlebotomus) mascittii* Grassi, 1908 (*Diptera: Psychodidae*) in Germany. *Parasitology Research* 86 (4): 335-336.
- Pearson, R. G., Dawson, T. P. (2003): Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful? *Global Ecology & Biogeography* 12 (5): 361-371.
- UBA (2006): Künftige Klimaänderungen in Deutschland – Regionale Projektionen für das 21. Jahrhundert, Hintergrundpapier. www.umweltbundesamt.de/uba-info-presse/hintergrund/Klimaaenderungsworkshop.pdf
- Wymann, M.N., Flacio, E., Radczuweit, S., Patochi, N., Lüthy, P. (2008): Asian Tiger Mosquito (*Aedes albopictus*) – A threat for Switzerland? *Eurosurveillance* 1-3: 1-2.
- Young, D.G., Perkins, P.V. (1984): Phlebotomine sand flies of North America (*Diptera Psychodidae*). *Journal of the American Mosquito Control Association* 44: 263-279.

Dominik Fischer

Dipl.-Geograph

Department of Biogeography
University of Bayreuth

95440 Bayreuth

0921/ 552307

dominik.fischer@uni-bayreuth.de