Differential effects of climate change on forest insect pests in Germany

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Three entomological paradigms of climate impact assessment

- bark beetles are the winners of climate change;
- thermophilic insects respond most positively;
- major pine pests that overwinter in the soil have not profited from climate change due to higher mortality rates during increasingly mild and wet winters

were analyzed based on the infestation history of bark beetles on spruce, heat-loving species of moths, and the classic pine insect pests in Southwestern Germany and North German federal states from 1969 to 2012 and 1991 to 2011, respectively. The multivoltine and predominantly resource-dependent bark beetles are especially subject to direct as well as indirect influences of climate change. They often had substantial amounts of attack-prone host material at their disposal due to the increase in extreme storm events during the last 40 years. There was a contemporaneous increase in the amount of suitable host material available and area attacked by *Ips typographus* on spruce in Baden-Württemberg, whereas the area attacked by *Pityogenes chalcographus* decreased despite the fact that they colonize the same trees.

Regarding heat-loving moths attacking hardwoods, the occurrence of *Thaumetopoea processionea* on oak was initially low, but increased substantially over time. In contrast, *Lymantria dispar*, long since established in Baden-Württemberg, did not show a further increase. This may be due to a lack of special climatic conditions that coincide with, and are required for, its progradation.

The areas of attack of the 4 univoltine lepidopteran pests on pine (*Bupalus piniarius, Panolis flammea, Lymantria monacha, Dendrolimus pini*) mostly remained small in Southwestern Germany during the last 40 years. The area attacked in some of the northern federal states was high from 1998 to 2003, but decreased from 2003 onwards with some exceptions due to the sawflies (*Diprion pini*) with their plastic bionomics, i.e. mainly bivoltine, but able to diapause for more than one year.

In conclusion, it seems appropriate to differentiate forecasts for forest insect pests due to various climatic scenarios as species- and stage-specific according to life strategy and seasonal occurrence of their so-called critical stages, as well as their occurrence in the core or peripheral range of their distribution, even within closely related eco-systematic groups and their respective host tree species.

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