Energetic impact of climate change on two paper wasp species (*Polistes*) from temperate and mediterranean climate regions.

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Introduction: The survival of insects in a changing climate is mostly discussed with respect to upper or lower temperature limits. The change of energetic demands with rising ambient temperature, however, is often neglected. Ectothermic insects exhibit a direct linear relationship of body and ambient temperature in most phases of their life cycle. Considerations of energetics are crucial because the metabolism of ectothermic insects necessary for basal maintenance increases approximately exponentially with ambient temperature. We here present a model comparing the energetic demands of two paper wasp species (*Polistes dominula*, *Polistes gallicus*) from temperate and mediterranean climate regions throughout a breeding season.

Methods: We measured the microclimatic temperature at the nests of the two wasp species during an entire breeding season (April – September) with thermocouples and data loggers. The temperature data recorded at intervals of 15 minutes were used for further calculations. Energetic demands were calculated from standard (basal) metabolic rate measurements performed on individual wasps in the entire ambient temperature range wasps are likely exposed to during a breeding season (~5 - 45 °C). Model calculations were performed for actual temperature values recorded at the nests, and for a predicted temperature increase of two and four degree celsius. Across the compared part of the breeding season (May 15th – September 1st) the nest temperatures varied between 6.7 – 45.7 °C (mean = 22.5 °C) in Gschwendt/Austria, and between 8.4 – 45.3 °C (mean = 24.9 °C) in Sesto Fiorentino/Italy. For both climatic regions the wasps' energetic demand was calculated from the microclimatic data of a representative nest. Energy demand ranged from 74 – 1206 J/d (mean = 518 J/d) in Gschwendt/Austria and from 214 – 993 J/d (mean = 487 J/d) in Sesto Fiorentino/Italy.

For the whole compared seasonal range this amounted to 58010 J in *P. dominula* and 53536 J in *P. gallicus*, calculated from the average worker weight of 88 mg and 44 mg, respectively.

Results & Discussion: It was a surprising finding that the impact of a predicted climate change on energy consumption turned out to be quite similar for the two species despite the average climatic difference in their habitats. A predicted temperature increase of + **2 °C** at the nest resulted in a seasonal increase in estimated energy demand of **22.5%** in *P. dominula* and **21.1%** in *P. gallicus*. A doubling of the predicted temperature increase to + **4 °C** resulted in a more than twofold increase in energetic demand of **49.1%** in *P. dominula* and **49.2%** in *P. gallicus*.
The model shows that an ambient temperature "only" 2 °C higher results in a considerable increase of energy demand for the maintenance of basal biological functions. A worse case scenario of a 4 °C increase means nearly a 50% growth of the necessary energy supply. This will force the insects to considerably rise their efforts to supply energy for themselves and their brood. More flight and foraging activity will in turn lead to an additional increase in energy demand and also to a higher predation risk.

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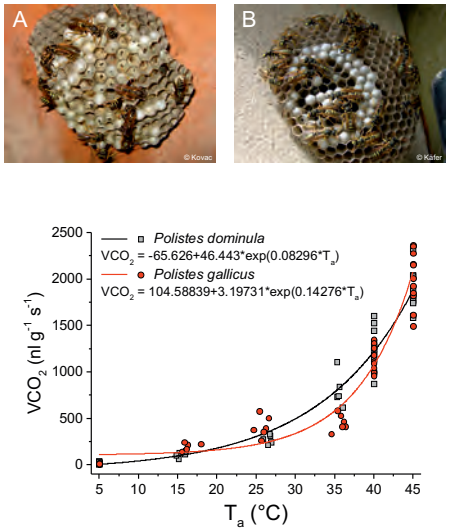

Fig.1 Standard (basal) metabolsim of two paper weasp species, *Polistes dominula* from temperate regions (A) and *P. gallicus* from the Mediterranean (B). Although the general data course is similar, the two species show slight differences at higher temperatures (around 35 - 40 °C)

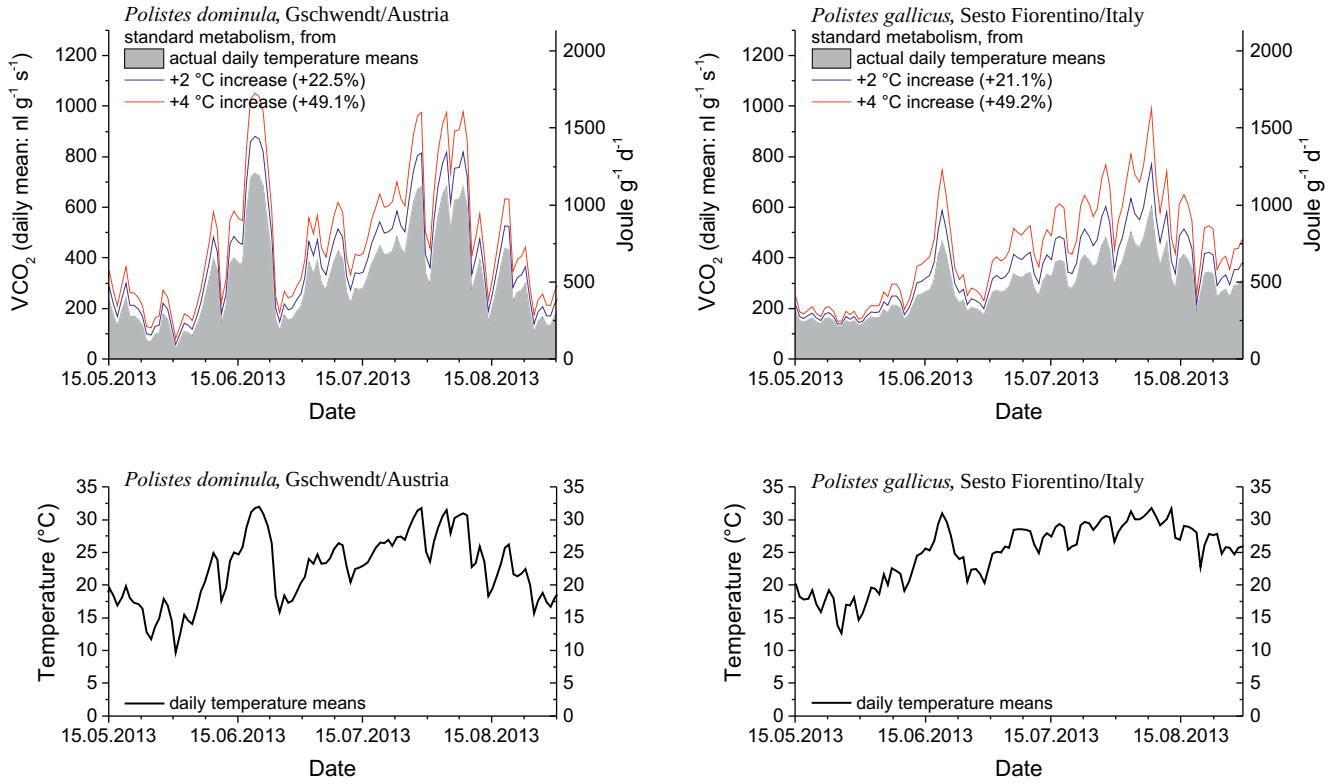

Fig.2 Daily energetic demand of two paper wasp species, Polistes dominula from a temperate climate region and Polistes gallicus from a mediterranean climate region, during a breeding season. Calculated are VCO_2 and Joule per day for the actual temperature measured at the nest and for a temperate increase of 2 and 4 °C.