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Tracing the sources of water for life at the dry limit using stable isotopes

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Living tissues require water to function. Nevertheless, highly adapted insects are observed in the fierce water limited conditions within the fog free hyper-arid core of the Atacama Desert [1]. Where do they get water from? Individual food and water sources comprise distinct oxygen and hydrogen isotopic compositions, that are reflected in body water $\delta^{2}H$, $\delta^{17}O$ and $\delta^{18}O$. Therefore, the stable isotopic composition of insect body water may inform on distinct water sources and respective survival strategies of individual species.

For direct sampling in the field, we used a novel method [2] that is based on slow water transfer from the organic matrix to initially dry, hygroscopic $CaCl_2$ salt in closed containers. Our preliminary data for insects from the Atacama Desert show a large isotopic range. Adult darkling beetles of the genus *Antofagapraocis sp. nov.* (Coleoptera: Tenebrionidae) comprise extremely enriched body water, with $\delta^{18}O$ up to 21.6‰ close to air O_2. In contrast, the body water of the extreme xerophilous silverfish relative *Maindronia* (Zygentoma: Maindroniidae) is highly depleted with $\delta^{18}O$ down to -7.1‰. This low isotopic composition points to absorption of water vapor from undersaturated air, which is supported by our preliminary modelling. This finding is remarkable, because relative humidity in the area was mostly below 20% over months, much lower than the minimum relative humidity of 47% presently described for water vapor absorption in the literature.

For all investigated Insects, metabolic water is an important source. It is produced from the oxidation of dry food and air O_2, with its characteristic negative $\Delta'^{17}O$ anomaly. To further characterize this particular water source, a sprouted potato was analyzed. Clear negative $\Delta'^{17}O$ anomalies derived from air O_2 are observed within the water extracted from the shoots. Characterizing all isotopic endmembers in combination with species specific isotope enabled mass balance modelling allows to quantify all water sources and sinks, as in vertebrate models [3].

[1] Zúñiga-Reinoso A, Predel R (2019), *Global Planet. Change* 182, 103007.

[2] El-Shenawy M et al. (2024), *Rapid Commun. Mass Spectrom.* 38, e9646

[3] Feng D et al. (2024), *Geochim. Cosmochim. Acta* 365, 21-34.