ABSTRACT

APPLICATION: 2012777

Title: Gas exchange between animal burrows and the atmosphere: the effects of eddies and microturbulence at the surface on gas movement in single and multi-entranced burrows - from ants to aardvarks.

Berry pinshow and Pedro Berliner (Ben-Gurion University of the Negev, Israel); J. Scott turner (SUNY-ESF, SyracuseUSA)

Project Summary

We propose to explore the physical mechanisms promoting gas exchange in animal burrow systems. In particular, we shall focus on how transient-state phenomena, including unsteady flows and resonant mixing phenomena facilitate gas exchange in animal burrows. These are largely unexplored phenomena, yet are likely to be important in natural situations, where naturally turbulent winds will be the principal drivers of gas exchange.

We propose to study these mechanisms using a diverse array of burrows of Negev desert-dwelling animals, ranging from the simple tube-shaped burrow of the Israel gold scorpion *Scorpio maurus*, to the branched tubes constructed by the desert isopod *Hemilepistus reaumuri*, to the U-burrows inhabited by the common rodent Sundevall's jird (*Meriones crassus*). We will employ several methods to characterize and quantify transient-state flows in these burrows, as they are affected by the complex transient flows in the turbulent boundary layer near the burrow entrances. We will also use new technology to measure the gas exchange impedance (a transient-state analogue of the resistance) of natural burrows to correlate this with burrow architecture and its adaptation to local idiosyncrasies of the turbulent boundary layer. We will also explore the extent to which animals "tune" their burrows to local characteristics of the turbulent boundary layer. In so doing, we hope to clarify the design principles of a mode of respiratory gas exchange that has been neglected in previous studies of this phenomenon.

Intellectual merit: This research will bring a fresh approach to a long-standing problem in physiological ecology: how do animals, particularly those with high metabolic demands, live in sequestered environments, like burrows, where access to the atmosphere is restricted? It has been difficult, up to now, to answer this question intelligently because of long-standing confusion over how gas exchange operates in natural situations where turbulent winds are likely to be the principal drivers of exchange.

Broader impacts: We hope that developing a clearer understanding of how transient-state mechanisms of gas exchange operate in model burrow systems will clarify broader questions of the nature of the animal-built environment, the so-called "extended organism." We this

research may also shed light on new ways that human-built structures might capture energy in turbulent winds to power wind-driven ventilation of the human-built environment.

Added value of international collaboration: This proposal brings the unique expertise and skills of each of the PIs together in a uniquely complementary way. The PI (Turner) has extensive experience with characterizing and measuring transient-state flows in the complex environments of termite mounds, as well as expertise in design and implementation of field instrumentation. The first Israeli co-PI (Pinshow) is a renowned physiological ecologist who has extensive knowledge of organismal physiology, adaptation to environments, and the natural history of the model animals we propose to study. The second Israeli co-PI (Berliner) is a world-renowned expert in meteorology of microclimate, particularly of the turbulent boundary layer. All have a solid grounding in the physiological ecology of arid environments.