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A METHODOLOGY FOR APPLYING ENERGY HARVESTING TO EXTEND WILDLIFE TAG LIFETIME

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ABSTRACT

Wildlife monitoring tags are a widely used technique for studying animals in their natural habitats. At present, these devices are energy limited, based on the mass of the electrochemical battery that can be carried by the animal. Flying animals are particularly restricted, based on a requirement for minimal excess loading. This requirement causes tag lifetimes to be far shorter than would be useful from an ecological perspective, particularly for smaller animals. Energy harvesting is being widely adopted in applications where access to permanent power is limited. If applied to wildlife tags, this approach offers the possibility of extending functional lifetimes indefinitely; however, it presents unique challenges. Practical applications on flying animals are extremely mass limited, subject to environmental stress, and operate at very low frequencies. This paper is meant to address the critical issues in the design task, and makes attempts to place bounds on unknown design parameters, based on literature research where applicable, and on experiment when no data exists. We discuss candidate harvester materials, novel data acquisition tools, and a prototype harvester design.

INTRODUCTION

Wildlife monitoring and tracking tags enable biologists to gather detailed data on numerous environmental and ecological phenomena. These devices multiply the efforts of biologists and conservationists, allowing them to obtain information, even in real time, that would otherwise be impossible or would require enormous effort to sample. Wildlife tags have been used to sample location, activity, vocalizations, temperature, heart rate, blood flow, muscle activity and many other parameters [1]. Early applications for radio tracking include work by LeMunyan [2] and Cochran [3]. In the nearly sixty years since, wildlife tags have become smaller, and some now include microelectronics for control and data storage. While microelectronics have followed Moore's law toward smaller size, advances in power consumption and battery energy density have not kept pace. Battery lifetime imposes a hard limit on the performance of small tags for animal study. Radio-tracking tags are widely used to monitor animal movements, but the power consumption of these tags limits their use to a year or less. Multi-year lifetimes for tracking tags would enable researchers to observe animal migration patterns over multiple seasons, or track dispersal as animals mature. This information is not attainable with current battery technology. Larger batteries are certainly available, and are appropriate for some species, but for the vast majority of flying animals, larger and heavier batteries are simply not an option. While additional on-board energy storage may not be currently feasible, new developments in the area of energy harvesting provide promising means to extend tag lifetimes.

Multiple sources of ambient energy are available for harvesting, including thermal, solar and vibration, but some are more feasible than others. While the animal's core temperature is often well above the ambient temperature, low coupling coefficients, and the relatively large mass required by an effective heat sink, preclude the thermoelectric generator for very low mass systems. Solar energy is appealing; however measurements have shown that feathers and fur absorb solar energy very well. Even a single feather above a solar cell