Session 6

Wildlife Tracking II

Methodological challenges for studying penguin eco-physiology in remote environments

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Abstract

Higher vertebrates situated at the top of food chains are often used as bio-indicators to provide information about the health of their ecosystem. Penguins are one of these species of interest, but the harsh environments they live in, as well as their pelagic lifestyle, make the development and deployment of adequate instrumentation challenging; moreover, these animals have a long lifespan that allows for long term eco-physiological and population dynamics studies but also causes additional technical difficulties.

To address these limitations several techniques must be combined. First, since observed individuals live in dense colonies, Radio Frequency Identification by means of passive implantable tags provides a reliable and long lasting solution to monitor individuals while using automatic detection systems placed at strategic locations in the field. In parallel, physiology and behaviors (including long-distance swimming and deep diving activities) of penguins can be recorded for weeks or months using bio-logger attached to the feathers, and up to three years with surgically implanted devices. For most cases, recapture of the animals is necessary to retrieve the data. Yet, devices combining bio-logging and telemetric functions have been recently developed to allow periodical downloading of the data when animals come back to their colony.

Keywords: *bio-logging, biotelemetry, radio frequency identification, harsh environment, long duration monitoring, penguin, eco-physiology.*

Introduction

Global changes induced in the biosphere dynamics by human activities are becoming a major challenge for mankind; one of the most impacted component is biodiversity. Study of biodiversity presents difficulties in scientific, methodological as well as technological domains; one approach consists in using higher vertebrates as bio-indicators. As they are situated at the top of food chains, their observation provides information about the health of their whole ecosystem: an alteration at any level of the chain will impact the welfare and/or the behaviour of upper levels, and consequently of the highest one. Penguins are one of the species of interest for the survey of Antarctic and sub-Antarctic regions, and are therefore commonly equipped with instrumentation by researchers.

From a general point of view, wildlife monitoring became necessary in many fields of biology, extending from physiology to ethology, and to medical research; in medicine, understanding the mechanisms of physiological adaptive capabilities observed in animals helps comprehending and fighting some human diseases (obesity, diabetes, infection,...) [1]. To perform these studies, more or less continuous information over long periods of time about physiology and behaviour of the animal, as well as about environmental conditions, is necessary: parameters of interest are for instance central temperature, cardiac rhythm or ECG, muscular activity or EMG, posture, energy expenditure (measured through 3D body accelerations), depth of diving or flight altitude, external temperature (air or water), sun radiation, GPS position, and any other measurable parameter required for a given study. They are obtained from miniature data-loggers (bio-loggers) attached on animals and comprising the adequate transducers. These measurements have commonly to be performed on free ranging animals covering long distances (hundreds or thousands of kilometres), and over long periods of time (up to 2 or 3 years) when investigations concern hibernation, reproduction cycles or migration for instance [2]; it is then mandatory that the electronics has an

extremely low energy consumption, in order to get long life time using the smallest and lightest batteries. And last but not least, all these measurements have to be performed without inducing, neither to the subject nor to its herd, penalties or artefacts that would entail the significance of the study: attention must of course be paid to the ergonomics and the size and weight of the device attached to animals, but also the contacts with humans should be restricted to the minimal absolute necessity [3].

Bio-logging is used in many laboratories over the world and has proved its efficacy for years now. Even if this technique is hardly replaceable, it suffers however intrinsically of severe drawbacks: information become only available for the scientist at the end of the experiment after re-capture of the animals, this inducing uncertainty about data collection and postponing of data availability.

Materials and Methods

Studying penguins encounters the technical difficulties previously mentioned, but is also subject to specific constrains related to distinctive feature of this species.

Identifying individuals

Penguins represent, for several reasons, a favored species to perform eco-physiological and population dynamics studies, which are preferably carried out over long periods of time. A first reason is that they have a long life span: about 18 years for little penguins, 20 years for Adélie penguins and up to 25 years for King penguins. Another advantage of these animals is that they come back to breed each year at the same geographic place, offering biologists the possibility to monitor them season after season. However, a penalizing point is that they live in colonies which may comprise up to hundreds of thousands of animals: localizing and recognizing a very animals carrying instrumentation is virtually impossible without a dedicated technological strategy.

To address the problem of identifying animals all through their life, an adequate technology is Radio Frequency Identification (RFID). It uses implantable tags, encapsulated in cylindrical glass casings; the smallest size is about 1mm in diameter and 6 mm in length, the largest is 4mm in diameter and 35 mm in length. These tags are passive and send back a unique identifying number in response to a powering electromagnetic field impulse. As they are passive, their life time is not dependant on a battery and is in principle infinite: a chick undergoing subcutaneous injection of a tag is stamped for lifetime. A limitation of the technique is the short reading range: a few centimeters for the smallest tags, and up to 60 cm for the largest. This means that the tagged animals cannot be localized or identified when mixed amongst others in a colony, but may only be detected when they come within a short distance of antennas disposed along natural transit pathways. A judicious location of the detector is the passing from the colony towards sea. As the maximal dimension of an RFID antenna is comprised between 2 and 6 meters, it has to be placed at a narrowing of the pathway; this narrowing may be natural in some sites, but can also be arranged by the biologists. Valuable additional information can be retrieved by disposing a second antenna near the first one in order to get the direction of displacement: it will be known whether the animal was going to the sea or coming back into the colony. As a penguin's colony may be spread over a large area, it is possible that an individual uses more than one route to sea: all the potential entrances must then be equipped with detectors.

Information collected 24 hours a day by the various antennas on a site must be centralized in a database to determine the location (on land or at sea) of each tag at any moment. As this activity diagram is characteristic of behaviors related to feeding, breeding, hatching, etc..., it is used to construct the history of each individual, allowing determination of traits of life related to members of a colony, and finally leading to population dynamics information. Another function of the system is spotting of individuals of interest: real time reading of the RFID detectors allows following visually an animal, in order to capture it for instance to perform blood samples, to attach a bio-logger or retrieve a previously deployed device.

Recording individual performance

While long lasting scientific survey of a penguin's colony entails marking for life each year hundreds of chicks, only a comparatively small number of them will be, at a moment during their life, temporarily equipped with data recorders; this is generally due to the high financial cost of instrumentation as well as to the practical complexity of its deployment. Data obtained on these animals about their physiology, behavior and environment are considered as representative for the group. A first kind of investigations is performed over a few months during the Antarctic summer, and concerns reproduction; information is obtained thanks to external data-loggers attached to the feathers on the animal's back. Other studies concern observations covering more than one year: because of the annual moult, instruments must generally be surgically implanted.

A technical constrains on instruments concern functioning of external devices at low temperature: when animals are standing isolated or at the outer side of a penguin's huddle, they may be exposed to temperatures as low as -30°C. This implies that the electronic components are chosen in the industrial temperature grade. The battery technology must be adequate too, and this is not always obvious: for small size batteries, even when data sheets specify an extended temperature range, a large increase in the internal resistance occurring at low temperature may hamper their ability to deliver the peak currents required by the recorder (for instance for memory writing).

Information of interest to be recorded on penguins at sea is generally diving profiles (depth versus time). The measurement may be done either with external or surgically implanted devices. Depending on the breed of penguin, they are likely to dive at depths ranging from 30 to 500 meters [4]: care has to be taken when designing the electronics casing, and tests must be performed on batteries to verify that there is no gas release induced by hundreds of 0/50 bars pressure cycles.

Recovering data

Penguins have a pelagic lifestyle, alternating sojourns at land and foraging trips at sea: they are able to swim for hundreds of kilometers to find schools of fish, dive at great depth to hunt (holding their breath up to 20 minutes) and store food in their stomach to bring it back to the chicks. Obviously, no biotelemetry system can be helpful for recording parameters in these situations, and bio-loggers are universally used. The consequence is that animals must be recaptured at the end of the experiment time, at a moment when they come back from sea and pass through the RFID detector. An alternative is provided by newly developed systems combining bio-logging and telemetric functions [5]. Data are stored in a memory when the animals are at remote places; when they come back near a base radio station placed near the colony, communication is established in order to download the previously stored sets of data.

Discussion and Conclusions

Studying animal in the wild is the only approach that allows linking a given behavior to the environmental conditions. An important challenge for conservation is a quantitative understanding of how stressors will interact to modulate environmental change at a community or individual level. The challenge is to develop variables that are sensitive enough to detect short term changes in performance at the top predator levels, as these species integrate changes occurring in the lower levels of the trophic chains; this is critical since climate change is altering the structure and functioning of marine systems. Penguin is a preferred model for studies in Antarctic and sub-Antarctic territories; they are performed attaching temporarily data-recorders onto the subject so as to record in a quasi-continuous way its activity, its physiological parameters, the physical parameters of its immediate surroundings and the interactions among these. Bio-loggers to be attached on penguins must resist to the harsh conditions they live in and to their pelagic lifestyle; they should moreover be light, small and hydrodynamic to have the smallest impact on the animal's performance. And finally, in order to minimize human handling effects and to provide data during the experience, periodical radio transmission of data contained in the logger's memory is advisable.

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