

A Multisensor Telemetry System for Studying Flight Biology and Energetics of Free-flying Griffon Vultures - *Gyps fulvus*. A Case Study

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INTRODUCTION

In the study of flight energetics, several approaches are common: 1) measuring oxygen consumption, 2) measuring turn-over-rates using double-labelled-water, 3) adapting models of flight mechanics to the dimension of birds, and 4) using heart rate as an estimate for metabolic rate. All of these approaches have specific disadvantages: method 1) is restricted to lab conditions, 2) delivers only average turn-over-rates within a defined period, 3) is a pure theoretical approach with little experimental evidence, and 4) delivers relatively rough estimates, which are influenced by other factors. However, several studies have proved that heart rate can be a reliable indicator for metabolic rate, especially if regression functions are individually correlated to different activities. To study flight energetics of free-flying Eurasian Griffon Vultures *Gyps fulvus* under natural conditions, a telemetry device was developed to measure flight-specific parameters and to correlate them with observed flight behaviour.

This study was supported by the GIF research grant No. I 0370-154.01/94.

METHODS

The multisensor telemetry transmitter which was developed, measures heart rate, body temperature, plumage/ambient temperature and air pressure/flight altitude. The transmitter is divided into 2 subunits: an intracorporal unit (64 x 35 x 12 mm, 42 g) detects heart rate from the ECG signal, measures body temperature and transfers this information to an external repeater via a short range telemetry link (100 kHz-band). A self-adaptable trigger circuit and adequate filter characteristics minimize interference with EMG-signals and ensure proper ECG-triggering over the long term. The external repeater which is fitted with a semi-flexible silicone/teflon-harness (78 x 37 x 27mm, 150g) decodes the parameters from the implant, measures plumage/ambient temperature and air pressure and transmits all information through a telemetry data link (150 MHz band). All parameters are transmitted in sequence with a PDM/PIM modulation scheme. During 24 hours, the following data

rates are collected: heart rate 2880 data sets (which represent averaged values over a half minute period), air pressure 1440 data sets (which represent 4 averaged values each), body and plumage temperatures 720 data sets (which represent discrete values). Thus, depending on the fluctuations of the various parameters, update intervals range from 30 sec (heart rate) and 60 sec (air pressure) to 120 sec (body and plumage temperatures). On average, 85% of the theoretical data rates are recorded under field conditions. Lifespan of the transmitter is approx. 2 years, and the range under field conditions is approx. 5 kilometres. For datalogging a standard TELEVILT RX900 receiver is used.

For a detailed description of the transmitter and implantation techniques see Schober *et al.* (1998) and Walzer *et al.* (in press). For a calculation of altitudes from air pressure values under different weather conditions see Bögel (1996).

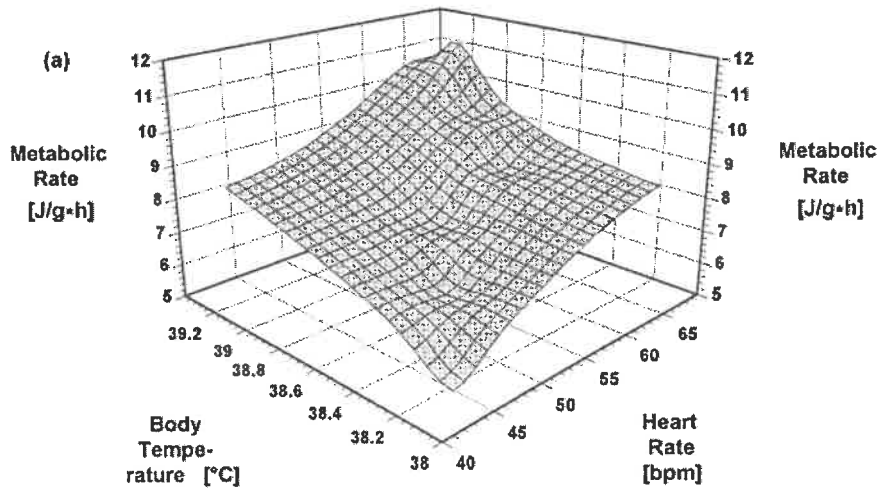
To calibrate energy turnover versus heart rate, detailed measurements on oxygen consumption under various conditions were made in a metabolic chamber at the Frankfurt University.

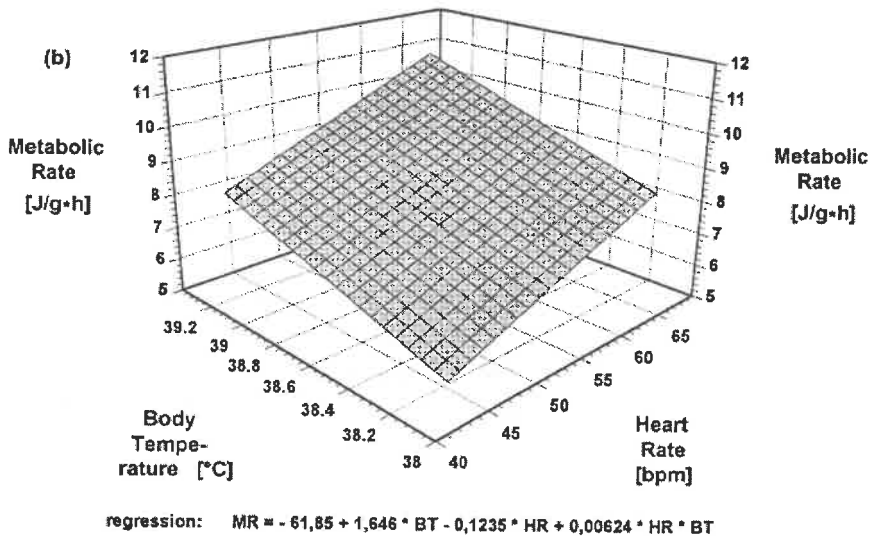
RESULTS AND DISCUSSION

Figure 1 shows the relation and regression function between heart rate, energy turnover and body temperature resulting from the measurements in the metabolic chamber. If data are pooled and averaged, and body temperature is implemented as an additional variable, residuals are below

0.2 J/g*h, indicating an excellent correlation coefficient of 0.974. However, under field conditions heart rates can easily exceed 200 bpm, and energy turnover rates have therefore to be extrapolated from laboratory measurements where heart rates did not exceed 100 bpm. Thus, energy turnover rates derived from heart rates >100 bpm cannot be confidently estimated at present.

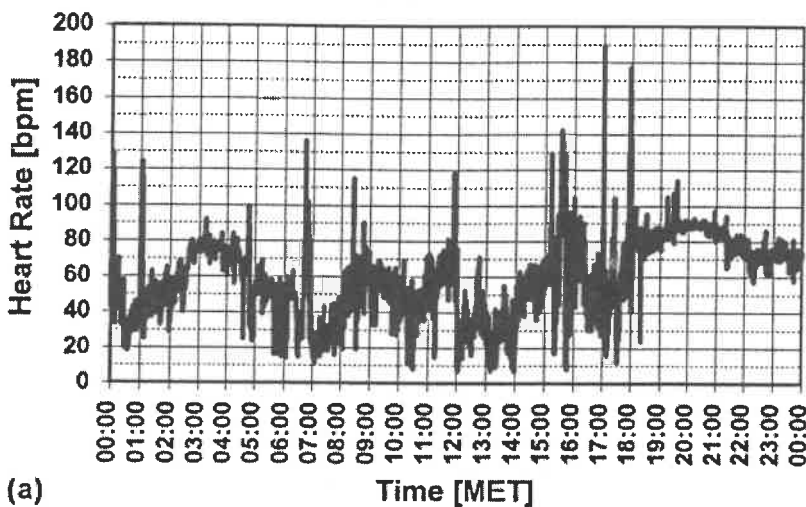
Figure 1: Metabolic Rate (MR) versus heart rate (HR) and body temperature (BT), (a) pooled data and (b) surface regression for a Eurasian Griffon Vulture in a metabolic chamber.

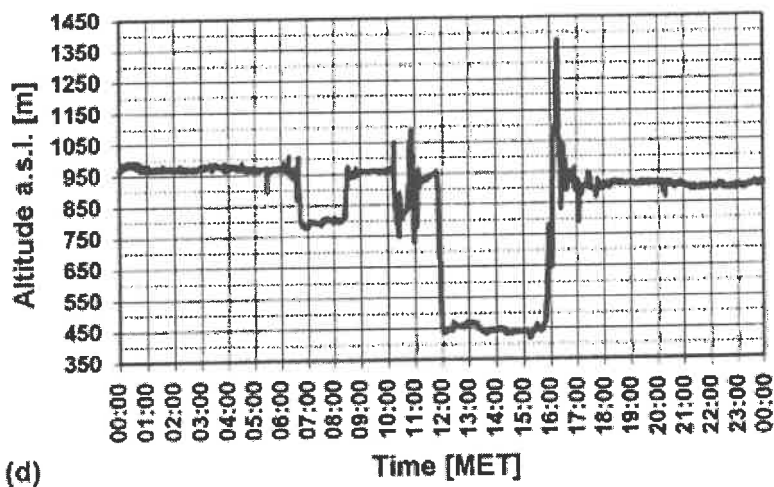
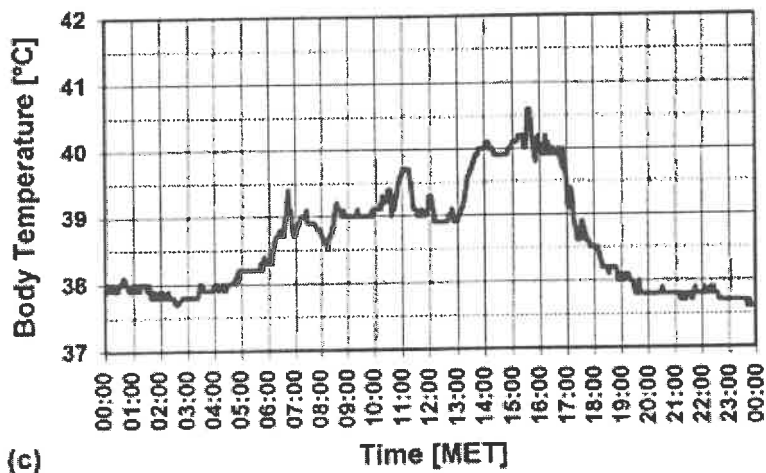
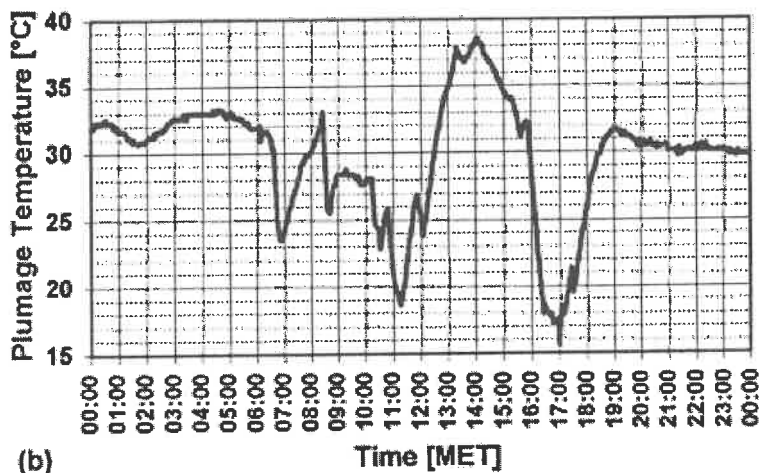




Using the method described above, flight profiles of a Eurasian Griffon Vulture with corresponding heart rates and patterns of body and plumage temperatures were recorded in the northern European Alps (Karl 1998). Figure 2 shows these for 24th March 1998 over a 24-hour period. The bird left its nesting cliff at Mount Untersberg at 06.30 hrs and performed various flight activities and changes in roosting sites before it finally arrived at the zoo at 12.00 noon. After feeding, the vulture left around 15.45 hrs and perched at its nesting cliff at Mount Untersberg around 17.10 hrs. Heart rates ranged from <20 to almost 200 bpm and varied substantially over most of the diurnal cycle according to the

Figure 2 a-d: Patterns of (a) heart rate, (b) body temperature, (c) plumage temperature and (d) altitude for a free-flying Eurasian Griffon Vulture on 24th March 1998.





performed activities (Fig. 2a). Body temperature (Fig. 2b) showed a clear diurnal pattern with peaks which are caused by flight activities (around 06.45 hrs, 11.00 hrs, 15.45 hrs) but also by feeding activities that included a high level of intraspecific aggression (between 14.00 and 15.00 hrs). Plumage temperature (Fig. 2c) is an excellent indicator of flight activities (cooling effect) and clearly reflects changes in flight altitude (Fig. 2d). It can be seen that flight activities can be an energy-efficient mechanism for thermoregulation if flight conditions are favourable due to efficient updrafts (around 16.00 hrs). Peaks in body temperature and heart rate correlate, but due to different flight behaviour (gliding versus flapping flight) these peaks correlate closer around 06.45 hrs and 15.40 hrs than around 11.00 hrs. However, many bursts in heart rate which are not caused by physical stress, are not represented in the body temperature pattern. It is also interesting to note that heart rates during inactivity vary between approx. 40 and 80 bpm, and may even be decreased to lower levels, probably as a "compensatory mechanism" after stress (Fig. 2a). Correlating the selected flight tracks and profiles with the corresponding flight conditions as predicted by GIS-models on thermals and dynamic updrafts reveal that the vultures optimize their flight behaviour in order to minimize their energy consumption (Bögel 1996).

The described method is also very useful to detect and quantify perturbations in the vulture from disturbances which may be caused by various reasons. This has been documented, for example during fireworks on New Year's eve (Bögel *et al.* in press)!

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