

Measuring Locations and Flight Altitudes of Griffon Vultures *Gyps fulvus* by an Automatic Telemetry System*

Ralf Bögel

INTRODUCTION

Conventionally radio-tracking and habitat use has been restricted to a two dimension analysis: radiolocations and home ranges are plotted as polygons, isopleths, clusters or assemblies of grid cells (Kenward 1987; White & Garrott 1990). In spite of that, birds use their habitats three dimensionally and therefore require specially designed transmitters and adapted methods of data recording. Kenward *et al.* (1982) used thermistors for recording the cooling effect of the air during flight as an indicator for flight activity. However, this didn't incorporate the measuring of the altitude. At the 4th European Conference on Wildlife Telemetry in 1991, a prototype transmitter design for birds was introduced featuring a barometric altitude meter (Bögel & Burchard 1992). In the meantime, the transmitter design has been improved in terms of altitude range. In addition, temperature coding has been adapted for an automatic recording device. Data recording is done by a Doppler-telemetry system (Schober *et al.* in press) which improves the accuracy of radio locations compared to a former type of an Automatic Direction Finding (ADF) system (Bögel 1991). The studies are part of a project on home range size and flight biology of a small colony of Griffon Vultures at the northern slope of the European Alps (Bögel *et al.* 1990), that descend for food to a feeding station at the Salzburg Zoo (Mäck & Bögel 1989). The main motives for applying this new technology to Griffon Vultures have been:

i) Griffons have proved to fly at altitudes of 10'000 m and more. Like other soaring gliders, they have a pronounced ability for a three dimensional habitat use.

ii) According to visual observations, vultures can even fly during snowfall or rain, indicating that they have different strategies for an effective exploitation of different air currents. Observations of Pennyquick (1972, 1973) confirm this hypothesis.

iii) It has been argued that flight activities of vultures are depending on thermal updrafts and thus climate changes could have caused the extinction of Bearded Vultures in the Alps (Haller 1983).

iv) Flying at high altitudes may be important for vultures in terms of thermoregulation. The data presented here should quantify the effects and the benefits that Griffons can get out of different weather and wind conditions.

* financed by the BFANL and the StMLU Bayern.

METHODS

An air pressure sensor is used for a pulse-interval-modulation (PIM) and thus different pulse intervals indicate different air pressures (Fig. 1). Time intervals ranging from 200...1100 ms correspond to air pressures of 350...1000 mb or altitudes ranging from 8000...0 m. A calibration at the laboratory and a regression function (see Fig. 1) is used for determining the air pressure at flight altitude from the pulse interval reading of the telemetry receiver. Then, by recording of air pressure and temperature references (P_o, t_o) at a known altitude (a_o), the bird's altitude can be calculated as follows:

$$a_{(T)} = a_o + \frac{5\,023\,200 + 18\,400 \cdot t_o}{273,15 + \frac{59,8}{\log(P_{(T)} / P_o)}}$$

$a_{(T)}$: flight altitude $P_{(T)}$: air pressure in flight altitude a_o : ground level P_o : reference air pressure (ground level) t_o : reference temperature (ground level)

For maximum precision and the elimination of thermal drift effects in the electronic circuits, it is useful to measure the temperature of the tag (see Fig. 1). This is realized by another PIM (Fig. 2). Identification of the transmitted parameter is done by a pulse duration modulation (PDM), resulting in 10 ms pulses for temperature readings and 20 msec pulses for air pressure recordings. If the temperature gradient of the atmosphere is constant, the remaining errors have an extent of max. +/- 80 m (see Fig. 1). Fig. 3 shows a tag for Griffon Vultures designed as a back pack harness using silicone ropes and a weak link with a 2 year lifespan (the same as the batteries). The dimensions are 80x35x28 mm, the weight is 100 g = 2% of body weight. The maximum range is approximately 20 km but could reach up to 50 km for birds at great altitudes. It is interesting to note, that within a few days the tag is completely covered by feathers. If the harness is adjusted carefully, no behavioural effects can be observed. However, the tags might have some impact on the energy budget during flight (Pennycuick *et al.* 1989). For data sampling during field work, a conventional receiver with pulse duration and pulse period option is used (B+R Ing. GmbH, type 235090). For quick results, altitudes are then determined graphically (Fig. 4). An example is given for a pulse period reading of 830 ms and a reference air pressure of 970 mb at 440 m, resulting in a corresponding flight altitude of 2200 m. However, for simultaneous tracking and altitude measuring of several individuals in a mountainous research area, an ADF-Doppler system has been developed (Schober *et al.* in press). It handles the whole data sampling, both automatically and with a high chronological and spatial resolution. In order to minimize error sources, the system was designed as a Doppler Direction Finder (Burchard 1989). An integrated radio data link provides a direct data access. Due to bi-directional data communication the whole system is completely remote controlled by the central personal computer (Fig. 5). This means that all parameters of the receivers (channel selection, frequency fine tune, gain, etc.) can be adjusted according to the actual situation and data can be checked immediately for their plausibility. Retry options are running in such cases as: i) no radio contact is obtained ii) bearings indicate more than one intersection iii) meterings are not likely or con-tradictory iv) changes of receiver parameters are required.

Figure 1: Air pressure - time interval calibration, regression function and evaluation of accuracy.

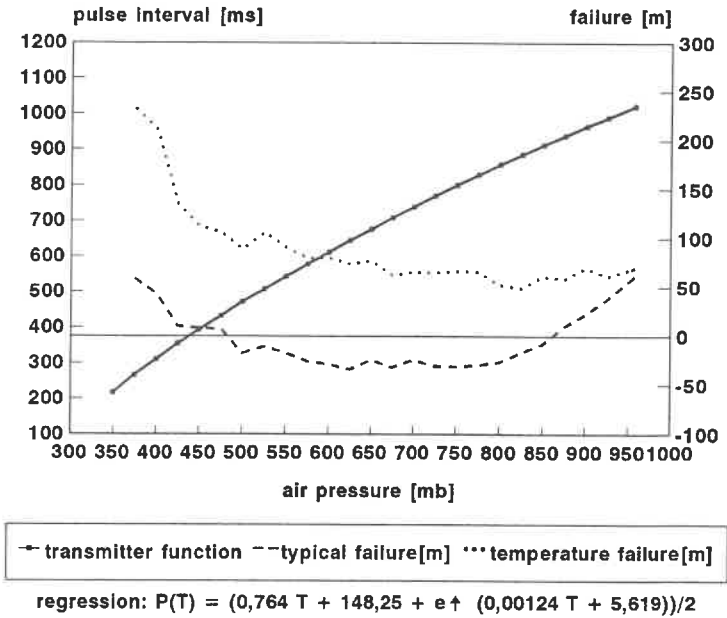


Figure 2: Temperature - time interval calibration and regression function.

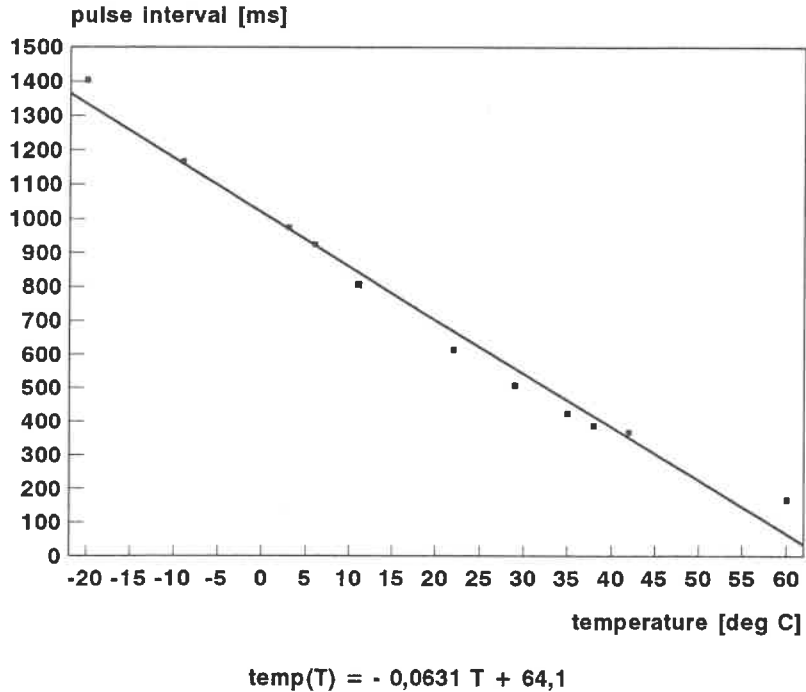


Figure 3: Back pack harness with telemetry transmitter featuring a barometric altitude meter.

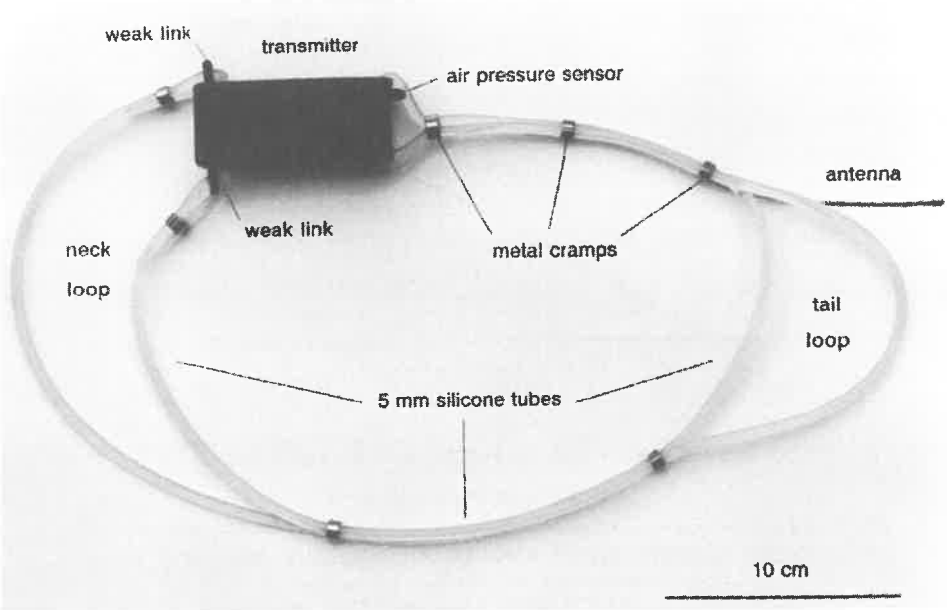
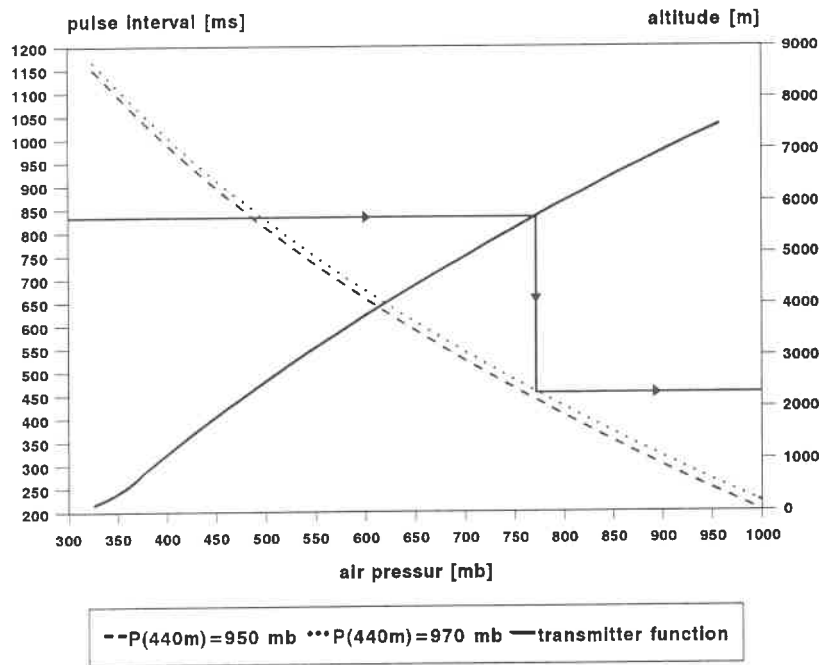


Figure 4: Pulse interval - flight altitude diagram used for field work.



for standard atmosphere: $T(0m) = 15^{\circ}C$; $-0,65^{\circ}C/100m$ altitude increment

Figure 5: Block diagram of the ADF-telemetry system.

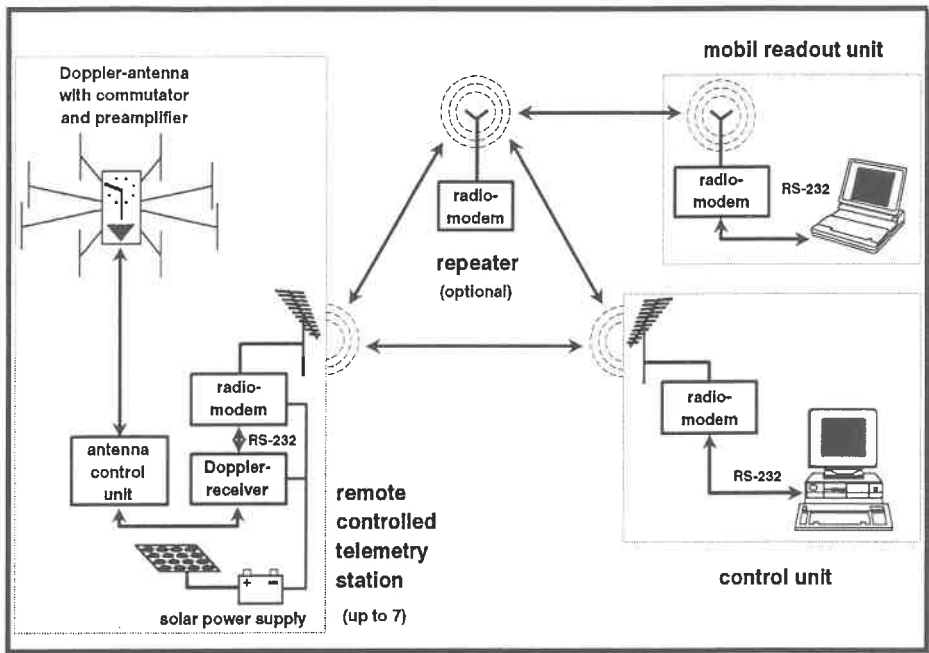


Figure 6: Translocation from the roosting cliff to the zoo. (numbers indicate radio locations and chronology)

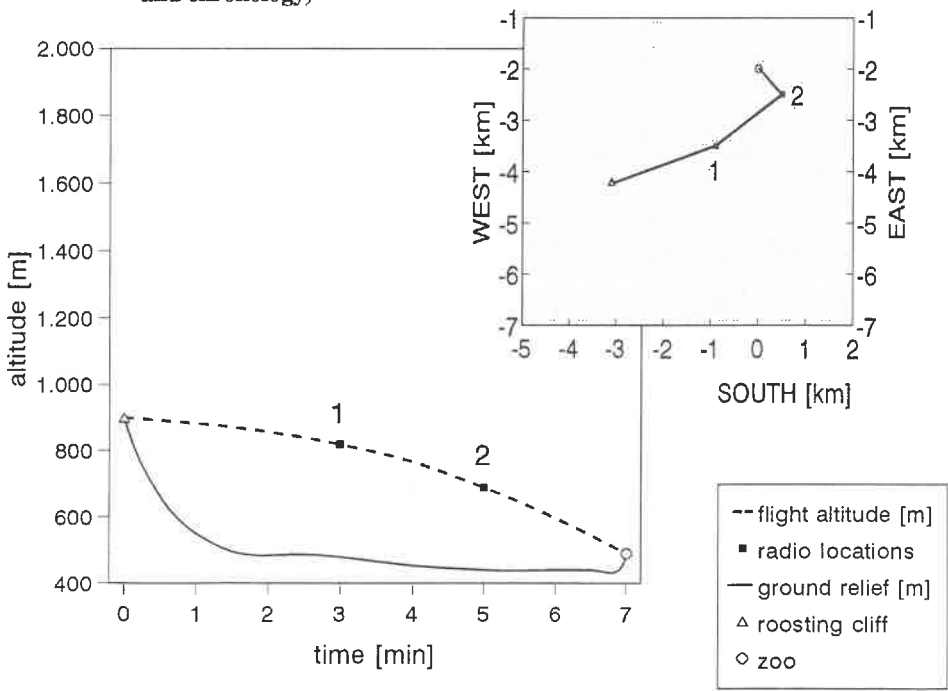


Figure 7: Translocation from the zoo to the roosting cliff: thermal updrafts with NW-winds at 6 m/s. (numbers indicate radio locations and chronology)

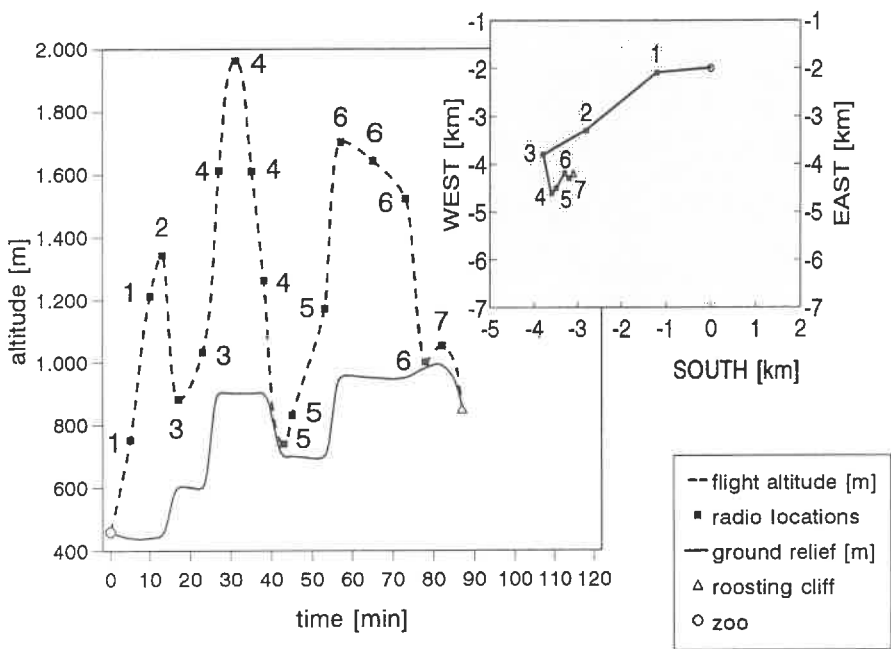


Figure 8: Translocation from the zoo to the roosting cliff: thermal updrafts with W-winds at 3 m/s. (numbers indicate radio locations and chronology)

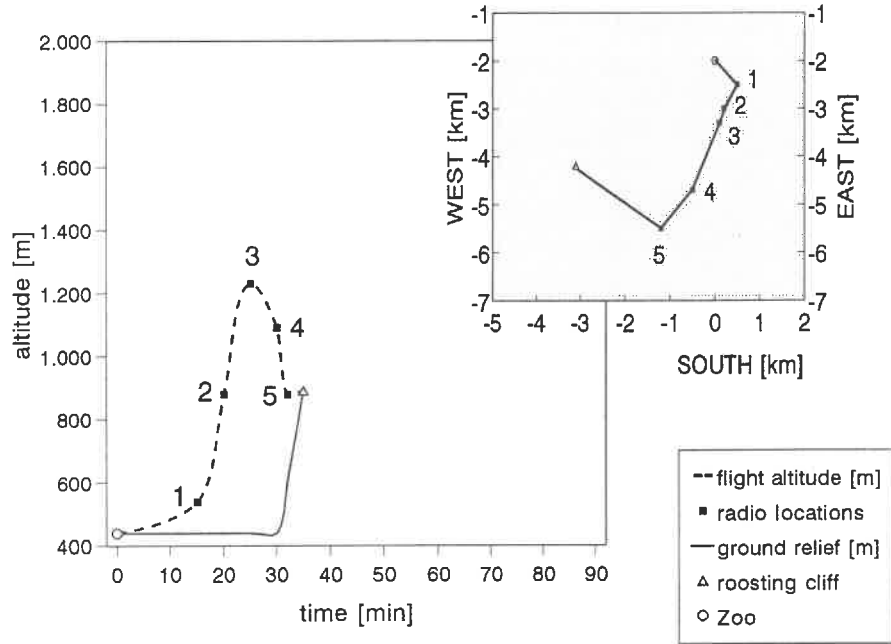


Figure 9: Translocation from the zoo to the roosting cliff: weather cloudy with ESE-winds at 4-5 m/s. (numbers indicate radio locations and chronology)

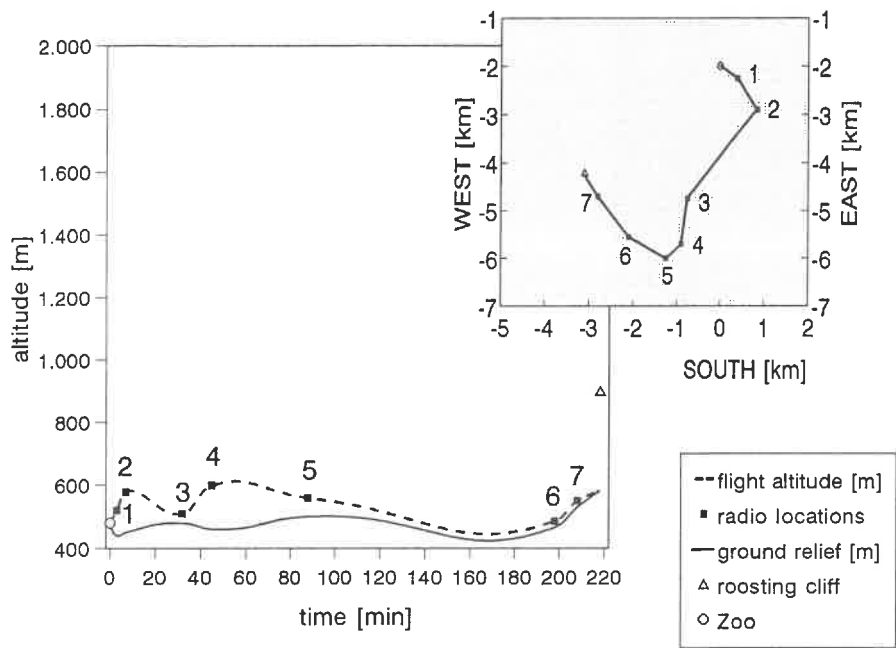
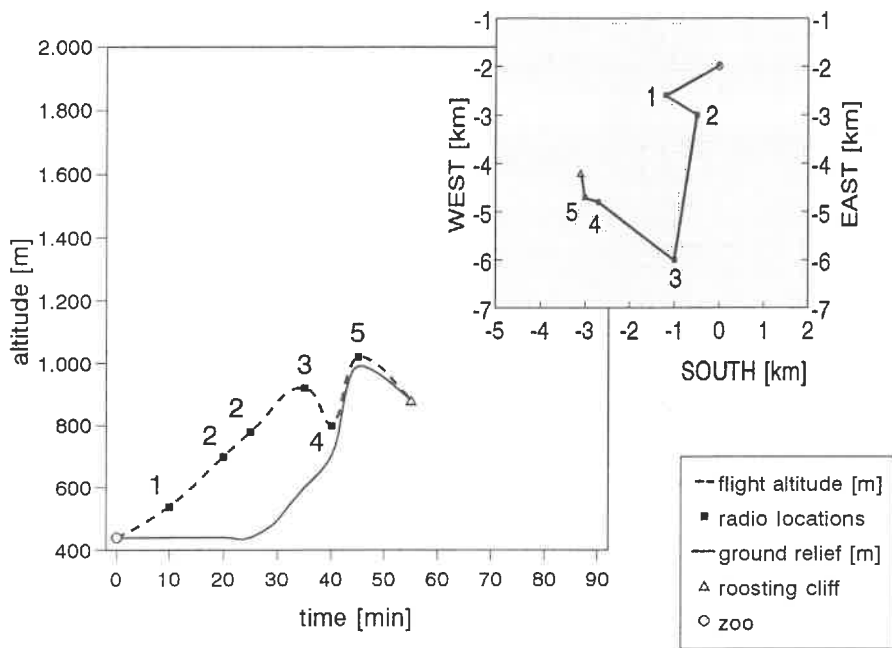


Figure 10: Translocation from the zoo to the roosting cliff: snowfall with W-winds at 7-8 m/s. (numbers indicate radio locations and chronology)



RESULTS AND DISCUSSION

The following examples represent the flight behaviour for various translocations under different weather conditions. Figures 6-10 show tracks and flight profiles as separate graphs. Fig. 6 is typical of all translocations from the roosting cliffs on the Untersberg mountain to the zoo. According to the gliding ratio of 15:1 (Pennycuik 1972), a difference in altitudes of 260 metres would be sufficient for pure gliding. As the zoo is located 500 metres lower, this type of translocation occurs stereotypically under all weather conditions: the vultures choose a direct track. This is different for the translocations in the other direction: in these cases, tracks and altitude profiles differ significantly with different weather and wind directions. Fig. 7 shows the flight behaviour for good weather conditions with NW-winds at 6 m/s and good thermal updrafts. The vulture gains altitude rather effectively over a forested area west of the zoo (points 1-2), then loses height during the translocation to point 3. Approaching the northern slope of the Untersberg mountain, the Griffon gets lifted very quickly by the relief updrafts. At point 4 the vulture changes to relief flight, probably in search for food. Before it is landing at the roosting cliff, it is regaining height without much effort (points 5 to 6), suggesting that its change to relief flight had not been forced by the wind conditions. Fig. 8 demonstrates that for weak W-winds at 3 m/s but fine weather with some thermal updrafts, a quick translocation is possible by gaining altitude over the western slope of a chain of hills southeast of the zoo (points 1 to 3), followed by a short cross-wind translocation with few changes in altitude (point 5 to the roosting cliff). Fig. 9 shows what happens if flight conditions are really bad: the vulture takes a flight track similar to that of Fig. 8, but is trying to be successful by crossing and circling over the eastern slope of the same hills (SE-winds at 4-5 m/s). This is not very efficient and even after a long period of trying and exhausting wing flapping, the Griffon does not succeed in reaching the roosting cliff but is perching below in the mountain forest 600 m a.s.l. Fig. 10 demonstrates that certain wind conditions can totally replace thermal updrafts: even in this bad weather condition with snowfall, the vulture is quite effectively gaining altitude by circling in the strong westerly winds (points 1 to 3), then crossing westwards in close relief flight to the roosting cliff (lee-area of the Untersberg mountain!). It is interesting to note that the time for this translocation is not noticeably longer than in cases with good weather conditions. Temperature decrease during the translocations ranged from 4 to 24 degrees C, varying with air temperature, velocity and altitude difference. If plumage temperatures were close to or exceeded body temperature (vultures inactive on the ground and exposed to full sunshine), the cooling down effect due to flight activities was greatest. Therefore flight behaviour can be interpreted as mechanism for thermoregulation.

CONCLUSIONS

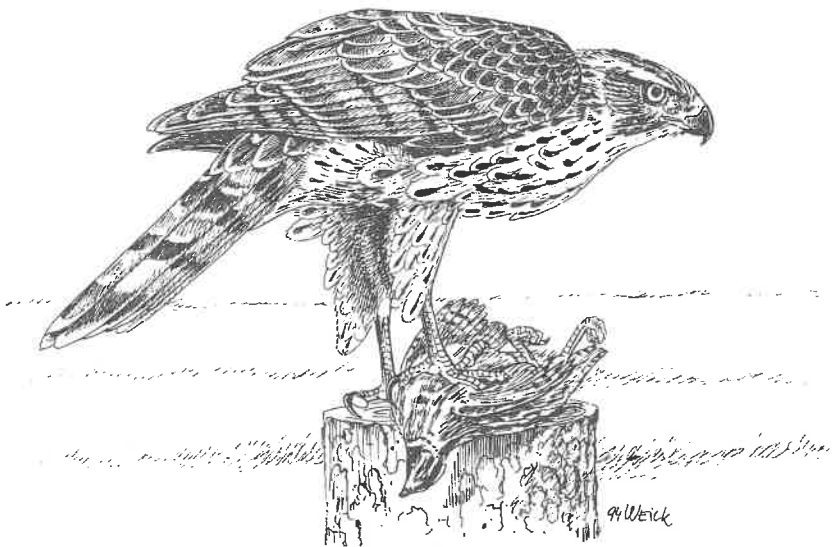
The flight behaviour of Griffon vultures indicates that the birds use adapted strategies for specific wind and weather conditions. They obviously seem to know from the start how to act most effectively in a certain situation. Only in cases with bad flight conditions, a trial-and-error strategy can be observed. In addition, the flight behaviour has a clear impact on thermoregulation. For an evaluation of the best strategy for a specific condition, it would be necessary to measure the corresponding energy requirements. As energy budgets of flight mechanics can only be quantified for constant flight conditions (Pennycuik 1990), this would only be possible by simultaneously recording of ECG and / or Oxygen consumption. However, on free-ranging animals this won't be practicable due to the risk of injuries that might be caused by implanted sensors. The data presented here are still preliminary. Data recording by the Doppler-ADF-system will deliver more detailed results due to an increased chronological and spatial resolution. Moreover, it will provide a sample size that is adequate for a statistical analysis.

REFERENCES

BÖGEL, R. 1991. **Automatic Radio Tracking**. Parc National du Mercantour (Ed.): Acte du Colloque Internationale "Suivi des Vertèbres Terrestres par Radiotélémetrie", Monaco, 1988. pp. 115-124.

- BÖGEL, R., U. MÄCK, & W. d'OLEIRE-OLTMANN 1990.** Radiotelemetrische Untersuchungen an Gänse- und Bartgeiern (*Gyps fulvus*, *Gypaetus barbatus*) in den Alpen. In R. Van Den Elzen & K.-L. Schuchmann (Eds.): *Proc. Int. 100. DO-G Meeting, Current Topics of Avian Biology*, Bonn 1988, pp. 201-210.
- BÖGEL, R. & D. BURCHARD 1992.** An Air Pressure Transducer for Telemetering Flight Altitudes of Birds. In I.G. Priede & S.M. Swift (Eds.): *Wildlife Telemetry*. Ellis Horwood, Chichester, U.K. pp. 708
- BURCHARD, D. 1989.** Direction Finding in Wildlife Research by Doppler Effect. In C. J. Jr. Amlaner (Ed.): *BIOTELEMETRY X*, pp. 169-178. University of Arkansas Press, Fayetteville, USA.
- HALLER, H. 1983.** Die Thermikabhängigkeit des Bartgeiers *Gypaetus barbatus* als mögliche Mitursache für sein Aussterben in den Alpen. *Der orn. Beob.* 80, 263-272.
- KENWARD, R.E., G.J.M. HIRONS & F. ZIESEMER 1982.** Devices for Telemetering the Behaviour of Free-Living Birds. *Symp. Zool. Soc. London*, 49: 427-432.
- KENWARD, R.E. 1987.** *Wildlife Radio Tagging*. Academic Press, London, pp. 222.
- MÄCK, U. & R. BÖGEL 1990.** Untersuchungen zur Ethologie und Raumnutzung von Gänse- und Bartgeiern. Nationalpark Berchtesgaden, Doktorberg 6, 8240 Berchtesgaden, Germany: Forschungsbericht Nr. 18, pp 147.
- PENNYCUICK, C.J. 1972.** Soaring Behaviour and Performance of some East African Birds observed from a Motorglider. *Ibis*, 114:178-217.
- PENNYCUICK, C.J. 1973.** The Soaring Flight of Vultures. *SAM*, 229(6):102-109.
- PENNYCUICK, C.J., M.R. FULLER & L. McALLISTER 1989.** Climbing Performance of Harris' Hawks *Parabuteo unicinctus* with Added Load: Implications for Muscle Mechanics and for Radiotracking. *J. exp. Biol.*, 142: 17-29.
- PENNYCUICK, C.J. 1990.** *Bird Flight Performance*. Oxford Press, Oxford, New York, pp.153.
- SCHÖBER, F., R. BÖGEL, W.M. BUGNAR, D. BURCHARD, G. FLUCH & N. ROHDE in press.** An Automatic Direction Finding and Location System Based on Doppler Effect. *Proceedings of the XIIth International Symposium on Biotelemetry*, August / September 1992, Ancona, Italy.
- WHITE, G.C. & R.A. GARROT 1990.** *Analysis of Wildlife Radio-Tracking Data*. Academic Press, San Diego, California, USA, pp.383.

Ralf Bögel
 Berchtesgaden National Park
 Doktorberg 6
 W-8240 Berchtesgaden
 Germany



Goshawk *Accipiter gentilis* - juvenile