Christine Braunreiter, Matthias Rothmund, Georg Steinberger and Hermann Auernhammer, Freising

Potential for GPS Collar Application for Alpine Pasture Management

Free grazing livestock influence the structure and composition of their habitat through their differing grazing behavioural patterns. Because of the structural change in mountainous regions, the goal of maintaining an open landscape conflicts with the damage caused by grazing animals. By attaching GPS collars with integrated activity sensors, the precise position and behavioural data of each individual animal can continuously be recorded. The results of various studies on cattle and goats were the basis for developing control strategies to reduce environmental damage from grazing animals and to facilitate pasture management for the farmer.

An important externality of agricultural production in mountainous regions is the formation of the unwooded cultural landscape. This is not only a living space for their inhabitants, but also important for recreation and tourism and therefore of economical interest.

According to the 1991 Alpine Convention it is necessary to support mountain agriculture in the implementation of a site-specific and environmentally sound cultivation.

The 1380 (40000 hectares) Bavarian alps (alpine pastures) are traditionally managed with 50000 cattle, sheep and goats during the vegetation period [1]. These free grazing animals, as well as wild herbivores influence the structure and composition of their habitats by practising different grazing behaviour patterns. Because of their ecophysiological evolution, there are many ruminant types, which were established in different ecological niches. They are classified in browsers (e.g. roe deer), grazers (e.g. cattle) and intermediate types (e.g. goats) [2].

Opposite to the positive effects of the preserved unwooded cultural landscape by grazing of variable species are problems such as compaction, repression, over- and under-fertilisation, nutrient displacement and erosion. Until now, these problems are not solved. The information gained with positioning and behaviour-sensor technology can be used to reduce the stress on the environment. For the development of modern sustainable pasture strategies, basic knowledge about landuse behaviour of farm animals on alpine pastures is needed. Therefore, GPS-collars of Vectronic-Aerospace GmbH with integrated two-axis acceleration sensors have been tested for their adequacy to collect spatio-temporal activity patterns in a trial at the Technische Universitaet Muenchen (TUM). This tech-

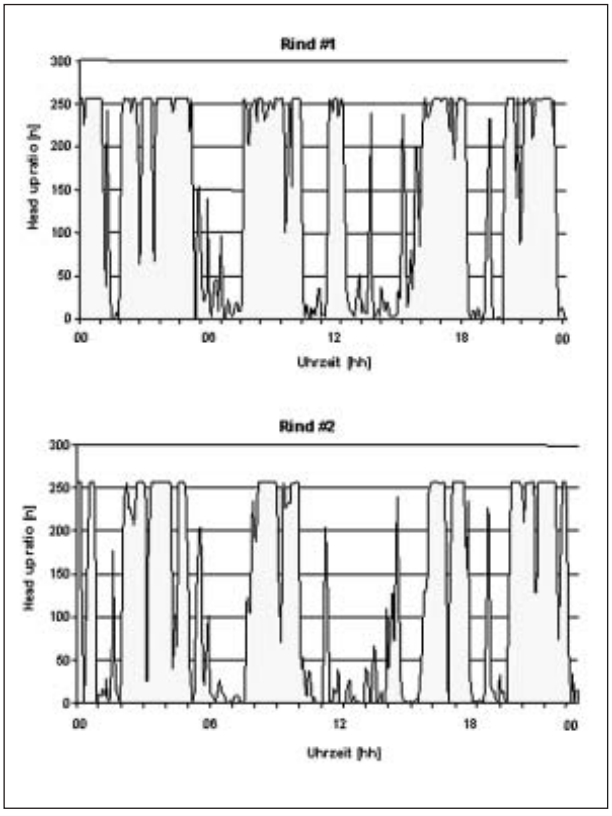

Fig. 1: Activity patterns of one single day for two grazing cows, recorded with GPS-collars

Dipl.-Ing.agr. Christine Braunreiter, Dr. agr. Matthias Rothmund and Dipl.-Ing.agr. Georg Steinberger are scientific assistants of the Chair of Agricultural Engineering (provisional leadership: Prof. Dr. Hermann Auernhammer) of the Technische Universitaet Muenchen, Am Staudengarten 2, 85354 Freising-Weihenstephan; e-mail: *christine.braunreiter@wzw.tum.de*

Keywords

GPS-collar, grazing animals, spatio-temporal behaviour, pasture management

nology has been used in wildlife research for the exploration of habitats for several years. Within different trials, the collars were fixed to goats and cattle in a continuous-grazing situation. Based on the first results, software modifications were made for optimised behavioural data acquisition of the collars, which will be used for all further investigations.

Test, configuration and validation of the measurement technology

At first, the GPS receiver of one collar was statically tested over three days in order to get knowledge about position quality. The 12 channel GPS receiver records the position at 4 Hz and saves the averaged position every 14 seconds in the internal storage. The result showed, that only 2.5% of the recorded positions had a relative deviation of more than 10 meters.

The established relative accuracy of <10 m at 97.5% of the time is considered to be sufficient for the set requirements.

The following data collection has been executed in 2006 on Boer goats and Limousin cattle in a continous-grazing situation at the experimental station "Grünschwaige" of the TUM.

With the aid of direct-observation of behavioural patterns of the animals, the activity data recorded by the collars have been checked. The results of the integrated two-axis acceleration sensor (x-axis: forward-backward-acceleration and y-axis: right-left-acceleration) showed that the quality of the calculated behaviour conclusion (81.7% accordance with observation on cattle and 75.7% on goats) was not satisfactory. Therefore the algorithmic data acquisition within the collars has been modified. Before starting a trial, the collar has to be set with a species-specific treshold, which reflects the distinction between "head up" or "head down"-situation. By scanning the activity sensor every 250 ms, the "head up ratio" is stored every 64 seconds as portion of time with "head up"-situation. The internal value-range from 0 to 255 allows a resolution of 0.4%. The modified system was again verified with a 17 h observation of the cows as reference. The accordance of the data with the observed behaviour patterns accounted now 97.1%, which is absolutely sufficient for the following trials.

Results of behavioural data acquisition

Subsequently, basic spatial correlations have been analysed with four out of eleven cows for one week in a continous-grazing situation. The swampy pasture area covers 5.91 ha with a very homogenous distribution of forage plants regarding appearance and nutrient value. Data have been stored in a SQL-database. Further analysis was done in a spreadsheet (MS Excel) and in a geographic information system (Open Jump GIS). *Figure 1* shows exemplary the comparison of the diurnal rhythm of behaviour of two cows. Both animals had already a calf at that time. The curve shows in both cases, that the cows have a slightly different rhythm, but the basic activities are starting and ending at the same time and are typical for ruminants (alternation of activity (value < 125) and resting (value > 125)). The location as well as the behavioural of cow "Funny" during the whole test period is illustrated in *Figure 2*. The distribution over the area and the associated activity shows the individual preferences. On the left side of the area is a high density of data points, indicating "head up" (black colour). That means that the cow prefers these sub areas for resting (standing, lying and ruminating). A reason for this behaviour could be that there is a broad tree row along this side, which provides protection. White data points showing "head down" ("feeding") are distributed relatively homogenous. The right side of the pasture is generally less used as the remaining area, because of a cart track.

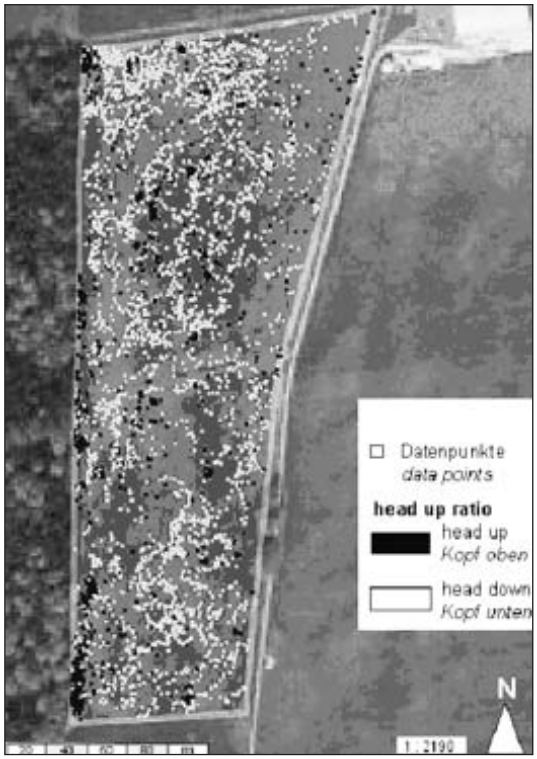

Fig. 2: Positions and „head up"/ „head down" activity of one cow during one week data acquisition period with GPS-collar

Further work and outlook

In a next step, the results should be compared to those of a "free-grazing"-situation, where not only environmental parameters such as vegetation, weather, stocking capacity and location plays a role, but also a third dimension, the topography is influencing the behaviour. Thus, the year 2007 trials will be made with cattle on an alpine pasture. Beside GPS-collars, ALT-pedometers to measure step numbers, lying time and ankle temperature will be used for an extended behavioural data acquisition [3]. By overlaying alpine pasture maps with behaviour mappings of the animals, type and importance influencing parameters should be analysed. Based on this, logical algorithms should be deduced and control strategies worked out.

The general aim of this work is the development of tools for "Precision Landscape Management" allowing the farmer to connect production targets with environmental protection.

Acknowledgement

The Deutsche Bundesstiftung Umwelt (DBU) funds the project „Telemetric recordation of location- and behavioural data of extensive kept livestock herds and their analysis for potential estimation for a sustainable landscape management".

Literature

[1] *Eckardt, C., M. Rothmund and H. Auernhammer*: Sustainable pasture management with high resolution location and behavioural data of farm animals. In: CIGR XVI World Congress: Agricultural Engineering for a better World, Bonn, 3.-7. September 2006, pp. 4401/1958

[2] *Hofmann, R. R.*: Evolutionary Steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. Oecologia, 78 (1989), no. 4, pp. 443-457

[3] *Brehme, U., U. Stollberg, R. Holz and T. Schleusner*: ALT pedometer – a new sensor-aided measurement system for improvement in oestrus detection. Res. Agr. Eng., 52 (2006), no.1, pp. 1-10