COMPUTERS AND ELECTRONICS IN AGRICULTURE 65 (2009) 85–92

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ScienceDirect

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Performance of three GPS collars to monitor goats' grazing itineraries on mountain pastures

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ARTICLE INFO

Article history:
Received 20 November 2007
Received in revised form
26 June 2008
Accepted 29 July 2008

Keywords:
Altitude
Animal tracking
GPS
Mountain agriculture
Position accuracy
Rugged terrain
Oman

ABSTRACT

Despite more than 15 years of GPS use in studies with domesticated animals, surprisingly little high-resolution data was collected on grazing itineraries of livestock. It seems as if each research group has its preferred GPS tracking equipment, but little comparative data about the reliability of different types of collars are available. This study provides such data for three very different GPS collars that were tested on a human observer's back and on herded goats in the rugged Hajar Mountains of northern Oman. At a set logging interval of 15 s, the obtained number of position fixes per minute varied from 2.3 to 3.8 and differed significantly ($P < 0.001$) between the three devices in obstructed terrain while differences were negligible ($P > 0.05$) in open terrain. The large variations between the devices in the obtained latitude, longitude and particularly the altitude data were likely due to differences in the factory-made basic setup of the GPS receivers which placed specific weights on signal reliability and trigonometric properties. In the topographically disrupted study environment, recorded values of the position dilution of precision (PDOP) proved to be of little use as indicators of position quality as they were poorly related to the precision of latitude, longitude and altitude values obtained. If accurate altitude data are required, such as for studies on animals' energy expenditure, separate recording of variations in barometric pressure at the same time intervals as those of the GPS collars is recommended.

1. Introduction

In the Hajar Mountain range in northern Oman, for centuries goats have been the most important livestock species in the predominantly agro-pastoral systems (Mandaville, 1977; Defremery and Sanguinetti, 1979; Nagieb et al., 2004; Zaibet et al., 2004). Today, the former nomadic husbandry system has been transformed to a semi-sedentary or fully sedentary system and goat numbers have increased substantially above historical records (Nagieb et al., 2004). Therefore, since 30 years considerable attention has been devoted to the problem of overgrazing of the sparsely vegetated mountain pastures surrounding the spring-fed oasis settlements (Mandaville, 1977). Although farmers feed their goats with cultivated green feeds such as maize (*Zea mays* L.), sorghum (*Sorghum bicolor* Moench) and alfalfa (*Medicago sativa* L.) and with concentrate feeds such as dates (*Phoenix dactylifera* L.), dried sardines and cereal by-products, goats' diets still contain a high proportion of plants ingested on the steep slopes and the plateaus of mountains surrounding the oasis settlements (Schlecht et al., 2008). Given the difficult accessibility of these mountain pastures, continuous manual observation of the animals' grazing itineraries is

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doi:10.1016/j.compag.2008.07.010

difficult or even impossible. One alternative to closely monitor grazing itineraries is the day-long recording of the exact geographical position (latitude, longitude and altitude) and time using a global positioning system (GPS). By superimposing this information on high-resolution terrain, soil or vegetation maps, detailed information about grazing ranges and the animals' spatial interaction with the natural environment can be extracted. In addition, the GPS recordings also allow calculation of the distances covered by grazing animals, which, on mountainous pastures can be separated into a horizontal and a vertical component. Since the energy expenditure for these two types of movements differs significantly (Lachica et al., 1997), separate information on horizontal and vertical distances covered is also of value if one wants to assess the animals' energy expenditure.

A major determinant for the utility of the collected data is the accuracy and precision of the geographical positions recorded by the GPS device, which can be quantified statistically. Thereby accuracy is defined as the closeness of a set of coordinates to the true location, while precision is defined as the proportion of locations within a pre-defined quantile (Hulbert and French, 2001). The accuracy of GPS recordings mainly depends on four factors: (i) the satellite geometry at the time of recording; (ii) the obstruction of satellite signals by physical obstacles; (iii) the number of channels of the GPS device (which determines the number of satellites signals the device can maximally track at one time); (iv) the apparatus' precision mode (which determines whether a geographical position is recorded when less than four satellite signals are captured at one time). Although all GPS devices that record data at the same time and location are similarly exposed to the effects of the first two factors, the way they handle these differs due to the latter two factors which thus define the final accuracy of a device's recordings. Given the site-specific dimension of the mentioned errors, the suitability of the GPS device to be used in an animal study (and elsewhere) should therefore be tested *ex ante* (Moen et al., 1996,1997,1998; Rempel et al., 1995; Rodgers et al., 1996; Hulbert and French, 2001; Agouridis et al., 2004), especially where terrain features such as overhanging cliffs and steep mountain slopes can obstruct satellite signals. Given the above, the present study aimed at comparing three commercially available GPS-based tracking collars for their precision in recording latitude, longitude and altitude of positions visited by goats during their daily grazing itinerary in the particularly rugged northern Hajar Mountains of Oman. The data obtained might help other scientists to make more informed decisions about the type of device to be used under conditions similar to those of our study area.

2. Materials and methods

2.1. Study site

The study was carried out in the Jabal al Akhdar Mountain range of the Hajar Mountains in northern Oman. The climate in this area is arid with annual rainfall varying from 100 mm to 340 mm (Gebauer et al., 2007); however, successive years of very low or no rainfall are common. During the cooler period of the year (October to March) daily temperatures average 20.1 °C at 1000 m a.s.l. and 14.2 °C at 2000 m; during the months of April to September average temperatures of 29.4 °C and of 23.2 °C were recorded at 1000 m and 2000 m, respectively.

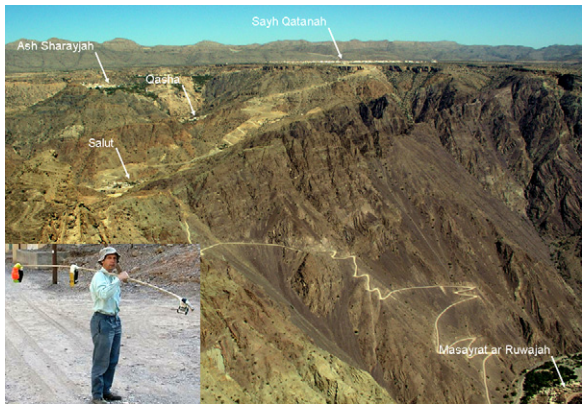

Fig. 1 – Watershed in the rugged Jabal al Akhdar Mountains of northern Oman in which the study was conducted, showing the villages of Masayrat ar Ruwajah (1030 m a.s.l.), Salut (1550 m), Qasha' (1640 m) and Ash Sharayjah (1900 m) and the main town of Sayh Qatanah (1965 m). The inserted image shows the setup to test the three GPS-receivers.

To test the equipment, an altitude gradient from 1000 m to 2000 m was chosen in the watershed from Masayrat ar Ruwajah (23°02′37″N, 57°40′13″E, 1030 m) through Salut (23°03′14″N, 57°39′31″E, 1550 m) and Qasha' (23°04′00″N, 57°39′50″E, 1640 m) to Ash Sharayjah (23°04′10″N, 57°39′30″E, 1900 m), situated in the neighborhood of the town of Sayh Qatanah (Fig. 1). In this area, irrigated agriculture on terrace fields of annual food crops, forages and perennial tree crops such as predominantly date palm (*Phoenix dactylifera* L., 1000 m), pomegranate (*Punica granatum* L., 1500–2000 m), peach (*Prunus persica* L.), walnut (*Junglans regia* L.), apricot *Prunus armeniaca* L.) and roses (*Rosa damascena* L., 1800–2500 m) is combined with goat husbandry.

2.2. GPS rovers

Three types of commercially available GPS rovers were used for the present study. Two of them had explicitly been developed for animal tracking studies, while the third device was of more a universal use and had been fitted into a self-designed collar made from nylon tissue. All three collars were slim, light and easy to secure around a goat's neck. Care was taken to make sure that the antenna position of each rover was located on the unobstructed top portion of the animal's neck and would not move regardless of the animals position on the mountain slopes or when brushing against an obstacle. For a perfect fit of the collars adhesive tape was employed wherever necessary.

The tracking collar GPS_H[2] consisted of a μ-Blox 16-channel GPS receiver and a UHF[3] Telemetry Beacon powered by two

[2] Brand names of the devices can be obtained from the authors upon request.

[3] Ultra high frequency.