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ORIGINAL PAPER

Long-term automatic video recording as a tool for analysing the time patterns of utilisation of predefined locations by wild animals

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Abstract The design and application of automatic video recording systems for wild animals are described. Such systems enable continuous, long-time and repercussion-free surveillance of selected areas in the field. The performance characteristics of a conventional VHS video-tape system are compared to a digital video recording system. The recordings were used to develop daily and annual plots of occurrence for the different species and to display the preferences for darkness, twilight and light phase by the different species over the year. Absolute utilisation frequency as well as relative species composition can be obtained and compared between seasons or different places. The videos also were analysed for time budgets of basic behaviour patterns like feeding, walking, observing, social interaction, flight and comfort behaviour. Automatic video technique is a highly convenient tool for systematic long-term field research on occurrence of wild animal species, daily and annual activity rhythms, behaviour and area utilisation. Such systems can be applied especially to record animals at clearings, feeding or bait places, water sources, salt licks or traps.

Keywords Deer · Game · Wildlife · Field method · Camera

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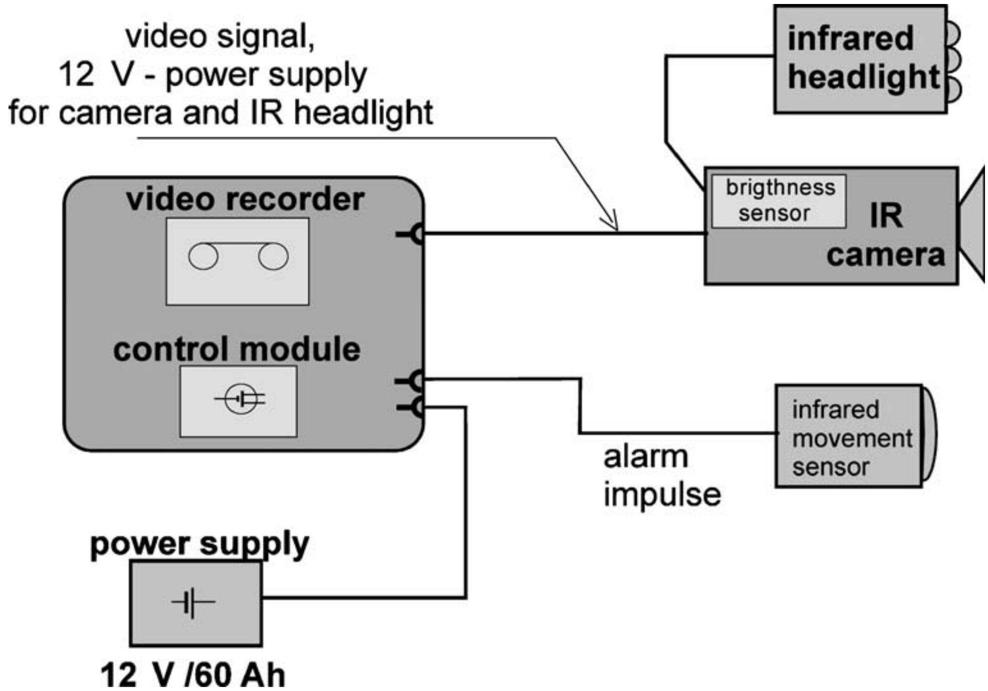
Introduction

Wildlife ethologists are likely to be recognised by wild animals during observation and therefore may influence the animals' behaviour and conspicuousness (Prins and Bokdam 1990). Even if invisible or camouflaged, observers may be smelled or heard by wild animals on hardly predictable distances, which is especially important for the observation of hunted game species. Furthermore, observing time is restricted, particularly under cold or wet conditions as well as at high temperatures. Therefore, automatic and weather-proof recording systems possess advantages compared to human observers. Such methods may even be regarded as a precondition to fulfil the requirements of repercussion-free data collection in the field.

Because wildlife observation areas are frequently far away from power nets, streets or forest lanes, the recording system itself should not be too large, heavy and energy-consuming. This will guarantee simple installation and sufficient service intervals, thus additionally reducing the potential disturbing impact of human presence.

The utilisation of video recording to investigate the behaviour of birds of prey at nests has recently been described (Reif and Tornberg 2006). In this study, we present a video camera system for continuous surveillance of selected areas or spots in the field as a time-saving, reliable and durable tool for monitoring large wild animals. We also describe the mode of application, procedures of data processing and interpretation, including the utilisation of such data for analyses of daily rhythms and seasonal variations in wildlife occurrence.

Fig. 1 Automatic video recording system, block diagram



Materials and methods

Camera system

The system comprised a camera, video recorder, movement detector, brightness sensor, infrared (IR) illumination, control module and power source (Fig. 1).

For recording, a highly light-sensitive and IR-sensitive programmable monochrome video camera was selected (MTV-12V1-EX, Mintron). The camera lens was chosen according to the required angle of vision; for most conditions, a lens with a focal distance of 4.5 mm was applied (Panasonic WV-LA4R5AE Auto Iris Lens). The camera was placed in a weather-proof casing and arranged on a tripod, along with two IR illumination panels. The brightness sensor, which triggered IR illumination during darkness, was also placed in the camera casing. For illumination, panels with IR-emitting diodes (type VX301, 895 nm wavelength) or single high-power IR-emitting diodes (LED850-66-60, 850 nm wavelength) were applied (Fig. 2).

The video recorder represented a battery-powered VHS time lapse recorder (Panasonic AG 1070DC) installed in a weather-proof box (Zarges GmbH & Co. KG, Germany). This box may also contain a battery for short-time activation. The recorder was mounted on damping material to avoid any sound emission to the environment. The recorder box also contained a control module, which enabled different modes as follows: (1) continuous recording or on/off mode triggered by motion sensor and (2) power supply by internal or external batteries. As a main external power source, special batteries for low power consumption (12 V/60 Ah) were preferred. The whole system was triggered by a passive IR movement detector (PID: different conventional types modified for 12 V DC) and remained disconnected from the power source in the

Fig. 2 Automatic IR video camera with IR diode panels (*left*) and high-power IR-emitting diodes

on/off mode. This resulted in a resting consumption of only 2 mA required by the PID. The disadvantage of this configuration consisted in a start-up time of approximately 12–15 s between the alarm signal and the start of recording. However, the 'stand-by' configuration offered by the recorder required continuous energy (ca. 600 mA) that cannot be delivered by a battery for longer periods. Furthermore, the economic life-time of both tape and video head was extremely reduced in this mode. During registration, the system spent 1.2 A (plus 1.5 A in darkness), i.e. at least one tape of 240 min could be used per battery even under very cold conditions that significantly reduce battery capacity (100% at 20°C vs 50% at 0°C). To guarantee dew-free conditions inside the camera casing and recorder box also in wet weather and during rapid temperature changes, drying granulate (Silicat Gel Orange, Carl Roth GmbH) was applied and regularly substituted. The front screen of the camera casing was regularly impregnated with anti-dew gel to prevent dew and ice. The recording time was set to continue for about 1 min after the end of an alarm without interruption during a series of consecutive movement signals. The recorder was programmed in real-time mode to record date and time on tape.

Additionally, we tested a new digital video recorder (DVR, DiREX-Pro.A30, BWA Technology GmbH Munich). Without changes to any other components, this device reduced the consumption of both recorder and camera to 300 mA and thus enlarged storage capacity to approximately 200 h (depending on video parameters).

Application

Since the year 2000 up to now, four cameras were applied to record wildlife at salt licks and watering places in forests of Brandenburg (Germany). They were used for at least a whole year at one site. The longest application time of one camera lasted 3 years without interruption. The cameras were arranged as far as possible in the northern direction to prevent sun-blinding of both camera and PID. Plants were removed in front of the PID to reduce the risk of false alarms. Cameras were placed between bushes or trees and open observing areas if possible but also on open meadows. Nevertheless, moving trees, branches or bushes as well as shadows caused some false recordings.

The cameras were visited at intervals of 7–21 days, depending on utilisation frequency at the respective

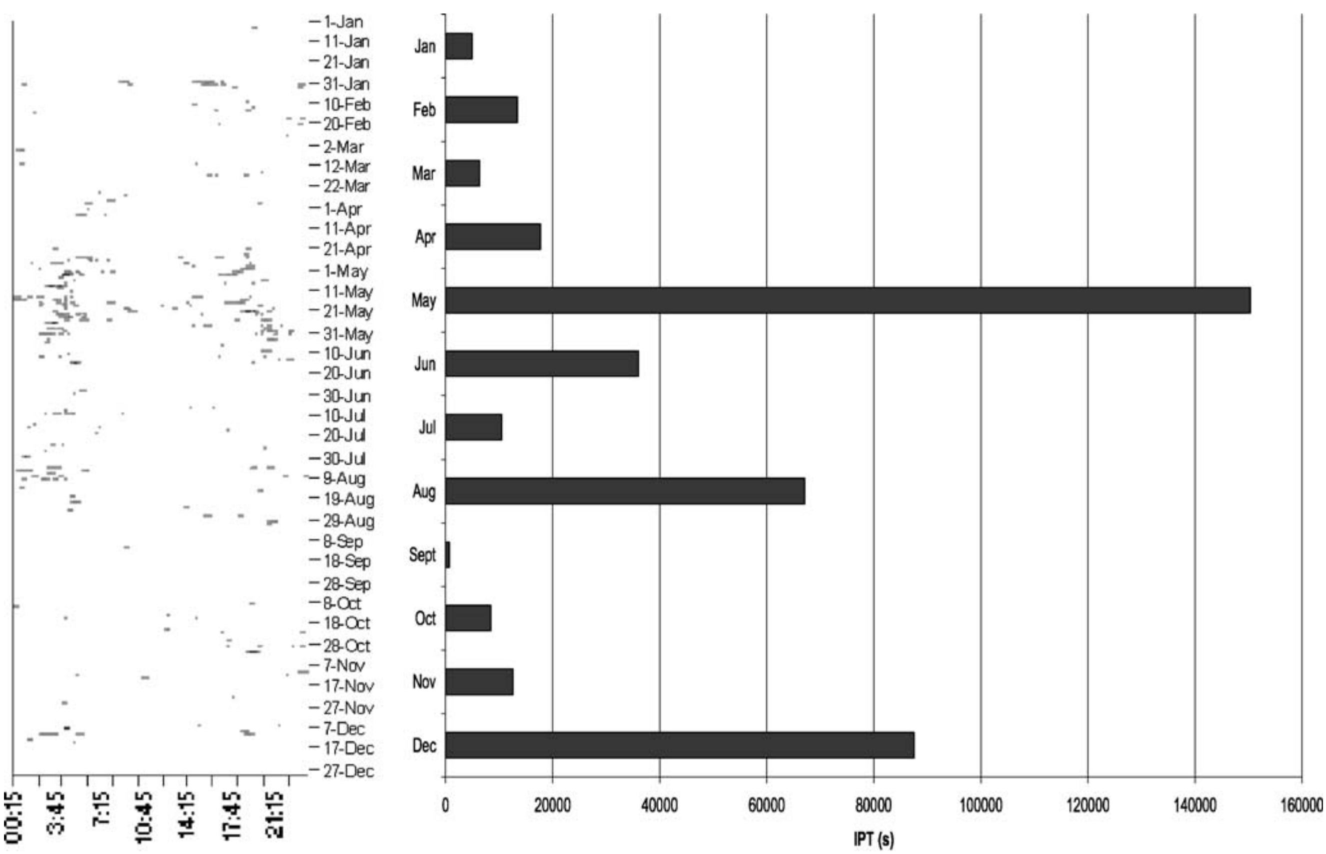


Fig. 3 Individual presence time (*IPT*) for all species throughout the whole year 2003 as plot (*left*) and total monthly IPT (*right*). Days of the plot (*left*) are arranged as *lines* one *beneath* the other; the presence of animals during time intervals (in IPT) is coded in *grey scales* (*white*, 0%; *black*, 100%). Example from a game sanctuary zone with a salt lick in the Schorfheide area (Brandenburg, Germany)

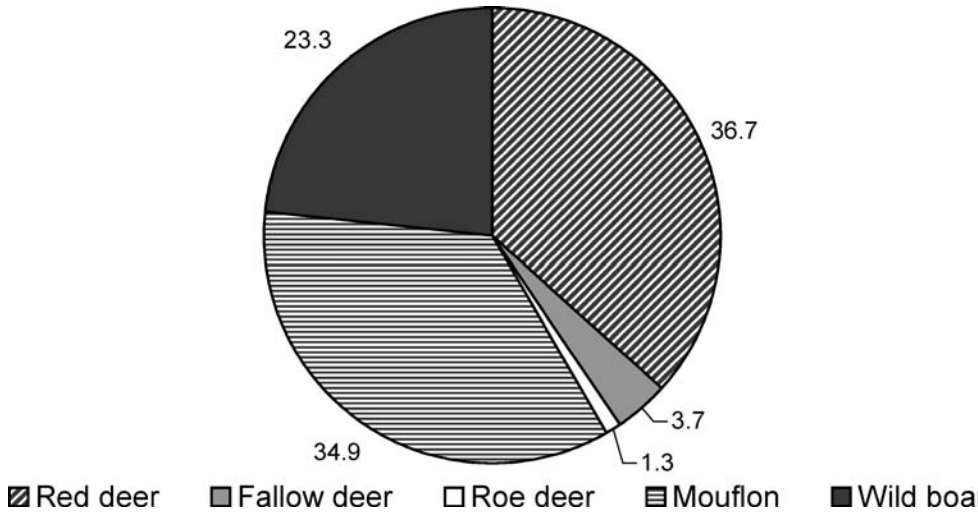


Fig. 4 Relative composition of different species (*red deer*, *fallow deer*, *roe deer*, *mouflon* and *wild boar*; IPT in *percent*) recorded at the same place and for the same complete year as in Fig. 3

location. They were checked on average fortnightly. Video tapes and batteries were replaced if required, and the drying gel was substituted regularly.

Utilisation of records

The tapes were first analysed following a time scheme of consecutive intervals of 15 min. For each interval, the 'individual presence time' (IPT) of different game species (roe deer, red deer, fallow deer, mouflon and wild boar) was determined using the date and time records on tape. The IPT represents the period of individual presence per interval in seconds; if two or more individuals were recorded simultaneously, the IPT represents the sum of these single presence times. Results were recorded in Excel tables for each individual species as well as pooled for all species, listing 365 days/year and 96 intervals/day in lines and columns, respectively. The tables were then converted into surface diagrams (plots). These diagrams or plots are equivalent to the classical actograms used in biological rhythm research. They display the daily occurrence pattern of wild animals at a specific location over a long period such as 1 year.

The tables were also used to compute the presence time of different species throughout the year. Furthermore, they offered the possibility to analyse the utilisation of different illumination conditions such as darkness, twilight and daylight by the animals. For this purpose, the Chesson's index (Chesson 1978) was used. Originally developed for the evaluation of food preferences, this index is adequate to describe the selection of different limited resources by animals. Indices higher than 0.25 have been interpreted as positive selection, lower values indicate avoidance (Manly et al. 1993).

In a second step, the video tapes were visually re-inspected, and the behaviour of single individuals was recorded by means of the software Observer V (Noldus Information

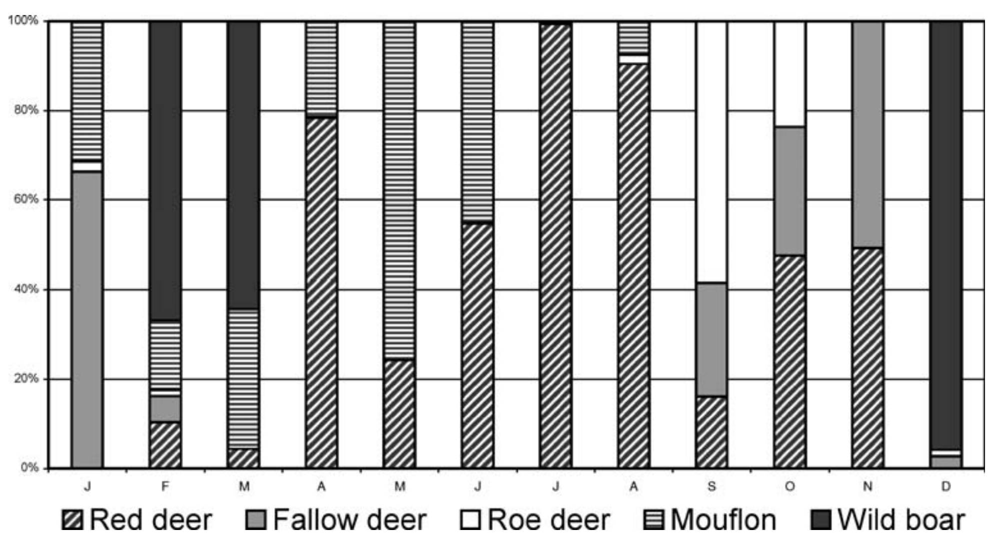


Fig. 5 Relative composition of species (IPT in *percent*) for each month at the same place and for the same year as in Fig. 3

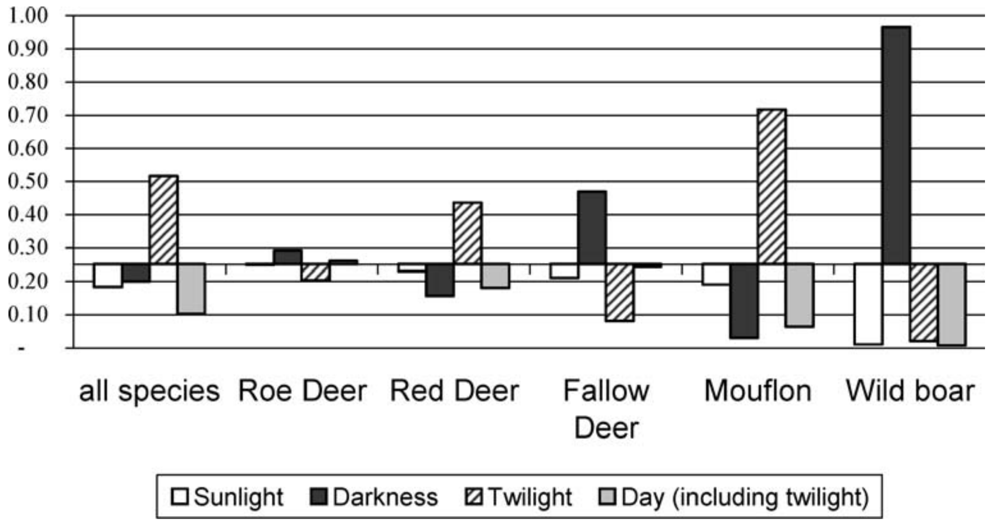


Fig. 6 Preferences for the utilisation of the different illumination phases of a day (Chesson's indices) by different species at the same place and for the same year as in Fig. 3. *Upward bars* from the baseline at 0.25 indicate a positive selection, *downward bars* indicate a negative selection of the respective illumination phase

Technology b.v., Wageningen, The Netherlands). Time budgets for the basic behaviours were computed separately for the different species and for daylight and darkness.

Examples of results

An example of a plot diagram is given by Fig. 3. It demonstrates the utilisation of a game sanctuary zone by all game species throughout the whole year. Utilisation of the area during all 24 h of the day becomes apparent with a concentration in the morning and evening. The presence time of different species per year is given by Fig. 4. Red deer and mouflon dominated in this area and were nearly equally present followed by the wild boar. Fallow deer and roe deer were observed less frequently. The species composition changed in the course of the year (Fig. 5). For example, mouflon was the most frequently observed species in Mai; while roe deer were more frequently seen in September. The Chesson's index demonstrates which of the different phases of the day is preferred or avoided by the animals at a specific location (Fig. 6). Wild boar and fallow deer preferred darkness to visit this area and avoided both sunlight and twilight while pooled; for all species, twilight is preferred on average. This general preference for twilight resulted mainly from the behaviour of mouflon.

Behaviour time budgets are given by Fig. 7. Feeding (including licking salt) is the behaviour displayed for the longest time of recording during both light and darkness in all species.

Discussion

A review of several applications of automatic field cameras has been given by Cutler and Swann (1999). Different types of cameras were applied to record, for example, feeding ecology, temporal activity patterns, presence or absence of species (Pina et al. 2004) and to estimate population

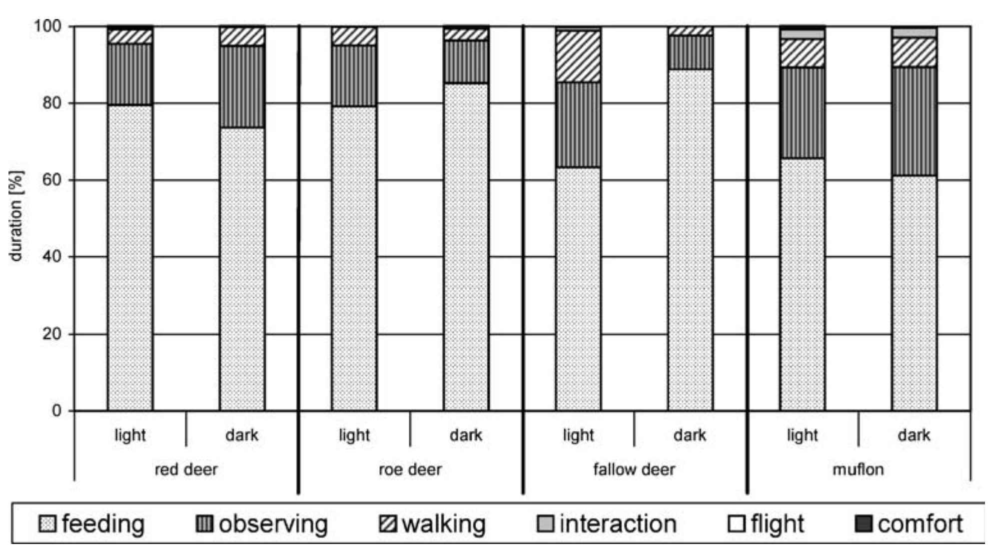


Fig. 7 Example of behaviour analysis: time budgets (percent of observation time) of basic behaviours of different species during daylight and darkness at the same camera position as in Fig. 3

parameters. Cutler and Swann (1999) concluded that for many applications, remote photography can be less time consuming, less costly and less invasive than traditional research methods.

Kucera and Barrett (1993) applied an automatic camera system for the surveillance of wildlife crossings, burrows and kills. Population parameters were estimated based on records of automatic film cameras (wild sheep, Jaeger et al. 1991; white-tailed deer, Jacobson et al. 1997). To examine scavenging events by pumas on mule deer, camera traps for single pictures were used (Bauer et al. 2005; Hernandez et al. 2005). In addition, single photographs were used to record adult female white-tailed deer on seasonal bait sites (Campbell et al. 2006). The frequency of wildlife visits in areas at different stages of post-fire recovery within a pine flatwood habitat was also analysed by automatic cameras (Main and Richardson 2002). The application of a web-based, digital camera system for monitoring wildlife in remote, inaccessible environments was presented by Locke et al. (2005). They collected 486 digital still photographs within 22 months.

Video recordings were used, for example, to investigate the response of badgers to chemical repellents, to observe the reaction of white-tailed deer to fences (Beringer et al. 2003; Baker et al. 2005) or to assess the scraping behaviour of white-tailed deer in a free-ranging population (Alexy et al. 2001).

White-tailed deer at salt licks were recorded earlier in the night by cameras than by conventional observation (Wood et al. 1999). This may be due to reduced disturbance.

Conventional video tape recordings already proved to be highly relevant and useful in the field. A substantial improvement in recording time resulting from high storage capacity and low power consumption may be achieved by digital recorders. This technique also offers the possibility to reduce the start-up time to 2 s by some increase in power consumption (Table 1). However, the quality of the video signal of DVR records was perceived to be lower than that of conventional video tapes. A notable disadvantage is the extremely high amount of digital data (monochrome, approximately 450 kB/min). These involve long transmission times from the recorder, require an equivalent hard disk capacity for the analysis of longer records and thus complicate the handling of the files. Original files of the tested equipment required a special viewer-program with limited functions. The export files (*.avi format) of the tested version were of 2.5-min duration and of 1.06-GB size each. A new software version will create longer scenes, but files will increase proportionally.

Animal-triggered video camera systems like the one described here are always appropriate when animals visit specific locations infrequently or unpredictably. However, as with all technical systems in the field, the application of cameras may be more expensive than assumed, causes different problems and is thus restricted to specific spots or areas.

Although automatic video recording techniques are known and available since many years as the cited papers demonstrate, they were rarely applied for a long-term systematic analysis of the utilisation period and frequency of specific areas by wildlife. The advantage of recording videos in such a systematic way consists in the extremely large and reliable data sets that can be collected with reasonable effort. No other technique allows for the monitoring of specific areas for such a long period without any interruption and almost no repercussion. This technique offers the possibility to record the time of presence (IPT) and additionally to analyse the behaviour repertoire and time budget of the observed animals.

Because our video cameras were always located in a distance of about 15–20 m from the preferred place, with the recorders being about 5–10 m further away, we could hardly record any other response to the equipment than occasional curiosity. In very few cases, we observed reactions indicating that animals perceived the start of registration, e.g. the IR illumination, but these may also have been caused by other sources. We repeatedly conducted test observations in several locations by means of a remote-controlled camera and IR illumination from a van. These observations likewise only yielded few indications that equipment or IR illumination was perceived by the animals. We more frequently observed reactions to other approaching individuals of the same or other species;

Table 1 Comparison of performance characteristics between a conventional tape recorder (Panasonic AG 1070DC) and a DVR recorder (DiREX-Pro.A30)

	Panasonic AG 1070DC	DiREX-Pro.A30
Current consumption (recorder+camera; mA)	1,200	300
Temperature range (°C)	+5 to +40	−10 to +70
Relative humidity range (%)	35–80	10–90
Storage capacity	4 h	Approximately 200 h (depending on video parameters)
Start-up time from on/off mode (s)	15	17
Start-up time from stand-by	1 s (not recommended)	<2 s
Dimensions (mm)	270×120×344.5	125×36×179

however, in general, such reactions were rare. In almost all situations, the animals behaved quiet, used the salt licks or grazed, and some even lied down for longer periods.

The only disadvantage of this technique when using conventional video recorders and on/off mode consists in the 12- to 15-s delay of registration caused by the starting procedure. Very fast moving individuals may sometimes have passed the viewing angle of the camera before the registration actually started.

The videos can be analysed in the laboratory, inspected repeatedly, and errors in species identification or in recognition of the number of individuals can largely be eliminated. Digital videos will provide for all options of computer-aided video analysis offered by behaviour analysis systems like "EthoVision" (Noldus Information Technology b.v.) and Interact (Mangold Software & Consulting GmbH, D). However, prerequisites such as a standardised and compatible file format and long uninterrupted scenes are not always fulfilled yet (Church and Martz 2005).

As exemplified by our preliminary results, the utilisation frequency of an area by wild animals can be evaluated. Accordingly, different areas may be compared in regard of utilisation frequency and species composition. For different species, the occurrence during varying illumination phases of a day can be investigated, and changes in the course of the year may be related to factors such as hunting pressure or visitor frequency. In the area where these results were taken, a general preference for twilight was found, but species differed clearly in their preference. Furthermore, the time budget analysis offers the possibility to compare the behaviour at different locations. The relatively long period of feeding behaviour displayed by all species at the studied site can be taken as an indicator for low disturbance levels. Recapitulating, we value the automatic camera technique, particularly video equipment, as a very useful tool for wildlife research. Carefully and systematically applied and analysed, the automatic video method will certainly be one of the most repercussion-free data collection methods in the field and may deliver highly reliable data on wild animal occurrence and behaviour.

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