Funded by the Erasmus+ Programme of the European Union

HUMAN RESOURCE DEVELOPMENT CENTRE

“Future Environmentalists - Linking EU Natural Capital Management to Field Research”
Agreement № 2018-1-BG01-KA203-047962

# New bio-logging technology of red deer and wild boar individuals and their spatial behaviour during homing experiment

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# 1. The GPS telemetry and bio-logging technology

## 1.1.Telemetry

Tracking of wildlife animals is widely used method in population biology. We can see a lot of improvement in this field of science. Wildlife tracking could be divided into three basic categories: direct observation – cameratrapping – telemetry. The first method is the easiest way how to observe animal in real time and environment. But there is no possibility of getting information when the observer is out from field. Cametrapping offer nice opportunity to see animals in real environment without presence of human but we are not able to receive information about animals where they are out of field of view. Telemetry could use advantages of previous two methods. User can get information directly from the field without need of his presence and without the gaps during tracking.

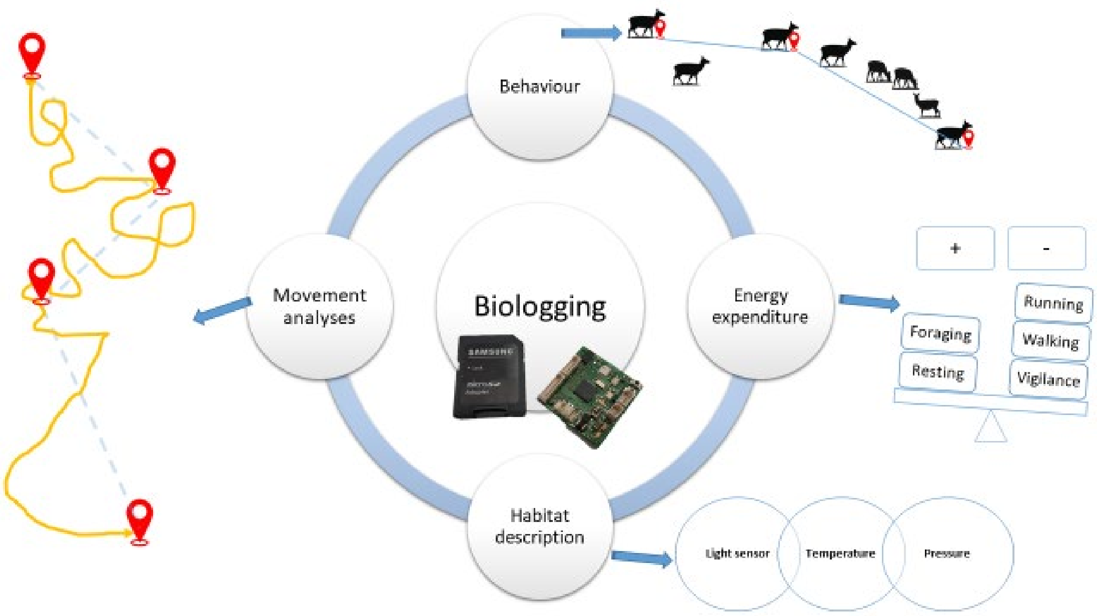
We can divide telemetry into two basic system. The first one is VHF (*Very High Frequency)* and second GPS (*Global Position System*) telemetry (Peterka, 2012). The GPS telemetry is widely used over last decade and it is providing interesting and important data from the field of animal ecology. It based on wireless communication between GPS module and satellites. It is necessary to get information from minimum two different satellites or more for getting valid GPS position. Numbers and ability of satellites is effected by several factors: land cover vegetation, topography and position of GPS module. The VHF telemetry was the first type of telemetry and we were able to get information about the position after radio communication between transmitter and receiver. The GPS telemetry is based on communication between GSM modules and satellite. These devices are producing sampling frequency of GPS fixes based on previous GMS module setting and user are able to get information from field in real time. Researchers are able to handle with data without time consuming field work and do first analyses during the animal's observation. The disadvantage of GPS telemetry is energy consumption caused by GSM modules and connection to satellites. GPS wildlife tracking devices could work over two years (depends on GPS-fixes frequency) but it is connected with battery size and animal's body constitution.

The recent studies are changing the strategy and a lot of biologists are working with small devices (also useful for small animals) called *"Daily Diary*" or"Biologgers".

### 1.2.Bio-logging

Biologging applications have permitted important, and often surprising, insights into the lives of many species, including mammals, birds, fishes and even invertebrates, substantially advancing both basic and applied research (Rutz et al., 2009). Biologging data are recorded by small devices called "Biologger" or "Daily Dairy" (see in previous paragraph). This device is able to measure, directly or indirectly, four basic elements – animal location and movement, animal behaviour, energy expenditure and environmental conditions (Wilson et al., 2009).

Biologging is able to reconstruct the path of animals between individual GPS positions, determine individual types of behaviour and quantify their timing, energy consumed and orientation towards the cardinal directions (Figure 1). This dataset is recorded in high-frequency and the resolution of sampling is from 4 Hz up to 40 Hz. The biologgers consist of several parts: accelerometer, magnetometer, light sensor, pressure sensor, temperature sensor, battery and micro SD card. The accelerometer is recording data in the axes (x-y-z) and data of every axe are recorded in the same sampling frequency. When you decide to log data in 10 Hz frequency you will get ten data points from axe x, ten different data points from axe y and another 10data points of axe z. The same schema of logging is for magnetometer. The other sensors (light, pressure and temperature) are set for logging in one axe in the same frequency.


Behaviour
Movement analyses
Biologging
Energy expenditure
Habitat description
+
-
Running
Foraging
Walking
Resting
Vigilance
Light sensor
Temperature
Pressure

Biologging could describe four areas of animal's life. It could be behaviour, movement, habitat use and energy expenditure (Figure 1). Every part of biologging is supported by different data.

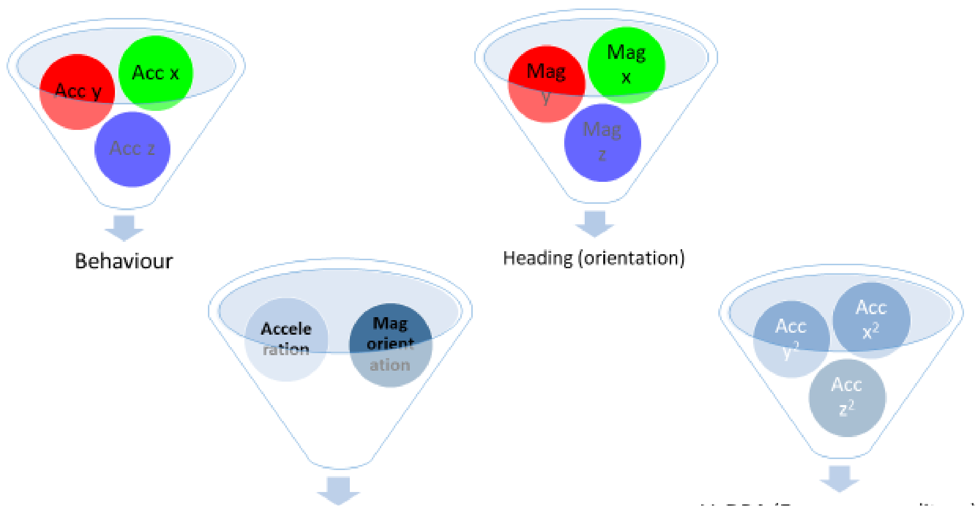



*Figure 2 - Biologging methods*

#### 1.2.1. Behaviour

The description of behaviour is usually done by accelerometer profiles based on three acceleration axes (Figure 2). This type of methodology is used across the species and many studies are using the same technology. The animal behaviour is unclean in many cases and the biologging measurements could show us detailed information about. Daily Diary is recording direct acceleration of device – it means acceleration of animal body. The loggers should be placed on the animal body. If not, data have to cleaned and corrected by factors based on direct and indirect body acceleration differences.

### 1.2.2. Heading

The heading (orientation) of animal is measured by magnetometer. The three axes of magnetometer allow to calculate animal heading and this information is used in dead-reckoning too (Figure 2). The heading of animal is connected with several parts of behaviour. It could describe us the differences during seasons or different behaviours. It is also useful for marine species. There you can describe the movements during diving for forage or navigation in the ocean.

### 1.2.3. Dead-reckoning

The both previous (accelerometer and magnetometer) data are used in dead-reckoning calcutaion (Figure 2). This part is connected with animal movement. Dead-reckoning function could place animal movement into the field and are able to visualise the detailed track of animal. The dead-reckoning algorithm is complex and the acceleration and magnetometer data are needed (Figure 2).

### 1.2.4. Hybrid technology

The animal movement reconstruction is widely discussed topic in scientific society. Usually it is done by straight line between two or more GPS fixes. But you can only guess the type of movement between two GPS fixes. On the other hand you can increase the sampling frequency of GPS fixes. Than you will get detailed information of movement but for short time period because of battery capacity. There is possibility to use one part of biologging and one part of GPS telemetry. When we combine these two part together and respect several rules, we are able to reconstruct the animal movement, save energy of battery, get information about behaviour and heading of animal.

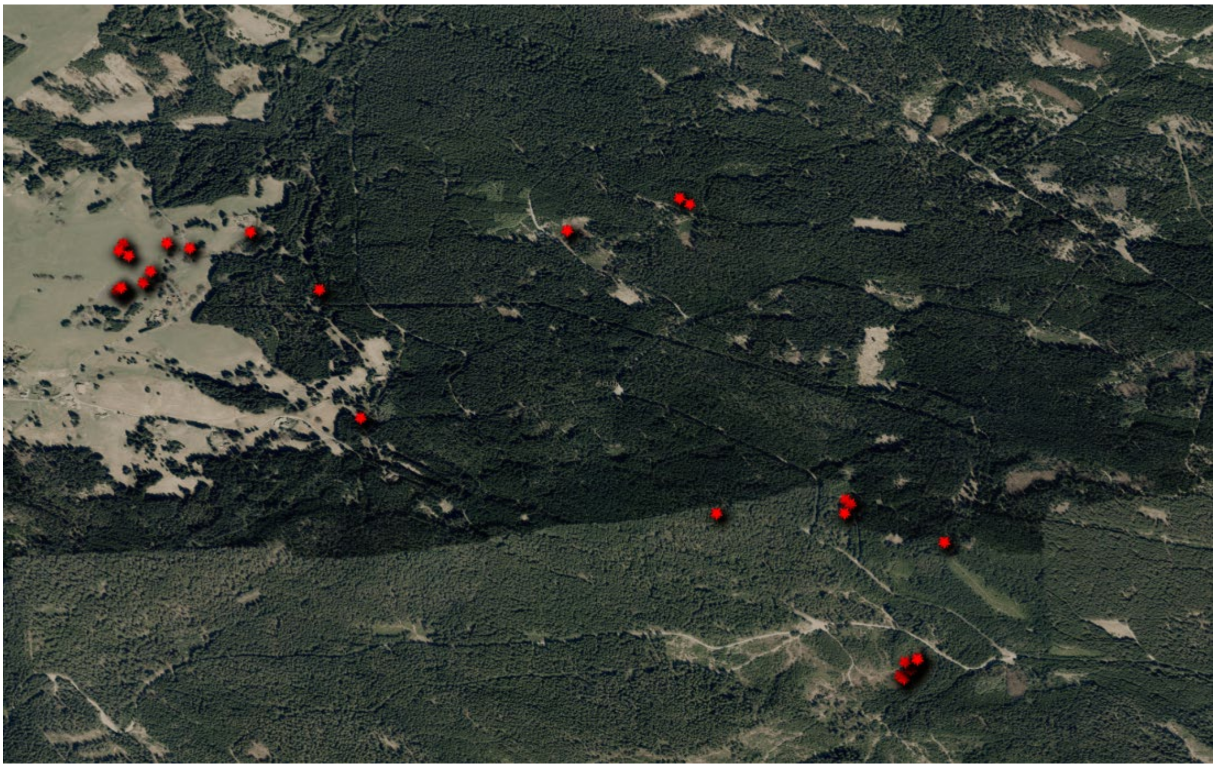


*Figure 3 - GPS Telemetry data*

The figure 3 show standard GPS telemetry with GPS fix every 30 minutes where the fixes could be connect with straight lines from point to point. There is possibility of using hybrid technology – it consist of GPS telemetry (GPS collar) and Daily Diary device. The hybrid technology can use dead-reckoning algorithm and create animal track in detail (Figure 4). The resolution of dead-reckoning track is on same level as biologging data.

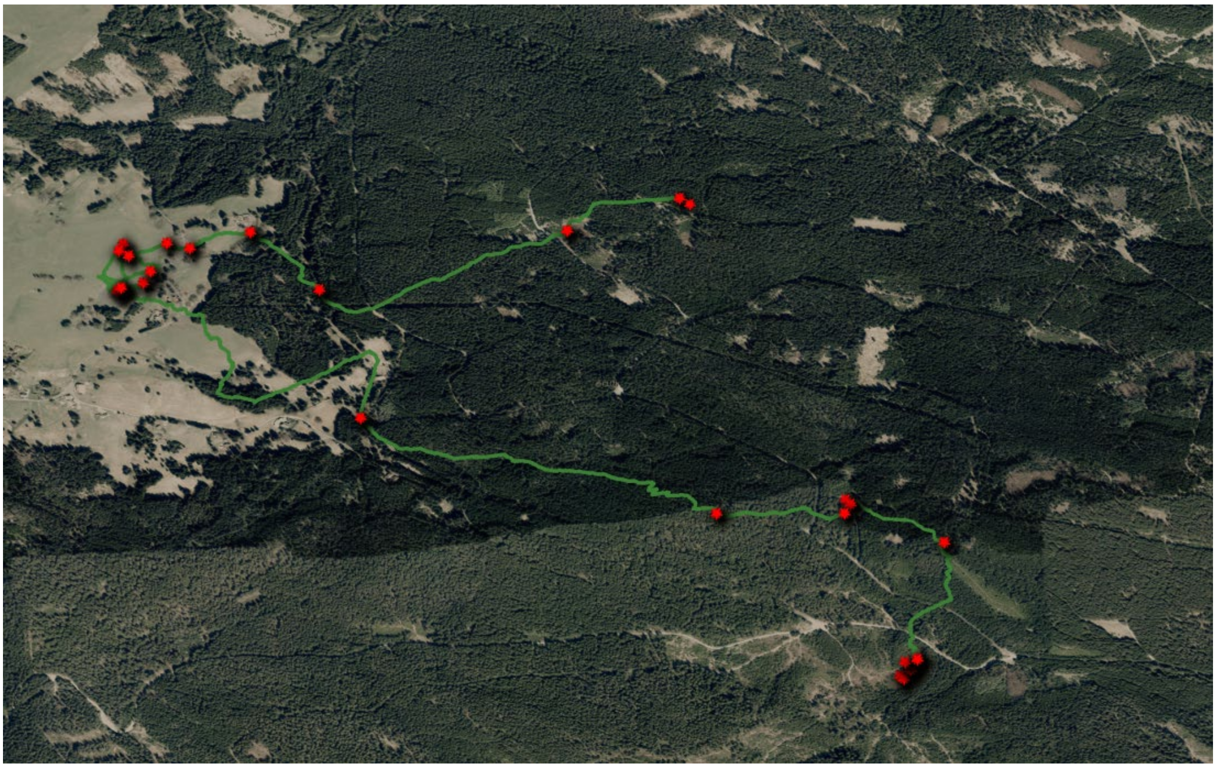


*Figure 4 - GPS Telemetry and Biologging Technology*

### 1.2.5. Energy expenditure (VeDBA)

Study energy expenditure based on the vector of the dynamic body acceleration (VeDBA). VeDBA is the proper way to derive the total magnitude of the acceleration vector at any one moment in time. The VeDBA proxy was described (Qase et al. 2012, Laich et al. 2011) as appropriate variable for energy expenditures studies. VeDBA value and oxygen consumption were found to correlate during animal movements (Wilson et al. 2018).

No organism on the Earth could live without expending energy. Energy is used for supporting important processes in every live organism (Careau et al. 2008; Wilson et al. 2019) and thus is key to movement (Halsey 2016). Tri-axial high resolution accelerometric sensors are increasingly being used for studies of animal orientation, movement dynamics and energy expenditure (Yoda et al. 2001; Watanabe et al. 2005; Shepard et al. 2008, Williams et al. 2017). These sensors attached to animals can provide data on the occurrence of a wide range of behaviours that are otherwise difficult to observe in the wild (Shepard et al. 2008).

Animals constantly adjust movements and activity levels in response to ecological conditions, all of which influence their energy expenditure (Careau et al. 2008). But can human activities significantly affect the energy expenditure of wild animals? The main reason why to study energy expenditure is that the energy that an animal spends in response to a human disturbance can significantly reduce the amount available to it for growth and reproduction (Halsey 2016). An animal can also consume a lot of energy if, in response to human presence, it expends energy too quickly, for example to escape, resulting in an inability to compete for or attract a mate (Lees et al. 2012) or escape a predator (Wilson et al. 2013; Wirsing et al. 2002).

Energy expenditure is the most difficult part of biologging technology. We are not able to do direct energy calculation of wild animals to compare with values of VeDBA. But improvements and more applications of biologgers and VeDBA calculations will increase the energy expenditure precision.

## 2. Homing behaviour

Navigation of wildlife animals is well known and described for birds, insect and water species. The navigation of terrestrial mammals is not well investigated yet, and there are a few studies describing navigation during seasonal migrations, which is linked usually due to food resources.

Homing strategy is movement to previous home range and it is connected with navigation and comeback over thousands miles. The homing ability is usually decreased by increasing distance between home range and release point (Feldgamer et al., 2007). This movement could be connected with seasonal migration between two home ranges (summer/winter home range). Fernando et al. (2012) carried out a homing study of 12 elephants (*Elaphas maximus)* using GPS telemetry. There were three individuals with a positive relationship to homing strategy, and they came back for distances from 46 up to 116 kilometers. One individual was translocated three times and he always came back to origin home range. Also, Hawkins (1969) did an experiment on white-tailed deer (Odocoileus virginuanus) where he translocated 28 animals for 25, 36 and 6 miles into three different locations. All individuals were tracked by radio-telemetry and the homing behaviour was demonstrated by two animals. One female came back after 169 days and the second female after 23 days. There are several studies of black bear based on capture-recapture method after artificial displacement, which was linked with their undesirable behavior in the USA cities (see Harger, 1970; McCollum, 1974; Alt et al., 1977; McLaughlin et al., 1981; Rogers, 1986). They are indirectly connected with the homing behaviour of American black bear, but none of them was tested to behaviour during homing and describing the navigation of animal. Also the homing ability of Adélie penguins (*Pygoscelis adeliae)* was discover after artificial displacement in Antarctica (Shiomi et al., 2020).

Recent progress and improvement in biologging technology has advanced studies of animal navigation through the ability to study behaviour under natural and manipulated conditions (Rutz et al., 2009).

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