Report only by AREC on the evaluation of positioning systems for an adapted livestock/flock management complementing livestock protection measures and their possible use

Author: Reinhard Huber, HBLFA Raumberg-Gumpenstein

Summary
The pasture GPS project investigated the use of inexpensive GPS trackers in practice for grazing animals. The prerequisite for the function of the devices is a mobile network coverage and sufficient charge for the devices during the grazing season. For alpine pasture areas without GSM network coverage, there is the option of using LPWAN networks (Sigfox, LORA) if a public antenna is nearby, or to install your own antenna. With the use of foreign SIM cards in the GSM devices, which log into the best local network, the transmission power with poor network coverage and the GSM devices were better than expected. For data transmission with the Sigfox devices, the public antennas have better network coverage than the isolated solutions. Poor network coverage caused the GSM devices to consume more charge than expected, which is why the transmission intervals were extended for 2020. According to a survey, the farmers stated that they now check the animals more often, because a targeted search for the animals is possible at any time, e.g. in the evening. The fact that the devices are helpful in practice shows that farms have increased their number of devices and that other farms have acquired new devices.

Introduction

Modern positioning and navigation systems are used in many areas today. Inexpensive technology, compact devices and a corresponding accuracy of the position determination have made the devices usable for the everyday use and partly indispensable. Navigation devices guide us to our destination, routes are recorded exactly, on hikes, navigation devices show us whether we are on the right path, for example, even in fog. Every modern cell phone can display the coordinates, or if help is needed, the task forces can find the exact location of the operation site using the coordinates. With GPS devices, vehicles, boats, machines, containers, etc. are monitored, the current location is displayed, or in the event of an unauthorized change of location, the owner receives information. All this is made possible by navigation systems. Besides the European Galileo, Chinese Beidou and Russian Glonasss, the American NAVSTARS Global Positioning System (GPS) is the most frequently used system. Today, all systems are colloquially referred to as GPS.

The GPS system was developed by the American military in 1973 and was not fully usable until 1995. Due to the emission of a jamming signal for civilian users until May 2000, which produced an inaccuracy of the position data of more than 100 meters, it was only conditionally applicable for civilian use. With the interference signal switched off, the position can be measured from a few meters to centimeters. The accuracy depends on the technology in the equipment and the number of satellites available at the time of measurement.

Alpine pasture farming has a long tradition in the alpine countries. Only by relieving the pressure on the farm land the productivity of the individual farms could be increased. In recent decades, alpine

pasture farming has lost importance as an important source of fodder. With the purchase of cheap fertilizer and fodder, the production and performance of the animals could be increased on the same areas. Due to the workload (labor or sideline and farming) and the low profitability of small farms, many farmers have abandoned animal husbandry. Steeper land is leased from farms for grazing. The land is fenced and the cost of animal control is less. As farms specialize, for example, in milk or intensive fattening, with year-round housing, pasture land is no longer needed. Animal stocking is declining in most alpine pastures and the number of alpine pastures is decreasing (BMLRT 2020). Qualified alpine pasture staff for the animals is difficult to find and finance, which is why animal control is carried out by the home farm for many small alpine pastures, where the available working time is the greatest challenge.

A major factor for pasture management (from home range to alpine pastures) will be the return of large carnivores. The management practices we have traditionally used over the last century will no longer be sufficient in many cases to protect our livestock from large predator attacks. More personnel, guard fences and guard dogs would have to be used to protect the animals.

In a working group of HBLFA Raumberg-Gumpenstein, Bauernbezirkskammer Liezen and Naturpark Sölktäler there were considerations to promote the management of alpine pastures and to facilitate the work of alpine pasture management with the help of technical aids. Animal control is one of the most important tasks of the alpine pasture staff, and searching for animals often causes the largest part of the working time (MAXA et al. 2014). With the help of satellite-assisted tracking devices, finding the animals should be made easier, the working time for animal control should be shortened, or the time is available for longer animal observation.

Material and methods

There are many suppliers of animal tracking devices on the market, from expensive devices, e.g. for wildlife research, to the cheap, mass-produced devices, e.g. for dog and cat tracking. All devices work on the same principle. Simplified, a GPS device receives signals from several satellites about position and time, thus the device can calculate the coordinates of its own location. The determined data is sent to a server, from which the position data can be retrieved via cell phone, tablet or PC using an app. The coordinates are displayed by the providers as a symbol in maps and the users know where their transmittered animal is located. The accuracy of the position is determined by the number and geometric arrangement of the satellites, and there can be either no reception or distortion of the measurement in narrow valleys, rocky areas, dense cloud cover or in forests. An experiment conducted in 2013 to determine the dynamic accuracy of four different GPS collars resulted in a median of 1.02 - 2.07 m (MAXA et al. 2015). Static accuracy tests conducted on Austrian alpine pastures, show a mean deviation between 7.5 and 11.2 m (median) from the real position (THURNER et al. 2012).

Power supply of the devices

The devices have rechargeable batteries or batteries available for power supply. More power of the power sources causes more in size and weight. That is why there is a compromise on the runtime of the device and the cost (more powerful batteries are more expensive). The power is needed for receiving the GPS data, sending the coordinates and other parameters (temperature, battery level...) to the server. The number of position determinations and the sending of data determines the power consumption - thus the runtime of the devices. A "live tracking" with continuous positioning, as we know it from the vehicles, we can not afford with these devices, the batteries or the battery would be empty within a very short time. For animal search on alpine pastures an interval of several hours is no problem. For lower power consumption, devices based on Low Power Wide Area Networks (LPWAN) radio technology can be used. The prerequisite is an existing network or the installation of a separate antenna. Data is transmitted from the end devices (nodes) to the antenna (gateway), from which the collected data is transmitted, e.g. with a GSM network, to a server to which the end user has access. As with cellular networks, most LPWAN networks are chargeable. The networks are optimized for only small amounts of data, which are, however, sufficient for animal tracking. Due to the low bandwidth with 868 to 868.6 MHz, the antennas can cover ranges of 15 km and more. To save power, all devices go into a "sleep mode" between position determinations. For position determination, the devices wake up, dial into a GSM network and send the data. If they do not get a network connection, they try to dial in for 5 minutes before switching to sleep mode.

Panic detection

With the return of large carnivores, attacks on our livestock have increased recently. Electrified fences for herd protection or guard dogs can prevent attacks, but the use of dogs and the construction of a herd protection fence is not possible everywhere due to technical and financial reasons. Nevertheless, in order to have information in case of attacks by large carnivores, panic detection would be helpful. The panic function was primarily intended for sheep, sheep have the highest losses due to attacks by wolves. Sheep usually graze unfenced areas above cattle pastures, animal control does not always occur daily, so a technical aid would be a help here. Currently there is no tracking device that detects a panic of grazing animals and sends an information to the user. According to our considerations there should be technical possibilities, for example to program an algorithm by the data of the installed acceleration sensor in connection with the covered distance, which could recognize a panic and give alarm. The difficulty here is the power supply of the devices and the avoidance of false alarms. To detect a panic, the devices would have to be in accelerometer monitoring mode. If there is a strong acceleration, the GPS data would have to be continuously collected in real time and processed in a program. If the values coincide with the reference values, an alarm would be issued. This monitoring and live localization would require a lot of power and shorten the runtime of the devices enormously.

Attachment of the devices to the animals

All devices except the one from Digitanimal originate from vehicle monitoring, which is why the housing of the devices is built in such a way that it is possible to screw them on or lay them down on a surface. Optionally, a bag with or without strap for the devices can be obtained from the companies (company Qtrack has included a bag without strap). An inexpensive and durable option is old fire hoses, which can usually be obtained inexpensively from fire departments. The equipment is

packed into the hoses and threaded onto the existing neck straps or bell straps. Screws close the fire hoses and the equipment is held in the hose. In addition, the fire hose protects the equipment from mechanical damage.

Pilot area 1: Hauser Kaibling

From 2008 to 2013, the project "Innovative alpine pasture management through targeted grazing with sheep for sustainable management of the alpine cultural landscape" was carried out in this grazing area (GUGGENBERGER et al. 2014). To determine the grazing intensity, the sheep were equipped with GPS trackers from 2009 to 2013, which is why the test area is suitable for the new studies. Since 2008, a professional shepherd with an assistant has been responsible for the sheep. The pasture management is done by herding the sheep, coupling the animals, to accompanying a free grazing, depending on the requirements of each area and forage areas. The grazing areas begin in the valley with the slope areas and extend to the natural alpine pasture areas around the summit regions of Hauser Kaibling and Bärfallspitz. With the operation of a mobile and radio transmitter directly on Hauser Kaibling, GSM network coverage can be described as optimal.

In 2020, an additional Sigfox and a LORA antenna for the devices with LPWAN technology were installed in the top station of the summit lift. The top station is the best place for mounting the antennas geographically (view of the pastures on all sides of the summit) and with the permanent power supply of the lift station (Figure 2). With the number of 853 sheep in 2019 and 623 sheep in 2020, we had enough animals to choose from for GPS tracker tagging. Ewes and rams were randomly selected from the different farms.

Pilot area 2: Untersberg bei Salzburg

This is an alpine pasture area of 67 hectares and 9.9 hectares of forage area, which are grazed by approximately 90 to 110 sheep each year. The animal control is carried out from the home farms, which is why the use of the equipment is a great advantage for the farmers here. What makes it interesting as a test area is the location of the alpine pasture, directly on the Austrian state border, with moderate GSM network coverage. In addition, Sigfox network coverage is available, enabled by a public antenna in Salzburg and neighboring Germany. Therefore, a device from Digitanimal with a Sigfox transmitter unit was used here in 2020, compared to the GSM devices.

Pilot area 3: Tuchmoaralm 2020

The Tuchmoaralm is located northeast of Hauser Kaibling in a neighboring side valley of the Enns Valley. The pastures are grazed by dairy cows, heifers and sheep from various farms. The management still takes place in the traditional way, where the cows graze the best forage areas close to the huts, with the short drive ways for the stabling of the cows at milking times. The heifers graze the areas next to and above the cows. For the sheep, the steep areas remain up to the summit regions of the surrounding mountains. GSM network coverage is partly only available at higher altitudes, which is why GPS trackers with GSM modules are used for the sheep and partly for the heifers. For monitoring the cows, a Sigfox antenna with a solar power supply was provided by the Heliot company. The antenna was mounted in a convenient location with line of sight to the cows' grazing areas and GSM network coverage, for sending data to a server (Figure 3). For the functional

control of the antenna, a tracker was mounted on a tree about 15 meters next to the antenna, thus a data transmission to the antenna system was always given.

Another evaluation results from devices, which farmers purchased for the 2019 alpine season. Here, the data from July 15, 2019 to August 15, 2019 from the different alpine pastures were used. This period was chosen due to the previous snowy winter, as many alpine pastures were stocked late and the first animals were driven off with the end of August.

Results

Pilot area 1: Hauser Kaibling

During the 2019 grazing season, eight of the 853 sheep were equipped with a GPS tracker. Two FM 4 devices from Qtrack were mounted on the neck straps of adult sheep with the supplied pouch. The devices were set to a 2-hour interval and transmitted positions throughout the grazing season from June 13, 2019, to Sept. 18, 2019. On average, device 1 transmitted a position every 2:10 hours and device 2 transmitted a position every 2:05 hours. The transmit power of device 1 was 92.3% and device 2 was 96% of the calculated position points.

The two largest devices FM 11 from the company Simpletrack were packed in an A fire hose and mounted with neck straps to large mountain sheep. After consultation with the company, the intervals chosen for the devices were 3 hours for device 1 and 4 hours for device 2. The large transmission intervals had used only about 2/3 of the current for the entire grazing period, and the remaining current would have been sufficient for a shorter transmission interval of 2 hours. Device 1 showed an average transmit interval of 3:29 hours, while device 2 with the 4-hour interval transmitted position data every 4:28 hours on average. This results in a transmission performance of device 1 of 86.1% and device 2 of 89.6% of the calculated position points.

The two battery devices GL 505 from the company Infostars were programmed on an interval of one hour. There was a large difference in transmit power between the two devices, with device 1 transmitting a position every 1:12 hours on average. Device 2 transmitted data on average every 1:44 hours. The transmit power results in 83.3% of the calculated position points for device 1 and 57.7% for device 2. The power was not sufficient for the entire grazing season with the hourly interval, and the devices ran out of power 2 weeks before the alpine grazing season. The interval of the two devices will be set to 2 hours in the future.

The devices Infostars battery GL 300 A, also had an interval of one hour and device 1 had an average transmission interval of 1:01 hours and device 2 1:03 hours The two devices showed the best transmission performances in our tests in test area 1, with 98.4% and 95.2% (Table 2). With the favorable network coverage at Hauser Kaibling, the devices had sufficient power for the entire alpine season.

Pilot area 2: Untersberg bei Salzburg

In 2019, various devices were used, whereby the Alm was particularly looked after by the company Qtrack (company Qtrack is based in Salzburg). The devices from the company Qtrack had an interval

average of 2.26 hours with programmed 2 hours, or with 12 times send per day was 10.18 times actually a position determination sent. The FM 11 device was programmed with an interval of one hour and sent position data every 1.07 hours. The GL 300 A device stored a position of the test animal every hour. However, 4% of the data was not sent until the next available network connection. During the evaluation all data are displayed, which is an advantage for the evaluation of the movement patterns of the animals. A representation of the grazing of the Untersberg based on the GPS data of the test animals is shown in the following figure.

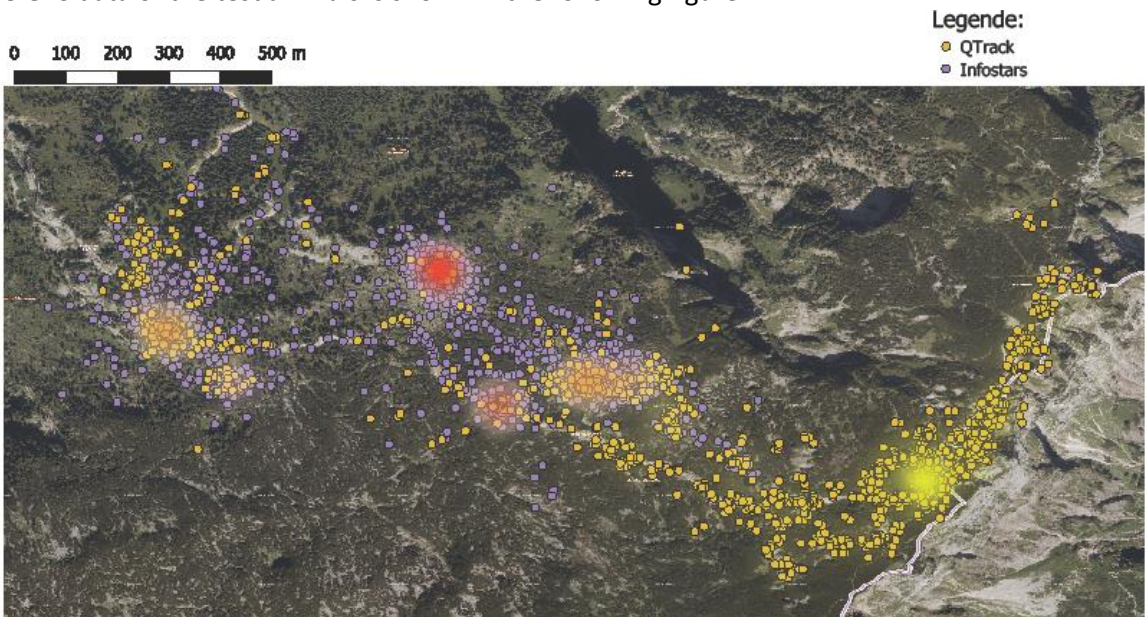

Figure 4: Example of grazing data obtained through GPS

In 2020, seven devices from the company Qtrack were used and two devices from Digitanimal one each with GSM module and one with Sigfox transmitter unit. With the public Sigfox antennas in Salzburg and neighboring Germany, Sigfox had better network coverage than the GSM network. Digitanimal's devices with Sigfox network achieved a data transmission of 92.7% compared to the one with GSM network of 49.7%. The FM4 devices had data transmission rates of 93.3%, 89.6% and 75.2%. The Q1 devices were able to significantly facilitate animal search with transmission rates of 92.8 %, 78.1 %, 77.5 % and 76, 3 %.

Figure 5 shows the transmission data of each tracker. AK 073 is the Sigfox device and Ak191 is the GSM device and would have to transmit 48 times per day. The other devices FM4_ to FM_4 are GSM devices and should transmit 12 times per day. From the line you can see when the animals grazed areas with poorer network coverage.

Pilot area 3: Tuchmoaralm

In the Tuchmoaralm there is no GSM network available for most of the pastures. A Sigfox antenna with solar power should bring the necessary network coverage for the cows in the Tuchmoaralm. The antenna was first mounted on a site where a blue radio antenna for the alpine pasture areas is installed. From there, we had no direct line of sight to the cows' grazing areas and thus no network coverage with Sigfox. Only by moving the antenna to a higher point on the mountain from which the grazing area of the cows is visible, the network coverage was given. Eight Digitanimal devices with Sigfox transmitting units were used. The AK080 unit, placed 15 meters from the antenna, transmitted 98.6% of its position data, while the units on the cows transmitted between 38.2% and 67.4% of their position data. The cows came into the barn several hours earlier at milking time and during bad weather or weather that was too hot, where no position data was sent.

Panic detection function

With live tracking of our flock of mutton and a panic generation by driving the handlers and with dogs, data was collected for the panic function. The sheep showed acceleration, which was also measurable, but there was also measurable acceleration at the sensor by, for example, two rams fighting, or sheep started running for no apparent reason. Only by the acceleration sensor we would have too many false alarms. The distance ranged as far as the sheep were driven with the dogs. Interviews with crack surveyors and the found arrangement of carcasses of torn sheep by large carnivores shows that the escape distance is short or the animals stop at all. There is no clear pattern of how sheep behave after an attack by a large prey predator. With this information, no clear parameters for panic can be derived, so currently the function cannot be implemented without additional information, such as heart rate, stress hormone, sounds, etc.

Future perspectives

With the return of the large predators, some federal states are already promoting technical aids for the pasturing of grazing animals. In addition to herd protection fences, GPS trackers are also subsidized with up to 80% of the purchase costs. The demand for GPS trackers for animal tracking will increase in the next few years, and new products and more cost-effective devices will come onto the market. The user-friendliness will be adapted to the requirements of the farmers. The power supply of the devices will be optimized even more, better batteries, power-saving devices, use of solar power or energy generation by movement of the animals etc. will be used in the future. With more power, shorter transmission intervals can be achieved up to live tracking. Additional information on the health status of the animals, e.g., heart rate, internal temperature, foot diseases (fashion limp in sheep), etc., could be implemented in the future. With the expansion of telecom networks, LPWAN networks or by own receiving stations it will be possible in the future almost everywhere a favorable animal monitoring.

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