GPS TELEMETRY COLLARS: CONSIDERATIONS BEFORE YOU OPEN YOUR WALLET

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***Abstract*:** Telemetry is a widely used method to gain information about animal movements, habitat use, and social behaviors. Standard radio telemetry involves hours in the field following animals to gain this knowledge. In addition, researchers could bias animal movements by their presence. GPS technology uses satellites to remotely monitor animal movements, store the information within the collar, and offers several options for data recovery. Additionally, the number and accuracy of acquired locations collected with GPS technology can far surpass traditional telemetry capabilities. However, GPS technology is not a panacea to all problems associated with conducting telemetry studies. The GPS equipment is considerably more expensive than standard VHF equipment and thus researchers expect a proportional increase in data quantity and accuracy. Unfortunately, collar malfunctions ranging from battery failure to hardware failure are a frequent complaint against GPS technology. Therefore, trade-offs occur between VHF collars and GPS collars and must be assessed by individual researchers. We used GPS collars on feral swine (*Sus scrofa*) in Texas. Using 51 GPS collars for 79 deployments, we experienced a >50% failure rate in collar performance. We report our experiences with GPS collars and offer advice and considerations that should be addressed prior to their purchase.

Key words: feral swine, Global Positioning System, GPS collars, *Sus scrofa*, telemetry, VHF

Proceedings of the 12th Wildlife Damage Management Conference (D.L. Nolte, W.M. Arjo, D.H. Stalman, Eds). 2007.

INTRODUCTION

Radio telemetry collars have been used to study wildlife biology as early as 1959 (Le Munyan et al. 1959). As technology improved and prices decreased, standard VHF telemetry became a widely used tool throughout the discipline. However, VHF technology is not without flaws. Many hours of effort are required to locate animals, and the triangulation method for estimating spatial locations of collared animals can result in a wide margin of error (Samuel and Fuller 1994). Additionally, the very act of triangulating or homing on an animal could inadvertently affect the animal's behavior, creating a bias in the study. Therefore, when global positioning system (GPS) collars became available for wildlife research in the late-1990s, researchers began transitioning over to this new technology. Utilizing the US Navstar GPS satellite system, this new technology promised pre-programmed and remotely collected data that could be taken as often as required, and with some designs the collar could be remotely downloaded. This reduced the average GPS position error from about 100 m to approximately 3 m, greatly improving the GPS collar application for fine-scale research concerning wildlife habitat use (Adrados et al. 2002, http://www.ngs.noaa.gov/FGCS/info/sans_SA/docs/GPS_SA_Event_QAs.pdf accessed 5/3/2007). GPS collar technology has improved over the past 15 years, promising smaller, more precise, and cheaper collars for wildlife research.

The large quantity of accurate location data that a GPS collar can potentially collect, with limited man-hours compared to standard radio telemetry research, is enticing. This, however, comes at an increased price that can reach several thousand dollars per collar. Considering the large investment, and often-limited research budgets, researchers expect comparable returns in data. For example, if a researcher desired 1000 locations from 10 animals in one month, then the researcher would need to locate an animal every 17 minutes for 10 hours each day and do this every day for the month to obtain his desired goal. Monetarily the cost would be minimal, about $3,000 (US currency) for 10 VHF telemetry collars, receiver, and antennae, but the investment in field time would be great (300 hours). By contrast the same goal could be accomplished via GPS collars. Field time would be negligible; however, the monetary cost would be substantial ($25,000; ~$2,500/collar; US currency). Unfortunately, as more research projects have employed GPS collars in their methods, the reality of technology glitches also has increased (Dussault et al. 1999, D'Eon et al 2002, Johnson et al. 2002, Gau et al. 2004,).

We use our research project, concerning movement and habitat use of feral swine (*Sus scrofa*), as a case study to highlight problems that were encountered with GPS technology. We also highlight considerations and specific features that we believe are helpful in planning a research project using GPS collars.

CASE STUDY

We used Posrec GPS/VHF collars (Televilt Co., Lindesburg, Sweden) manufactured in 2003. Collars weighed 850 g and were oval in shape. A GPS antenna was mounted on the top with a coax cable connecting to the data-logging computer and battery housing on the bottom of the collar. The VHF component of the collar used a standard VHF antenna that ran internally up the side and exited near the top. The collar belt fabric was a durable synthetic with an independent pre-programmed drop-off unit embedded in the collar belt along the side. Location data were logged and stored on-board the computer, requiring collar recovery to physically download the movement data by USB cable connection to a computer.

Removing a magnet activated the data-logging computer on the collar; it had a 13.5 minute activation window in which it attempted to acquire an initial location. If unsuccessful the collar would result in an inactivation error signal and need to be reactivated. Removing the magnet, at which point it began a countdown 760 days to dropping off, also activated the drop-off component; it ran on a separate battery and was not integrated with the data logging or the back-up battery. Additionally, replacing the magnet, like the data-logging component, could deactivate it; however, this reset the 760-day clock on the drop-off component.

The VHF component of the collar was used to track the collar during two 4-hour periods for 2 days per week. There were 5 different VHF pulses that the collar used to communicate its status. Forty pulses per minute (ppm) indicated the animal was alive but not active, 60 ppm indicated the animal was active; 80 ppm was the mortality signal indicating the collar had not moved for 2.5+ hours. These three signal types were only emitted during the pre-programmed intervals on Monday and Tuesday. A double pulse at a rate of 48 ppm indicated that the back-up battery was initiated and the collar was no longer acquiring and logging locations, whereas 240 ppm indicated inactivation and required reactivation to work properly. Both these pulse signals were emitted continuously until deactivated or the battery died.

We calculated that, at 24 location acquisitions per week, the main battery would last for 2.1 years, at which point the back-up battery would initiate and location acquisition and logging for GPS data would be discontinued. The back-up battery would emit the double pulse signal for 260 days before communication with the collar ceased. The collar was programmed with 90-second location acquisition windows. If at least three GPS satellites were not acquired during that window, the collar would make additional attempts every 15 minutes to acquire a location. Each location acquisition consisted of 6 rapid GPS locations, the first point and two outliers were discarded and the remaining three points were then averaged and recorded on the data logger. This averaged GPS location also was graded according to position quality with a dimensional score of 1D, 2D (3 satellites), 3D (4 satellites) and 3D+ (5 or more satellites), each grade increasing the expected accuracy, respectively. Data downloaded from the collar included date, time of acquisition, dimensional score, and latitude and longitude or UTM coordinates.

Our project used 51 GPS collars on feral swine in eastern and southern Texas. Collars recovered by hunters and trappers, or collars that the feral swine slipped out of were recovered, the data downloaded, and then redeployed. Seventy-nine deployments occurred over 2 years of trapping. Fifty-eight of the deployments were recovered. Collar recovery came from 20 feral swine slipping the collars off, 25 hunter or trapper returned collars, 1 road-killed animal, 6 undetermined mortalities, and 6 recovered by trapping or hunting the individuals by project researchers. Movement data was recovered from 42 collars, the remaining 15 did not record movement because the animal either died or slipped out of the collar shortly after being released.

Of the 42 collars containing data, the average amount of time the collar was on an animal in the field was 156 days, with a range of 3 to 531 days (s.d.=121). We calculated the expected time of data collection as the time between collaring the feral swine to the estimated date the animal was no longer wearing the collar, or we received a back-up battery signal from the collar. The expected number of locations was calculated by dividing the number of days the collar was on the animal, and working, by 7 (to approximate a week) and then multiplied by 24 (the number of locations to be collected each week). Twenty-two collars collected data the entire time that they were on the animal, with an average field period of 86 days and an average of 58.2% of expected locations recovered. The actual data recovered was sometimes of a shorter period than the expected time due to internal data-logging issues that are still unresolved. The collars, if malfunctioning, were to give a VHF inactivation signal indicating that the collar was no longer logging locations. However, some collars stopped collecting GPS data prematurely but failed to indicate this malfunction via VHF signal. Eight collars stopped early with an average of 246 days expected but only 130 field days actually collected, averaging 47.2% of expected locations recovered. Another 5 collars had patchy data, stopping and starting over the data-collecting period of 232 days averaging only 26.6% of expected locations. Four additional collars had patchy data and stopped short with an average of 223 expected days, but only 139 actual field days and an average of 20.4% of expected locations. Of the remaining three collars, one battery died early collecting 70.6% of the expected data during the time it worked, 1 battery broke off collecting 66.6% of the expected data, and the third collar switched to inactivation after 77 days and collected 95.4% of the expected data.

Overall 21 collars were not recovered from the field, potentially due to collar malfunction. Another 20 collars either had incomplete (patchy or shortened) data logging or otherwise malfunctioned. This resulted in 41 of the 79 (51.9%) deployments being categorized as malfunctions. We required location data to consist of at least 30 locations over 10 or more days for movement and habitat use analysis. Only 35 of the 42 location datasets qualified, and of those only 18 worked as expected.

To assess the impact that habitat and canopy cover may have had on the satellite communication with the collar, we assessed the accuracy of collars in open habitats as well as in each of the habitat types within our study area. Our verification indicated that canopy type had no effect on the acquisition of locations for the week we tested. This suggests that habitat was not a major contributor to the poor collar performance; instead, it was likely problems were due to collar design.

ADDITIONAL DESIGN PROBLEMS

The feral swine were rough on the collars, resulting in many of the VHF antennas breaking off at the point of exit from the top of the collar, which unfortunately reduced the transmission distance from 3 km to approximately 1 km. As mentioned before we suspect internal construction breakdown may have been the cause of much of the data logging malfunctions because the VHF signals were often working signals while the GPS locations were not being logged. Some batteries died early, and none of the drop off mechanisms worked on collared animals. We only know of one occasion where the drop off mechanism worked properly, and it was on a collar that was in storage during the scheduled time for collar release.

Some additional features we felt would have been beneficial to the collar design were the following. Our frequency and serial number labels were labeled on the battery housing of the collar with a resin material. Unfortunately, these labels did not weather well, and in one instance an unlabeled collar was returned without ear tags or explanation, and was no longer working. Only by deducing the deployment location and the range of dates present in the downloaded data were we able to identify which animal had worn the collar. A better label, and the inclusion of either the frequency or the serial number in the downloaded data, would be advisable. Additional data that would be helpful in the database would be ambient temperature, and the activity status of the animal, either inactive, active or mortality.

We also returned several collars to the company for refurbishment. One change they provided was to internalize the VHF antenna to prevent it from breaking off so easily. Internalization of the antenna reduced the signal strength, but its function was far superior to the diminished range of a broken antenna. The poor performance of the pre-programmed drop off components also was frustrating. We believe that a remote discharge option on the drop off would be advisable. Premature failure of the main battery should initiate the drop-off mechanism to active so that the collars can be retrieved, refurbished, and redeployed in a timelier manner.

Lastly, the VHF function of the collar is integral to knowing the status of the collar and to the eventual recovery of the data. The VHF signal must be strong and appropriately scheduled. The Posrec collars, when in mortality mode, only emitted the signal during the designated VHF signal periods each week, often retarding the recovery of the collars from the field. If the collar is in mortality mode, a continuous transmission of the VHF signal is advisable for the purpose of recovery. Additionally, during activation of the collars there was no VHF signal, only a LED light to indicate the progress and eventual status of the activation. Outside of the 13-minute activation window there was no way to verify if the collar was working unless it was during the designated VHF signal period on Monday and Tuesday. A simple 1-hour verification period with VHF signal upon activation would be convenient.

DISCUSSION

Samuel and Fuller (1994) state, "Equipment limitation, especially related to transmission range and life-span, probably will continue to pose the most severe restrictions on telemetry applications." A decade later the technology is still struggling to withstand the rugged conditions of the environment and the species wearing the collar. After speaking with other wildlife research biologists and referencing GPS performance papers, we realized that our experience of problems with GPS collars was not unusual, and despite a >50% rate of failure for our project, the location data that was recovered was arguably better than potential VHF telemetry estimates. Also, we have knowledge of wildlife research projects that were very successful using different brands of GPS collars than our study. The success rate may depend not only on the brand of GPS technology but also on the species collared. It is possible that feral hogs are excessively rough on collars, and therefore, they are not an ideal candidate species for GPS technology. However, despite the possibility of high failure rates, the technology is impressive and appealing. Researchers considering using GPS collars for wildlife studies must exercise caution in their study design, expecting a possible failure of nearly half the collars. For some studies, the cost of collars could easily compete with the cost of labor and supplies required for VHF telemetry. Each project must assess their needs and capabilities, but keep in mind that GPS collars are prone to problems and are not yet the panacea to the wildlife profession.

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