

Application of tail transmitters for tracking feral horses as an alternative to radio collars

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Abstract

Radio collars have been used to examine the spatial ecology of all North American ungulates, but are rarely used on feral horses due to concerns that they may cause injury. Due to public concerns for animal welfare, an alternative to radio collars for tracking feral horses, particularly stallions, over the short term would be useful. We developed a method of attaching a global positioning system (GPS) transmitter to feral horse tails, and provide step by step instructions so that others may apply this method. We braided the tail and affixed a transmitter tag to the braid with epoxy, cable ties, and an attachment cord run through the braid. Between 2016 and 2017 we fitted 114 VHF or VHF-GPS tags in the tails of free-roaming feral horses in western Utah. From when tags were fitted to September 2020 tag retention time ranged from <1 to 36 months ($n = 111$, mean = $8.50 \pm \text{SD } 6.39$ months). We found that our braided, tail-mounted transmitter tags can provide a viable alternative to radio collars for meeting shorter-term data collection needs once data transmission difficulties are overcome.

KEYWORDS

equid, feral horse, hair, radio collar, spatial ecology, tag, telemetry

Scientists are increasingly understanding the value of global positioning system (GPS) data derived from tracking devices affixed to animals. Geospatial data are invaluable for understanding movement ecology of animals (Kays et al. 2015) and can be used to reveal other aspects of a species' ecology such as foraging patterns (Owen-Smith and Martin 2015) and social networks (Peignier et al. 2019) and can be used to inform conservation and management actions. Traditionally, large mammals have been tracked remotely using radio collars (Hennig et al. 2020). Although collars have many benefits in terms of durability and longevity, due to public scrutiny and sensitivity of feral horse (*Equus caballus*) management (Scasta et al. 2018), an alternative for feral horses may be useful, especially for research and management that does not require multi-year data.

Transmitter backpacks have been commonly fitted on birds (Barron et al. 2010, Green et al. 2019) and transmitting devices have been directly applied to sea mammals (Fedak et al. 1983, Field et al. 2012). Transmitters have been glued directly on small mammals (Estes-Zumpf and Rachlow 2007, Teague O'Mara et al. 2014), but longevity is limited to days as terrestrial mammal skin is sensitive and most areas of body fur are frequently groomed. On larger mammals, small transmitting telemetry devices have been used externally by piercing ears or tails (Rothmeyer et al. 2002, Kluever et al. 2012) with risk of consequent injury if tags rip out.

Feral horse management can be contentious in the United States and generates strong emotions in proponents and opponents regarding their management on public lands (Scasta et al. 2018), yet there is little recent information on movement ecology, habitat use, and demography of feral horses in the western United States, due to a lack of radio collar data (Hennig et al. 2020). Until recently, radio collars had not been used on feral horses in the United States for about 30 years (Collins and Kasbohm 2017, Hennig et al. 2018). In the 1980s, several injuries and one mortality of a feral horse were related to radio collars (National Research Council 1991), thus land managers were reluctant to use radio-collars on feral horses until collar safety was validated. In a pasture trial, Schoenecker et al. (2020) found no adverse effects on female horses wearing radio collars in terms of behavior or welfare, and concluded that, with the right safeguards in terms of dropoff mechanisms and frequent visual checks, collars do not pose a significant health risk to mares. However, they found that males had a higher likelihood of the collar rubbing on the mandible and moving forward over the ears. Schoenecker et al. (2020) concluded that due to stallions' relatively large neck to mandible ratio, stallions were more challenging to fit with collars.

Schoenecker et al. (2020) briefly describe how they attached tail transmitter tags in a pasture trial and assessed retention of 5 tags. Subsequently we conducted a field trial applying over 100 tags. Our objective was to test retention time of tail transmitters on free-ranging horses across and between 3 models of different weight, size, and technical capacity. We present results of retention time, as well as more detailed step by step procedures to affix transmitters to the tails of feral horses for potential replication by other researchers or managers.

STUDY AREAS

We conducted our study at Conger (692 km²) and Frisco (244 km²) Herd Management Areas (HMAs) in Utah between August 2016 and September 2020. In November 2020 we deployed additional tags at Sulphur Springs HMA, Utah (1,075 km²) where monitoring is ongoing. All study HMAs had habitat typical of the Great Basin, with elevations above sea level ranging from 1,400 m in basins to 2,895 m on peaks. Vegetation consisted of spruce-fir forest (*Picea* spp. and *Abies* spp.) at the highest elevations, with pinyon-juniper woodlands (*Pinus edulis* and *Juniperus* spp.) on lower slopes, transitioning to sagebrush shrubland in the valley bottoms, dominated by *Artemisia* spp. with bunchgrasses (*Achnatherum hymenoides*, *Bouteloua gracilis*, *Elymus lanceolatus*, *Festuca* spp., *Hesperostipa comata*, *Pascopyrum smithii*, *Poa secunda*), and cheatgrass (*Bromus tectorum*). At the lowest elevations, sagebrush transitioned to salt desert shrub and semi-desert shrub steppe, characterized by grasses and shrubs including *Atriplex* spp., *Artemisia* spp., *Chrysothamnus* spp., and *Krascheninnikovia lanata*. Precipitation averaged around 190 mm annually, falling as snow in winter and monsoonal rains in late summer. Average temperature ranged from around 0°C in winter to highs of 27°C in summer. Other large ungulates present in the areas were elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*) and pronghorn (*Antilocapra americana*). Mountain lions (*Puma concolor*) and coyotes (*Canis latrans*) were also present, however we observed no evidence of direct predation on horses in our study areas.

METHODS

Animal handling

Horses were gathered by the Bureau of Land Management (BLM) according to management protocols (Bureau of Land Management 2015) and held in temporary corrals or BLM facilities prior to being fitted with tags. For tail tag application, horses were restrained in a hydraulic padded squeeze chute (hereafter squeeze) at the Delta Wild Horse and Burro Corral (Conger horses) or Axtell Wild Horse and Burro Facility (Frisco and Sulphur Springs horses). No tranquilizers or sedatives were used. Once held in place in the squeeze, the top half of the rear end door was opened, and we pulled the tail over the top. Some squeezes did not have a divided rear door, in which case we manipulated the tail to pull it through side bars. Horses did not need to be squeezed tightly, just enough to reduce movement forward and back. It was important to have a sturdy panel between researchers and the hind legs of the horse, but surprisingly few horses (estimated at <5%) kicked as we worked on the tail.

Transmitter tag application

We worked with manufacturers (American Wildlife Enterprises, Monticello, FL, USA, Biotrack [through Lotek Wireless, Newmarket, Ontario, Canada], and Ecotone [through Vertebrate Systems LLC, Chesterfield, MO, USA]) to design tags with a flat base to affix to the tail and holes of about 5 mm diameter laterally at both ends of the long axis to hold braiding cord and cable ties. To prevent static charge that builds up in horse tail hair which could interfere with electronics we glued electrically insulating fabric such as neoprene on the flat base of the tag. Any antennas (e.g., for VHF or UHF) were internal or longitudinal so that they hang naturally with tail hair. Equipment needed to attach tags to the tail hair is listed in Table 1.

Immediately prior to deployment we pulled cotton cord through the top hole, leaving about 20 cm dangling on each side, and put long cable ties through the bottom hole. If solar panels were used, we covered the solar panel with adhesive tape during application to prevent accidental smudges of epoxy. As hair tends to accumulate natural oils and dirt, we wiped down tail hair with alcohol wipes. We found it most efficient to work in a team of 2 people: one person did the braiding (termed braider below) and one person held the tag out of the way of the braid and applied epoxy (termed gluer below). The braider separated three sections of hair for the start of the braid, aiming for the tag to be placed on the braid in the top third of the tail just below the horse's hip bones (Figure 1A). The gluer held the tag with the cord hanging from 2 upper holes directly down the tail and the bottom of the tag facing out

TABLE 1 List of equipment needed to affix transmitters in animal hair.

Item	Description
Alcohol wipes	Screen/lens cleaners
Cord	Cotton cord 3–4 mm in diameter
Cable ties	30 cm long
Small elastic bands	About 20 mm diameter
Low-temperature curing epoxy	Devcon® 5 min (Field et al. 2012)
Tongue depressors	For epoxy mixing and spreading
Latex/nitrile gloves	For personal protection
Acetone or rubbing alcohol	In case of mis-application of epoxy
Adhesive tape	Scotch® Magic™ tape that leaves no adhesive residue when removed

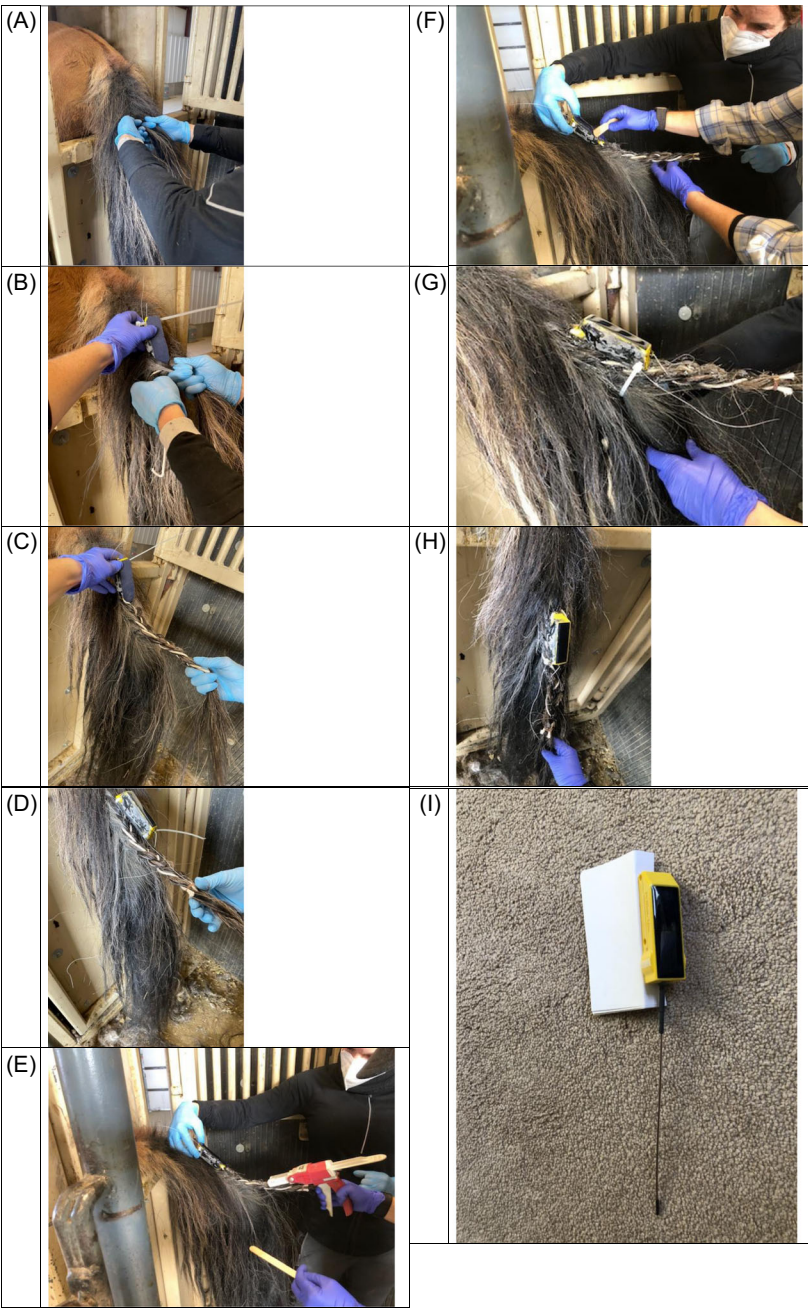


FIGURE 1 Method of affixing a telemetry transmitting tag in a horse tail. First a French braid is started (A), then cord attached to the tag is incorporated into the braid (B) and the braid is continued using all hair available (C) before being tied with an elastic band (D). Epoxy is then applied to the underside of the tag and to the tail hair (E) being spread and mixed with a tongue depressor (F). The tag is then further attached to the tail with a cable tie (G) and once the tag assembly is complete (H) the animal can be released. An example of an Ecotone solar powered tag is shown in (I).

away from the body of the horse, thus upside down, so the 2 cords could be incorporated into 2 of the 3 sections of the braid (Figure 1B). We pulled the cords taut regularly during braiding, so that there was no loose cord at the top when the braid was complete. At the beginning of the braid, hair was continuously added from both sides of the braid with each pass (a French braid) in order to secure the braid with more anchoring hairs. After the French braid extended beyond the length of the tag, remaining braid strands were braided normally for 20–25 cm (Figure 1C) and held in place with a small elastic band (Figure 1D). The braid was made as tight as possible.

Once the braid was complete, the braider held the braid out horizontally while the gluer applied epoxy to the neoprene-covered underside of the tag and the surface of the braid, covering the entire top surface of the hair (Figure 1E). Epoxy was directly mixed and smoothed on the tail hair (avoiding contact with skin) using a tongue depressor (Figure 1F). Low-temperature curing epoxy has been used to attach transmitter devices directly to phocid seals (Field et al. 2012), thus we considered it safe for use on horse hair. The gluer then flipped the tag down so that the epoxied underside of the tag and the epoxy on the braid came together, and gently squeezed the tag into position. The gluer ran the ends of the cable tie around the bone of the tail, or just around hair if the tail was sufficiently thick (Figure 1G). We made sure that the cable tie was around hair so it would not rub the tail bone or come in contact with the horse's rump. The cable tie was tightened to be snug but not tight and rotated so that the locking end was flush with the tag and did not rub the horse anywhere. Excess cable tie was cut off at the locking end leaving no sharp points (Figure 1H). Finally, we removed any adhesive tape from the solar panel of the tag. All back and side doors on the squeeze were then closed, and the horse was released through the front gate.

Field monitoring

All horses were individually identifiable from either a numeric freeze mark on their left hip or from unique pelage color or markings. Once horses were released back to the range at Conger and Frisco HMAs (August 2016 and February 2017, respectively), we located individuals with tail tags at least once a month by telemetry, or opportunistically by visual observation when they were encountered by ground observers if there was no VHF signal, until September 2020. The same methods were followed at Sulphur Springs HMA (released in November 2020), except that individuals were visually located every 2 months. When we located an individual we would record whether a tag was visually present or absent from the tail, confirm whether the tag was emitting a VHF signal, and for Biotrack tags at Conger and Frisco we would use line of sight to attempt to download data from the tags via UHF to a handheld device. At Sulphur Springs the Ecotone tags transmitted data through the cellular network to a web database, and/or via UHF to 2 base stations that were set at high elevations in areas used by the horses. Data were downloaded from base stations every 2 months.

RESULTS

Total tag weight depended on the components used to make the tag, whether each tag was battery- or solar-powered, and whether the tag had only global positioning system (GPS) capability or additionally had a very high frequency (VHF) radio transmitter (Table 2). We braided 114 Biotrack or American Wildlife Enterprises tags in feral horses' tails at Conger and Frisco HMAs between August 2016 and December 2017 (Table 3), then fitted 10 horses at Sulphur Springs HMA with Ecotone solar powered tail tags in November 2020. On average, a horse was held in the squeeze chute for 10 minutes ($SD \pm 2$ minutes) for tag application. Longer durations were generally due to other management tasks being done at the same time (such as freeze marking), or due to the horse's behavioral response. We had no incidents of a tag dislodging partially or completely while the epoxy cured. Of 111 tags for which retention time in the tail could be determined over 4 years, retention times ranged from one to 36 months (mean = $8.50 \pm SD 6.39$ months; data available in Schoenecker and King [2021]). Over 9 months (the time that tags have so

TABLE 2 Description of three telemetry tail tags fitted on feral horses at Conger, Frisco, and Sulphur Springs Herd Management Areas (HMAs) in Utah, USA, and Desatoya HMA in Nevada, USA Telemetry of the tags was by geographic positioning system (GPS) or very high frequency (VHF) radio, or both. Where applicable, data were transmitted from the tag via ultra high radio frequencies (UHF) or via the cellular network (SMS) or both.

Manufacturer	Telemetry	Data transmission	Power	Weight (g)	Dimensions (cm)	Number deployed	Mean retention time months (± SD)
Biotrack	GPS + VHF	UHF	Battery	41–45	9.5 × 2.7 × 3	56	9.5 (± 8)
American Wildlife Enterprises	VHF	None	Battery	79	8 × 3 × 3	58	8.7 (± 4)
Ecotone	GPS + VHF	UHF + SMS	Solar	30	9 × 2.5 × 2	10	

TABLE 3 Study sites, time frame, and number of feral horse individuals fitted with telemetry tags in the tail. Note that at Frisco the 8 females and 5 of the males fitted with American Wildlife Enterprises tags were 1 year old; all other individuals were adult.

Study site	Study duration	American Wildlife Enterprises		Biotrack		Ecotone	
		Male	Female	Male	Female	Male	Female
Conger	Aug 2016–Sep 2020	33		46			
Frisco	Feb 2017–Sep 2020	17	8	10			
Sulphur Springs	Nov 2020–ongoing						10

far been deployed at Sulphur Springs), 60% of American Wildlife Enterprises and 61% of Biotrack tags were lost, compared to 20% of Ecotone tags (Figure 2).

Across the three tag models we experienced several technical issues with tag performance (Table 4). Duration of VHF signal transmission was short in all tags, but was surprisingly short in the VHF-only American Enterprises tag. We had low success rate of data transmission from Biotrack tags.

DISCUSSION

Telemetry transmitters fitted to the tail of species such as horses have the potential to replace or complement use of radio collars for tracking individuals. On average, our method exceeded the retention times reported for telemetry-transmitting ear tags in semi-feral horse foals or cattle (*Bos taurus*) calf ears (180 ± 152.6 days; Kluever et al. 2012) or attached to beaver (*Castor canadensis*) tails (104 ± 129 days; Rothmeyer et al. 2002). In comparison, all horses fitted with radio collars at our study areas retained the collar until it was remotely or manually removed, with a duration of more than 4 years (Kate Schoenecker, U.S. Geological Survey, unpublished data, 2021). Owing to their reduced retention time compared to radio collars, we conclude that affixing telemetry transmitter tags to tail hair is a viable short-term alternative (i.e., 1 year) for feral horses. Shortcomings of transmitter tags affixed on hair is that they are likely to remain in place for a shorter duration than a collar, either because growth of hair expels the tag or because it becomes dislodged during an animal's daily activities. However, considering that most tags fitted on sea mammals are only expected to stay in place for days to weeks (Szesciorka et al. 2016), fine scale data even collected over a short period of time can provide useful information.

Feral horses are important to both public land managers and to the wider public. Due to concerns of horse impact on rangelands (Davies and Boyd 2019) there is a need for more data on fine scale habitat use, which can only

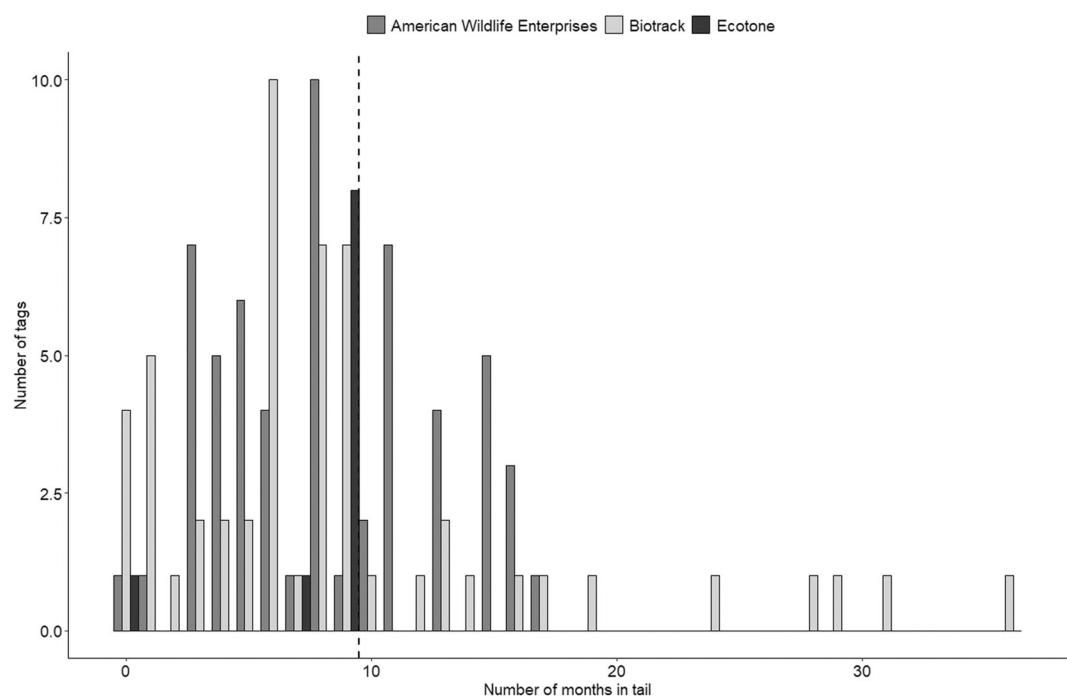


FIGURE 2 Retention time in months of American Wildlife Enterprises and Biotrack Ltd. telemetry transmitting tags affixed in the tails of feral horses at Conger and Frisco Herd Management Areas (HMAs), Utah, USA, between August 2016 and December 2017 ($n = 111$), and Ecotone tags affixed in the tails of feral horses at Sulphur Springs HMA between November 2020 and September 2021. Dashed line indicates 9 months, which corresponds to the most recent data available from Sulphur Springs. Tags that had a retention time of zero months were not seen in the tail of a horse one month after deployment.

TABLE 4 Technical results of three different tags deployed on feral horse tails in Utah. Note that Ecotone tags continue to be monitored, but we only have data for 9 months so far.

	American Wildlife Enterprises	Biotrack	Ecotone
Number deployed	58	56	10
Telemetry	VHF	GPS + VHF	GPS + VHF
Duration of VHF signal (months) mean $\pm$ SD (min-max)	7.1 $\pm$ 4.0 (0-16)	3.2 $\pm$ 3.1 (0-13)	5.6 $\pm$ 3.4 (0-9)
Average retention in tail (months) mean $\pm$ SD (min-max)	8.1 $\pm$ 4.3 (0-16)	8.9 $\pm$ 8.0 (0-36)	7.9 $\pm$ 2.8 (0-9)
Number recovered	19	7	1
Data transmission	None	UHF	UHF + SMS
Percentage of tags that transmitted data	NA	36	70

be gained from telemetry devices. Due to concerns about horse welfare, it is useful to have an alternative to radio collars for individuals, particularly stallions, where a collar may not be optimal, or for research questions where a collar is not necessary such as simply locating individuals without gathering GPS data. Due to their relatively short term retention in the tail, tags cannot replace radio collars for gathering long-term ecological data on horses, but our

study shows that tail tags have potential for shorter-term monitoring and research questions. Horse management can be contentious (Scasta et al. 2018); public perception of a small tag partially hidden in the tail may be different compared to seeing a collar on the neck of an animal, meaning that use of tags may be more acceptable or applicable in certain situations. Additionally our method of attaching a telemetry device presents other possible benefits: there is virtually no risk of injury from the device; the small size means that tags pose a negligibly low energetic cost to the bearer, and they can be designed to also have low aesthetic impact.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in Schoenecker and King (2021).

ETHICS STATEMENT

All work was conducted on wild horses managed by the BLM and animal handling followed their protocols (Bureau of Land Management 2015) and NEPA analyses (DOI-BLM-UT-W020-2015-0017-EA); our research was approved by USGS Animal Care and Use Committee permit FORT-IACUC 2015-10 and an Inter-Institutional Agreement with Colorado State University.

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