An expandable radiocollar for elk calves

Bruce L. Smith, William P. Burger, and Francis J. Singer

Abstract Expandable radiocollars, designed to monitor juvenile survival and movements, were placed on 132 neonatal elk (*Cervus elaphus*) in Yellowstone National Park during 1987–1990. A modified design of the same collar was placed on 164 neonates of the Jackson elk herd in northwest Wyoming during 1990–1992. One of the Yellowstone calves and 19 of the Jackson calves cast their collars before 15 July of their birth year. General deterioration of collar materials resulted in loss of the Yellowstone collars 12–18 months post-deployment. Separation of breakaway tabs resulted in loss of 13 collars from Jackson elk 504 ± 60 days post-deployment, but the remaining collars remained on elk for ≤4 years. These light-weight and adaptable collar designs achieved study objectives. We provide design recommendations for future monitoring of juvenile elk.

Key words *Cervus elaphus*, elk, expandable radiocollar, telemetry

Radiotransmitters have been used to study distributions, movements, cause-specific mortality, and survival of wildlife. Transmitters are usually attached to terrestrial mammals with nonexpanding collars, which are unsuitable for growing juveniles. Therefore, transmitters have been attached to juveniles with ear tags (Servheen, et al. 1981), implants (Green et al. 1985, Minta 1990), harnesses (Jackson et al. 1985, Blackwell et al. 1991), and a variety of expandable collars (Bon and Cugnasse 1992, Holzenbein 1992, Keister et al 1988, Kolz and Johnson 1980), with varying degrees of success. Ear tags require a smaller transmitter package than a collar mount. This typically results in reduced operational life, power output, and pulse rate, and a more fragile external transmitting antenna. Designs with internalized antennas reduce transmission efficiency. Implants, which have been successfully used in a variety of applications, involve a comparatively difficult and invasive procedure for "attachment" and yield a reduced range of signal reception. Harnesses have been used in applications on young felids, where collars would likely be removed (Jackson et al. 1985, Blackwell et al. 1991). Harnesses are more difficult to construct and fit than collars and are more likely to be sources

An expandable radiocollar on an 8-month-old elk of the Jackson elk herd in northwest Wyoming.

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of irritation to animals. Given these limitations, expandable collars have been the attachment method of choice for instrumentation of juvenile ungulates; whereas, ear tags, implants, and harnesses have more frequently been used on juvenile felids, canids, ursids, and mustelids.

Instrumentation of juvenile ungulates requires creative collar design, assembly, and deployment. Collars should expand to avoid harm to growing animals, but remain firmly attached during animals' grooming, social interactions, and brushing against vegetation. The earliest designs of expandable collars had limited applications and a number of problems (Fashingbauer 1962, Hamilton 1962, Hawkins 1967). One expandable radiocollar, designed for use on pronghorn (*Antilocapra americana*) fawns, was constructed of an inner, elastic collar suspended inside an outer, stiff collar (Beale and Smith 1979). The design was bulky, and the collar tended to snag vegetation. Steigers and Flinders (1980) described a collar constructed from an automobile safety belt with a coil-retractor for expansion and a surgical rubber insert serving as a breakaway device. This collar also was bulky and easily caught and removed on vegetation, and the breakaway mechanism lasted only 6 months in the field. A collar described by Kolz and Johnson (1980) had limited expansion capability and suspended the transmitter package as a pendant, that was potentially bothersome to the animal and subject to damage. More recent designs used on black bears (Strathearn et al. 1984) and ungulates (Holzenbein 1992, Keister et al. 1988) were constructed of stiff materials and were approximately round, rather than conforming to an ungulate's ovoid neck shape. They also had limited expansion capabilities.

We describe a light-weight, flexible collar that conforms to an ungulate's neck and readily expands with growth (Fig. 1). The collar is designed similarly to one used successfully on mouflons (*Ovis musimon*; Bon and Cugnasse 1992). It differs from the mouflon collar in not using tubular mountaineering webbing to enclose part of the antenna and transmitter package. Although the webbing has high tensile strength, it comes in a limited selection of widths, cut ends can fray, and it more readily becomes snagged in habitats with dense, woody vegetation than the material we used. The expandable collar we used in 2 studies of juvenile elk (*Cervus elaphus*) was an adaptable design by Telonics Inc. (Mesa, Ariz.) that was previously used to monitor other juvenile ungulates, including mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), bighorn sheep (*Ovis canadensis*), pronghorn, moose (*Alces alces*), caribou (*Rangifer tarandus*), and ibex (*Capra ibex*). This collar has not been previously described in the scientific literature.

Collar design

The collar was a woven elastic band encased in a sleeve of nylon-reinforced vinyl (Fig. 2). The transmitter package measured 3.5 x 3.5 x 2.8 cm and weighed 85–105 g (depending on battery configuration); it was riveted to the sleeve and elastic, and wrapped in vinyl tape to secure loose edges of the sleeve. The elastic, which provided a 2:1 ratio of expansion to contraction length, was protected from debris by stitching the length of the outer edges of the sleeve with number-69 nylon-bonded thread. Length of the elastic and sleeve materials accommodated the maximum neck circumference of mature elk (64 cm in F, 80 cm in M).

To provide a snug fit on neonates, 2 5-cm sections of the contracted collar were pinched into loops and sewn at their bases (Fig. 2). The base of 1 loop was zig-zag stitched with 1 row of cotton-covered poly-

Fig. 1. A 4-day-old calf of the Jackson elk herd in northwest Wyoming equipped with an expandable radiocollar in June 1991.

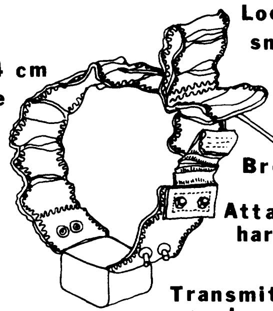

Fig. 2. Design of the radiocollar used to monitor neonatal elk of the Jackson elk herd in northwest Wyoming, 1990–1992.

ester thread, and the base of the other was sewn with 2 rows, allowing the loops to be added sequentially to the collar circumference under pressure from the growing neck. The collars were also designed with a breakaway tab, in which the elastic band was cut, and the 2 ends sewn together with cotton-covered polyester thread (Fig. 2). Our intention was for the tab stitching to degrade and break near the end of transmitter life, allowing the collar to fall off.

Field applications and collar performance

Yellowstone study

In 1987 a 4-year study was initiated in Yellowstone National Park, Wyoming, to determine causes of elk mortality during the first year of life. One hundred thirty-two neonatal calves (including 4 abandoned calves that died soon after capture) were captured during May and June 1987–1990 and fitted with expandable radiocollars of the general design described above (Singer et al. 1997). The collars weighed 170 g, measured 25 cm in circumference at the time of attachment, and afforded a 74-cm circumference when fully expanded.

Thirty-nine calves died prior to 15 July of their birth year, 27 calves died 188–343 days after capture, and 1 neonate lost its collar 39 days post-capture (Singer et al. 1997). No additional collars were lost from calves <1-year-old, the age at which routine monitoring was discontinued.

Jackson study

As part of a 4-year study of the Jackson elk herd in northwest Wyoming, 164 neonatal elk were captured and fitted with expandable radiocollars during May and June 1990–1992 to determine juvenile survival and distributions (Smith and Anderson 1996, 1998). We designed the transmitters to operate for >26 months, and we modified the collar design to extend its durability and attachment period beyond the 1 year required in the Yellowstone study. These modifications increased the collar's weight to 230 g, about 1.2% of the average capture weight (19.7 ± 0.28 kg) of 164 elk calves that averaged 3.6 ± 0.14 days-old. Collar modifications included:

1. Heavier sleeve material (0.61 kg\m^2 vs. 0.44 kg\m^2), which limited contraction of the elastic band and yielded a collar circumference of approximately 33 cm when deployed.
2. Wider elastic (3.8 cm vs. 2.5 cm).
3. Transmitter package attachment sites, which were the weakest areas of the Yellowstone collars, were reinforced with machine belting.
4. Backing plate and attachment bolts (Fig. 1) were reduced in size (from 3.2-cm spacing between the 2 bolts to 2.2 cm, and from 8-32 to 6-32 bolt size) to fit the machine belting (3.8 cm wide).
5. The contracted length of 2 loops sewn into the collar were increased to 7.6 cm, enlarging the fully expanded collar circumference to 80 cm.

Additional modifications were made to the collars deployed on Jackson elk in 1991 and 1992. Because the 6-32 attachment bolts on 3 collars broke in 1990, we used 8-32 bolts in 1991 and 1992. To accommodate the larger hardware we used 5 cm-wide machine belting reinforcement tapered to 3.8 cm to match the width of the metal tabs on the transmitter package. Additionally, 1.3 cm was added to the contracted length of each of the 2 collar loops, allowing the collar to fully expand to 85 cm. Finally, to minimize premature separation of the breakaway tab, a piece of heavy canvas was folded and stitched over each elastic tab.

Thirty-four elk lost their collars, 19 before 15 July of their birth year ($\bar{x}$ = 13.4 ± 2.4 days post-capture), and 15 after 15 July ($\bar{x}$ = 477 ± 60 days post-capture; Table 1). Calves that cast collars (slipped them over their heads) before 15 July were younger (smaller) when captured (t = 2.14, 161 df, P = 0.033) than calves that did not cast collars. Twenty-two elk died prior to 15 July of their birth year, and 56 died when ≥4 months-old (Smith and Anderson 1998). Collars on 50 elk (0.7–2.8-years old) were replaced with non-expanding radiocollars during February and March 1992–1994. Collars on 2 female elk (captured in Jun 1991 and Jun 1992) were not replaced and remained operational through 1995.

Discussion and recommendations

In 1990, we found 3 collars (lost from Jackson elk during the first 2.5 months after deployment) with broken coupling unit bolts. Although over-tightening

Table 1. Radiocollars lost from 34 of 164 elk captured during 1990–1992 as neonates from the Jackson elk herd, Wyoming, either before or after 15 July of their birth year.

Collars lost	Yr of capture	Sex	No. days collar on	Range	Reason collars lost from elk		
					Cast[a]	Bolt unit[b]	Tab[c]
Before 15 Jul	1990	M	19			1	
Before 15 Jul	1990	F	15.5	3–28	2		
Before 15 Jul	1991	M	9.2	1–23	5		
Before 15 Jul	1991	F	21.0	9–28	3		
Before 15 Jul	1992	M	13.5	1–28	6		
Before 15 Jul	1992	F	7.5	2–13	2		
After 15 Jul	1990	M	557	414–776			7
After 15 Jul	1990	F	298	72–623		2	4
After 15 Jul	1991	M	845				1
After 15 Jul	1991	F	622				1

[a] All cast collars were in good repair. Calves had apparently slipped them over their heads.
[b] Bolts of the coupling units broke on 3 collars 19–76 days after deployment.
[c] Breakaway tabs separated when the stitching securing them deteriorated.

may have weakened the bolts, we recommend use of the larger size bolts we employed in 1991 and 1992 to guard against collar loss.

Prior to 15 July (the date by which all neonatal mortality had occurred), only 2 Jackson elk cast collars in 1990 compared to 8 in 1991 and 8 in 1992. The addition of extra length to the collars (likely unnecessary) in 1991 and 1992, may have reduced the quality of fit on neonates. The circumference of some deployed collars exceeded 33 cm. For several particularly small neonates, an additional tuck was stitched in their collars at deployment. The lighter-gauge, more flexible sleeve material and elastic of the Yellowstone collars produced a snug fit that minimized collar casting by neonates. Expandable radiocollars of somewhat different design than ours were cast by 9 of 67 elk neonates in Idaho (Schlegel 1976) and 1 of 10 elk neonates in Oregon (Keister et al. 1988).

The sleeve material and elastic band used in the Yellowstone and Jackson studies provided the desired collar longevity and adequate elastic tension to fit snugly around an elk's neck without causing animal discomfort or inhibiting growth. Only 1 of 296 calves experienced obvious hair loss where the collar encircled the neck.

The lighter sleeve material of the collars deployed in Yellowstone deteriorated and the elk began losing collars 12-18 months after deployment. Separation of the breakaway tab was not a factor in collar loss. Singer et al. (1997) considered changing the collar design, but decided against it because they were only interested in first-year survival of elk. The collars served their intended purpose, and intentionally weakening the breakaway tab might have resulted in premature collar loss.

Loss of 13 of 15 collars (11 in 1990) from Jackson elk, after 15 July of their birth year, resulted from deterioration of the breakaway tab stitching. This was remedied by reinforcing the tabs with canvas in 1991 and 1992. When we replaced collars on elk or removed them from hunter-harvested elk ≤3.5 years-old, we did not find that expandable collars fit too snugly or caused noticeable hair loss or other lesions. We believe that these collars could be safely deployed without breakaway tabs, thereby potentially extending their functional longevity.

The collars we described can be readily modified for a variety of species and objectives. Scientists contemplating the use of expandable collars on juvenile ungulates must consider their research objectives carefully, particularly the size of animals at the time of capture, how long transmitters will be monitored, and the maximum expansion and durability requirements of collars if they are not to be removed from animals. For monitoring elk, we recommend the collar design used in Yellowstone National Park when collars need not remain on animals for >1 year. To monitor elk beyond 1 year of age, we recommend the sturdier collar, with a deployment circumference of 25-30 cm, that we used on Jackson elk in 1991 and 1992.

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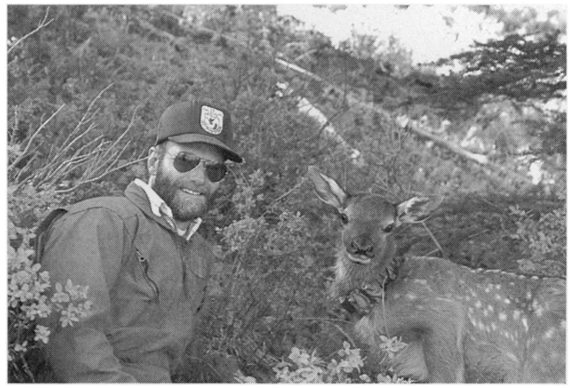

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