Short note

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An expandable radio collar for monitoring young terrestrial mammals

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Abstract: Although radio collars are widely applied in movement ecology, their use in animals with changing neck circumferences is challenging. We are proposing a model of a simple, cheap, and expandable collar that is suitable for the monitoring of young terrestrial mammals. We tested the collar on young crab-eating foxes. There was no register of injuries caused by the collar to the tagged animals, and they functioned appropriately. Thus, we hope this note will encourage further researchers to use our method to monitor the movement patterns of young animals, not only for canids but also for other species of terrestrial mammals.

Keywords: *Cerdocyon thous*; Cerrado; crab-eating fox; movement ecology; radio collar; radio tracking.

The use of radio collars began during the 1960s (Craighead and Craighead 1965), after which it steadily increased. Currently, it has become an invaluable tool for understanding patterns of dispersal (Lizcano and Cavelier 2004), behavior (Hubel et al. 2016), demography (Juarez et al. 2011; Murphy et al. 2019), spatial distribution (Kim et al. 2008; Smith et al. 1998), migration strategies (White et al. 2014) and home range (Melo et al. 2007). Besides, it also permits the monitoring of groups of small, medium and large mammals (Durnin et al. 2004; Juarez et al. 2011; Lizcano and Cavelier 2004; Murphy et al. 2019; Smith et al. 1998; White et al. 2014).

Although radio collars are now widely used in movement ecology, some issues such as the possible effects of collars on the behavior of monitored animals still a concern for many researchers. For example, in howler monkeys, the use of radio collars prevented the animal's grooming behavior (Campbell 2018). Furthermore, foxes carrying collars gained less weight on average than foxes without collars (Bruholt 2018), despite the care taken to ensure the animals' welfare during the placement of the collars (Wilmers et al. 2015). Furthermore, fitting collars on juveniles can lead to the abandonment of the puppy (Del Giudice et al. 2015). It is frequently reported that the use of collars does not alter the animal's behavior (Bruholt 2018; Durnin et al. 2004). However, reports of neck injuries in collared animals are not rare (e.g., Estes-Zumpf and Rachlow 2007; Juarez et al. 2011). In some cases, such injuries even led to the death of the individuals (Broekhuizen et al. 1979; Juarez et al. 2011). Also, studies with negative results tend not to be published (Lizcano and Cavelier 2004), thus possible behavioral effects of radio collars may be neglected.

Expandable collars appeared as a response to the need to monitor animals with neck sizes that vary during their lifetime. The use of such collars reduces the need to repeatedly recapture the monitored animals to replace their collars (Estes-Zumpf and Rachlow 2007). The neck of a male deer, for example, changes in size during the reproductive season (Ramos et al. 2002), and most of the current understanding of the dispersal patterns in these animals comes from the use of expandable collars (Hawkins et al. 1967). The use of expandable collars is recommended for these animals (Ramos et al. 2002). Despite the significant number of studies that have obtained high-quality results using expandable collars (e.g., Keister et al. 1988; Kolz and Johnson 1980), the currently available models still presenting some limitations (Obermoller et al. 2018). These include a large size that makes the collars more likely to be stuck in vegetation (Beale and Smith 1973;

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Steigers and Flinders 1980), the tendency to accumulate ice in freezing climates (Clute and Ozoga 1983), and a low expansion capacity (Broekhuizen et al. 1979; Keister et al. 1988; Kolz and Johnson 1980). Furthermore, the fast growth of small animals might lead to strangling (Kenward 2001). However, reports are showing the success of the use of expandable collars in young bobcats (Jackson et al. 1985), tigers (Goodrich and Miquelle 2013), pronghorns (Beale and Smith 1973), black bears (Strathearn et al. 1984), reindeers (Adams et al. 1995), elks (Singer et al. 1997) and white-tailed deers (Kunkel and Mech 1994). Notwithstanding these advances, there is still the need for a model of expandable collar that is structurally simple, made of accessible materials, and easy to produce.

Here, we propose a model of expandable collars suitable for the monitoring of young terrestrial mammals. To make the collar, we used an elastic band comprising of 75% polyester and 25% of elastodiene that can be easily found in regular stores. The collar has sewing thread, sealing clips to attach the radio transmitter, and hot glue to cover the most delicate parts and those with loose points, to avoid injuries to the animal. Its production is quick and straightforward, taking no longer than 15 min. It takes three steps: 1) cutting the elastic band to fit the neck circumference of the animal to be monitored (it is essential always to leave two additional centimeters as a safety margin) and sewing of the end; 2) joining of the ends to form a collar, followed by attachment of the radio transmitter with the sealing clip; and 3) covering of the sewn areas and the sealing clips with glue (to avoid potential injuries and increase the collar's robustness) (Figure 1).

We tested our custom-made collar on the crab-eating fox (*Cerdocyon thous*), a widely distributed species in South America (Lucherini 2015). We captured three young animals (two males and one female) using Tomahawk traps during October and November 2017 in natural fragments of the Cerrado (savanna-like vegetation), Brasília, Brazil (15° 51′53.66″S 47°55′46.60″W). The traps were baited with fresh bovine meat, armed before sunset, and checked the following morning. Captured animals were contained using hand nets, their mouth (to prevent injuries to both animals and researchers), and equipped with the expandable collars, with a Very High Frequency (VHF) transmitter (Lotek-SRX800, Seattle, WA, USA). We did not use any immobilizing drugs during the procedure. We then released the animals in the capture locations, with the handling time (the time between their retrieval from the traps and the release) lasting an average of 1:30 ± 0:30 min. We monitored the animals for a day and a night to check if the transmitters remained attached to the collars. We

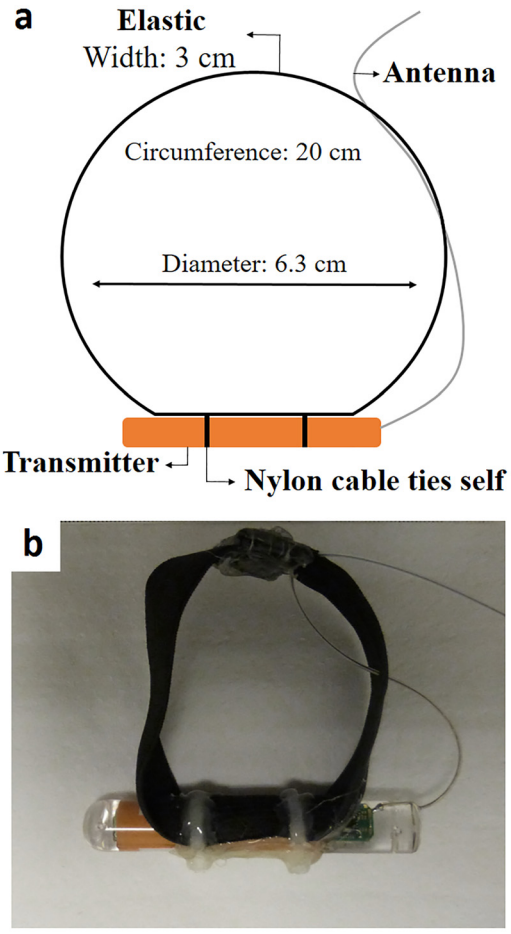

Figure 1: Expandable collar model devised for the monitoring of young terrestrial mammals. (a) Collar schematics showing the materials used and their exact measures. The diameter and circumference were determined based on measurements taken from the neck of young specimens of the crab-eating fox (*Cerdocyon thous*). (b) Picture of the collar, taken after its completion. In the zoomed part, it is possible to observe the patches of hot glue used to cover the sewn parts and the attachement clip.

recaptured the individuals four months after they were radio-tagged to test the effectiveness of our custom-made collars. We inspected the animals for any injuries potentially caused by the collars and inspected the collars for any damage. We also weighed and measured the animals to determine the size of the individuals and estimate their growth.

The results showed that the collar functioned adequately and did not cause any injuries to the tagged animals. We observed an increase of approximately 40% in the neck circumference and body mass (Figure 2). When the animals were recaptured, they had already reached sexual maturity and were considered adults (body length: 700 ± 26 cm, tail: 303 ± 5 cm, N = 3) (Reis et al. 2010). Despite an increase of 48 ± 3 and 32 ± 4% in body weight

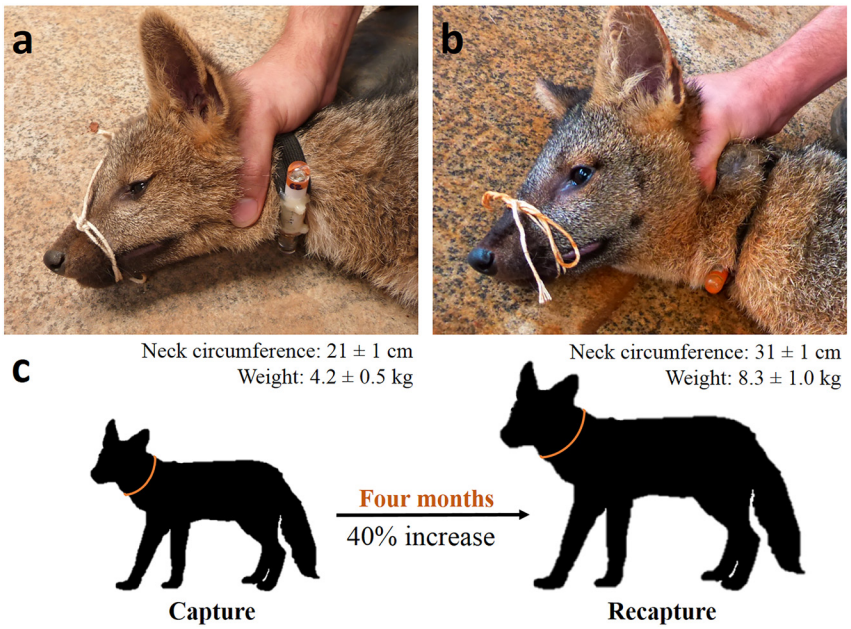

Figure 2: Summary of the results obtained with the collar proposed here and its subsequent test in youngs of crab-eating fox. (a) Young animal during the first capture and placement of the collar. (b) The same animal during the recapture (four months later), when it had reached the size of an adult. (c) Growth of the monitored animals, showing the percentage increase.

and neck circumference, respectively (Figure 2). We only observed bite marks on the transmitter' antenna. Considering that the animals' expandable collars could be easily removed, but they kept them, we assumed that the collars were not a problem for the animals. Thus, unlike most expandable collars described in the literature (e.g., Adams et al. 1995; Beale and Smith 1973; Goodrich and Miquelle 2013; Jackson et al. 1985; Kunkel and Mech 1994; Singer et al. 1997; Strathearn et al. 1984), our model exhibits several advantages. It is simple to manufacture (thus reducing costs), easily placed on the animals (with the only concern being the animal's mouth, as the collar must go over the snout to reach the neck), and efficient (given that, in four months, it was not removed and did not cause any injuries). It should also be noted that we fully described the material used and the steps necessary to construct the collars, which is uncommon in other studies (Broekhuizen et al. 1979; Kenward 2001).

Last, we recommend using this type of expandable collar to improve the tracking and monitoring of young terrestrial mammals. In the context of constant habitat change and fragmentation, the understanding of animal dispersal patterns is an increasingly important research topic (e.g., Holyoak et al. 2008; Nathan 2008). This procedure may help to answer questions on how urban expansion influences young dispersal patterns and the level of environmental management that can facilitate dispersal. Despite a relatively short tracking time and a narrow range of climatic conditions, we believe our model is promising. The replicability is improved due to the use of accessible and low-cost materials, which helps projects in movement ecology and other related topics (which may be crucial in developing countries). Because rare species are typically challenging to capture, the use of this method must be avoided until its safety is confirmed by a more significant number of animals tested. Therefore, we hope that our preliminary results will encourage further testing on our expandable collar, not only in canids but also in other species of terrestrial mammals.

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