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EVALUATION OF AN EXPANDABLE, BREAKAWAY RADIOCOLLAR FOR SUBADULT CERVIDS

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ABSTRACT - We designed and field tested an expandable, easy-to-build radiocollar for subadult male fallow deer (*Dama dama*). This collar is inexpensive (it only costs few euros), and breaks away due to the natural growth of the neck without causing injury. Elastic rubber bands (expandable section) are covered by a leather layer that protects it from premature breakaway. We evaluated the effectiveness of 37 expandable collars deployed on pricket (1-2 y.o.) fallow deer, by using the Kaplan-Meier survival analysis. Average duration of collars from their deployment to their natural drop off was almost 2 years (mean ±SE, 91.7 ± 6.4 weeks). This enabled us to monitor subadult fallow deer during maturation and to collect data on their spatial behaviour for the first time. Very little is known on the behavioural ecology and life history of subadult cervids. Accordingly, breakaway radiocollars are important research tools whose use should increase among field biologists.

Key words: Fallow deer, *Dama dama*, radiocollar, radiotracking

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To investigate and deeply understand the behavioural ecology and life-history of wildlife species, long-term studies on individually marked animals are essential (Jorgenson et al. 1993, 1997; Sarno et al. 1999; Bank et al. 2000). For ungulates, many long-term projects have dealt with behavioural ecology and population dynamics (Gaillard et al. 1997; Conradt 1999; Mysterud et al. 2002; Bonenfant et al. 2005; Mysterud et al. 2005; Ueno et al. 2010). When studying elusive or forest-dwelling ungulate species, researchers should use radiocollars, rather than simple ear-tags, to collect long-term data on individuals (White and Garrott 1990). In fact, radio-telemetry has enhanced the study of animals, even though materials, methodologies, and costs vary among species (Strathearn et al. 1984 and references therein). One issue that researchers have to contend with in relation to the use of radiocollars is the natural growth of the neck in deer. Accordingly, the radiocollar is supposed to accommodate not only the basic body growth, especially in the case of subadult individuals, but also the swelling of the neck of males during the rut. This is why expandable collars for subadults were introduced to allow monitoring as they grow (Hamilton 1962; Beale 1966). The evaluation of expandable radiocollars is ongoing (e.g. Keister et al. 1988; Hölzenbein 1992; Bon and Cugnasse1992; Smith

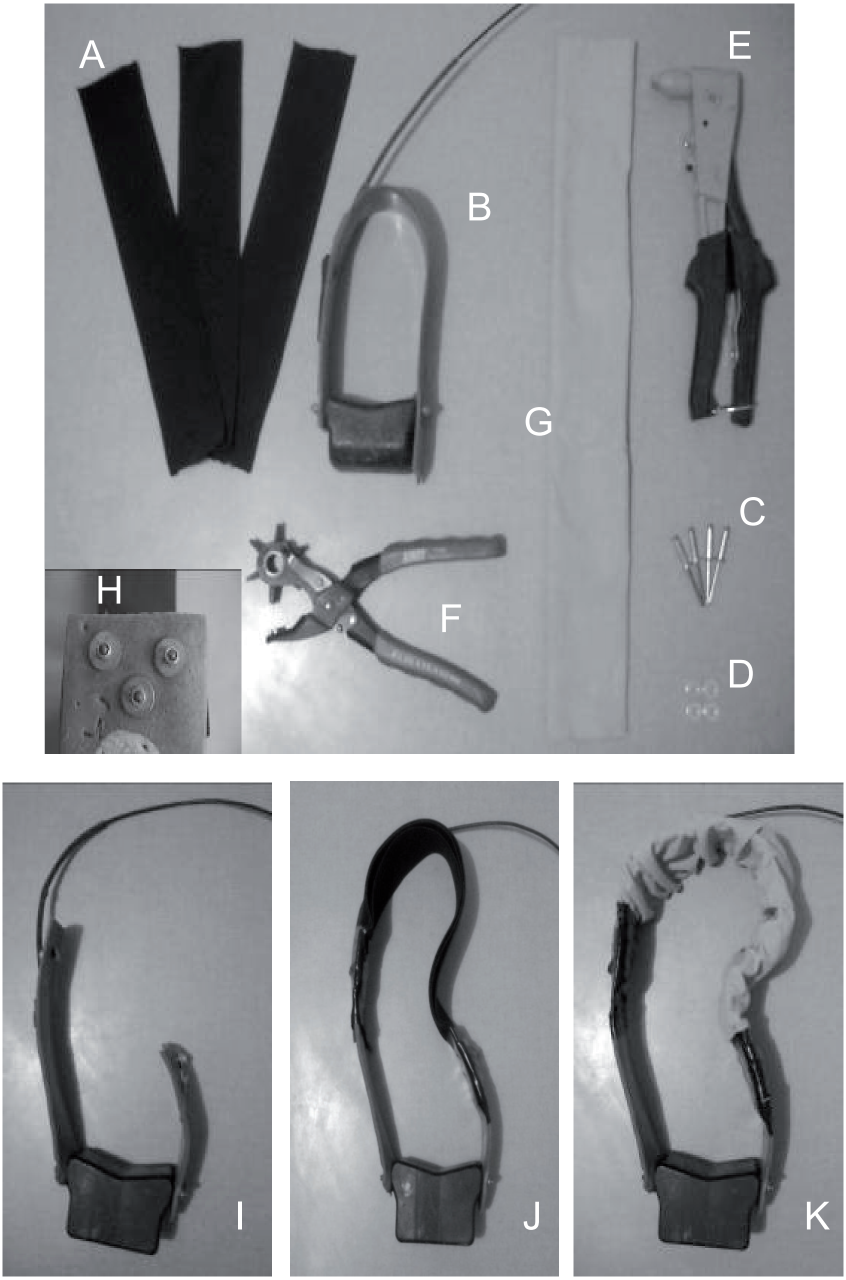

Figure 1 - Materials deployed to build expandable radiocollars for subadult cervids: A) Layers of elastic acrylic tissue. B) Televilt radiocollar TXV-10. C) Pop rivets. D) Spacing washers. E) Riveter. F) Punch pincers. G) Leather layer. *Assemblage stages*: H) Detail of riveted layers on collar. I) Cut collar. J) Collar with acrylic layers assembled. K) Final stage of the device with all parts assembled.

et al. 1998; Diefenbach et al. 2003) to avoid injuries to monitored individuals during long-term data collection. However, there is still lack of information about the reliability of expandable devices and their use is still limited to few studies. To date, no data on the spatial behaviour of subadult fallow deer have been published and generally such data are lacking for subadult individuals of many deer species. This is likely to be related to the high cost and low realiability of expandable devices. Our goal is therefore to increase the knowledge about this kind of device and possibly to increase its use among field biologists.

We designed and field tested a hand-made expandable radiocollar for subadult male fallow deer. We aimed to produce a device that could be effective, reliably lost by monitored individuals, inexpensive, and easy to make.

We cut TXV-10 Televilt collars (Lindesberg, Sweden) (*Fig. 1.B*) into 2 pieces, 11 cm and 16 cm long, respectively. The longer piece of collar (16 cm) was on the same side of the VHF antenna (*Fig. 1.I*) not to compromise the functionality of the radiocollar. We used three overlapping pieces of elastic acrylic tissue (1 mm thick, 30 cm long) (*Fig. 1.A*) on the inside to connect the two plastic pieces of the collar (*Fig. 1.H*) with three pop rivets (*Fig. 1.C*) per side (*Fig. 1.E*). A punch pincher (*Fig. 1.F*) enabled us to place and fix the pop rivets easily. Spacing washers (*Fig. 1.D*) were inserted between the pop rivets head and the collar plastic material to ensure the grip of rivets. The three layers of elastic acrylic tissue were covered by a layer of leather (*Fig. 1.G*) to protect the expandable tissue from wearing out, mainly because of vegetation, once that the collar was deployed in free-ranging animals (*Fig. 1.K*). These expandable devices were designed to gently accommodate the natural basic body growth as well as the swelling of the neck during the rut. The minimum circumference of the collar was a few centimeters larger than the average circumference of the neck (35 cm) of a fallow deer pricket (1-2 y.o.), while, by virtue of the expandable tissue, the maximum circumference corresponded to the average circumference of the neck of an adult male (65 cm). The device relied on the weak tensile strenght of the acrylic tissue. Indeed, such elastic tissue was supposed to accommodate the slow and constant growth of the neck, and should break when it reached its maximum length, with the consequent loss of the collar by the animal. Thanks to the presence of a protective leather layer, this device was designed to be resistant against abrasion by shrubs and trees, which typically occurs to animals in the densely vegetated Mediterranean environment. We tested this device in the field in order to assess for how long it was kept by subadult animals, and to ascertain the absence of injuries to sampled animals.

The study was conducted in the San Rossore Estate, Italy (see Ciuti et al. 2004 for characteristics of the study site). Between November 2004 and February 2008, we captured male fallow deer every winter (see Ciuti and Apollonio 2008 for details). We hand caught, blindfolded, ear tagged, fitted with expandable radiocollars, and released 37 prickets. Taking into account the natural growth of the neck of fallow deer males, especially during the rutting period (Chapman and Chapman 1997), expandable devices were fitted on each individual so that enough room (four fingers width) was left between the neck and the radiocollar transmitter, and injuries to animals during this process were avoided.

We performed statistical analyses using R 2.10.1 (R Development Core Team 2009). We used the "survival" R package to assess expandable radiocollar life length by means of the Kaplan-Meier survival analysis (Crawley 2007). We removed expandable collars and replaced them with new ones when we recaptured males (n = 13) between 1 and 3 years after the first capture.

Such replacements were regarded as censored events in the Kaplan-Meier survival analysis. Moreover, 4 individuals dispersed or ceased to transmit due to battery failure, while 6 died (n = 5 shot by game keepers during annual culling program; n = 1 predated by wolf). These animals were regarded as censored events in the survival analysis. Finally, we regarded the natural loss of collars by an individual as a breakaway event. Radiocollars were equipped with mortality sensors, which started up when a collar was motionless for 6 hours . A specific VHF pulse rate sent by the collar (mortality sensor activated) enabled us to recover the collar quickly and to assess the exact number of weeks occurred between the capture of the deer and the time of the natural loss of the device. The survival analysis was performed in the interval of time between the capture of the deer and the last breakaway or censored event (i.e. 132 weeks from deer capture).

One year after the deployment of expandable collars, the collar survival rate (i.e. collars still worn by subadult males) was 0.874 (95% C.I.: 0.76-0.99), and it decreased to 0.339 (95% C.I.: 0.085-0.59) at the end of the following year (*Fig. 2*). The quartiles analysis of the duration curve estimation showed that the 75%, 50%, and 25% likelihood for the 37 collars to be still on subadult males occurred on the 65th, the 101st, and the 115th week after release, respectively (Kaplan-Meier; quartile estimate $\pm$ SE: 1st quartile 65 $\pm$ 6.9 weeks, median 101 $\pm$ 7 weeks, 3rd quartile 115$\pm$8.4 weeks).

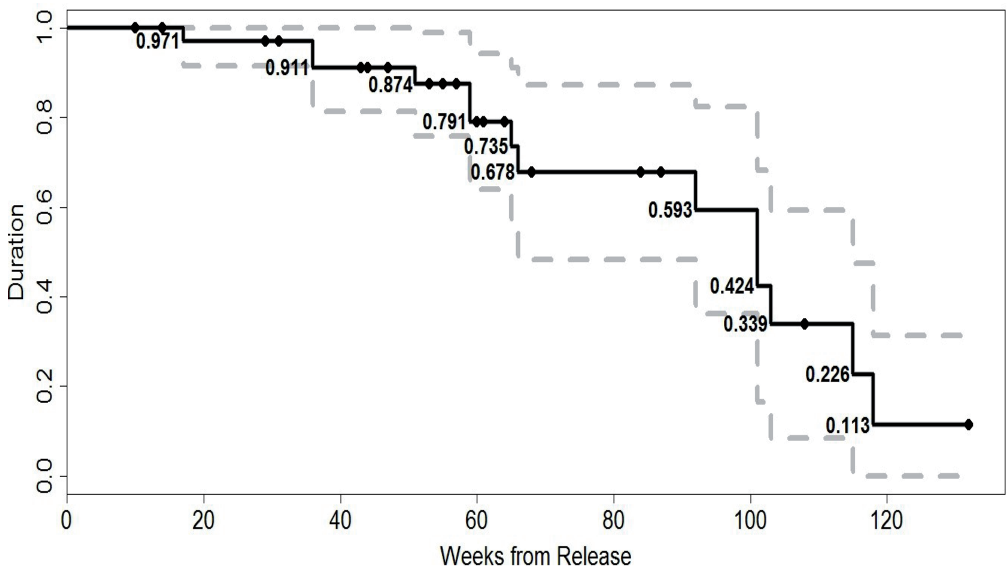

Figure 2 - Duration (from deployment to natural loss; bold line) of 37 expandable radiocollars deployed in fallow deer prickets (1-2 y.o.) in the San Rossore Estate. Dotted grey lines represent 95% confidence intervals, while black dots represent censored events (n = 23) in the Kaplan-Meier survival analysis. Time interval for the survival analysis ranged between the time of the capture of prickets and the time when we recorded the last breakaway or censored event (132nd week).

We also checked the neck condition of animals shot by gamekeepers or recaptured 1-3 years after their first capture. Upon all these occasions, animals were still wearing an expandable device and we never detected signs of neck injury, nor lack of fur, which is supposed to be the first side effect of collars to be reported as the neck increases in size.

Long-term studies are important to investigate population dynamics and life histories of ungulates (e.g. Lingle et al. 2008; Rodriguez-Hidalgo et al. 2010). However, long-term studies starting with the monitoring of young male cervids may be difficult. Our expandable, breakaway collar enabled us to monitor fallow deer males during the critical phase of social maturation (Chapman and Chapman 1997), and for the first time we were able to collect spatial data for this sex and age class (De Cena 2011). All animals that naturally lost the expandable radiocollar were eventually recaptured within few years (recognizable by numbered ear tags), so that we could keep on monitoring them, by deploying new radiocollars (De Cena 2011). In areas where the likelihood of recapturing individuals is higher (37% in our study case, De Cena 2011), the use of expandable radiocollars enables the collection of data almost throughout the life of an animal. Our expandable collars were not harmful to monitored deer, and no deer suffered from neck injuries caused by expandable collars. Most importantly, these expandable devices are inexpensive, easy to reproduce, and highly reliable, in that they can guarantee an average of 2 years of deer monitoring before their natural breakaway.

In conclusion, we discourage the use of radio ear-tags alone, on account of their short battery life, and we strongly recommend that researchers rather use time-delayed radio ear tags (e.g. active only 2 years after their deployment) in combination with expandable radiocollars. Such tags should allow the collection of data on subadult males in the time interval between the loss of expandable collars and the deployment of new collars. Time delayed ear-tags can also increase the probability of recapturing individuals. An increased use among field biologist of expandable devices for ungulates could enable us to fill the gap of knowledge on spatial behaviour, foraging strategies, and mating tactics of subadult cervids.

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