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The reliability of latex weak links on radio collars used to track eastern grey kangaroos (*Macropus giganteus*)

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ABSTRACT

Telemetry neck collars are commonly used to collect spatial data on free ranging animals. Two major challenges in application are entanglement prevention and retrieval of the collars after the study. Weak links made of a degradable material that breaks down while deployed on the animal are a potential solution to reduce entanglement and prevent the need to capture or sedate animals for retrieval. However, weak links can perform inconsistently depending on an animal's behaviour and environmental factors such as heat and humidity. A study of disease in eastern grey kangaroos (*Macropus giganteus*) in Victoria, Australia, provided an opportunity to test the performance of 35 radio collars fitted with a latex weak link between May and July 2022. At the conclusion of the study, 20 collars were manually removed from euthanised animals, and 15 detached in the field; all of these broke at the weak link. Of the 15 detached collars, 10 dropped from live animals due to degradation between 106 and 208 days (mean = 147 days) after deployment, four kangaroos were found dead and their collars were retrieved nearby and one dropped immediately after attachment. The performance of the device in this study demonstrates the utility of weak links as a cheap and simple remote detachment tool to prevent entanglement and achieve remote detachment of neck collars during animal tracking studies.

Keywords: latex, macropod, radio collar, spacer, telemetry, tracking, weak-link, welfare.

Introduction

Telemetry devices are deployed in a wide range of ecological and zoological studies to collect data on animal movement, distribution and survival (Brian and Michael 1987; Cawthen and Munks 2011; Cowan *et al.* 2020). A common technique to attach a high frequency (VHF) or global positioning system (GPS) device to an animal is by using a neck collar (Casper 2009). The use of a collar poses two challenges: prevention of entanglement of the collar during tracking, and retrieval of the collar at the conclusion of the study. The latter can be resolved by recapture; however, this poses welfare and safety hazards for both researchers and the animal, and is not always possible (Casper 2009; Buil *et al.* 2019), depending on the species and field conditions (Brian and Michael 1987).

The two current solutions to avoid recapture of collared animals are to either install a timed-release device (TRD) or a weak link onto the collar (Cawthen and Munks 2011). Timed-release devices have an internal timer that can be set by the researcher, and which will cause the collar to detach once a certain amount of time has elapsed. However, these devices are not always reliable, being prone to mechanical failures resulting in mistimed releases or failure to release (Matthews *et al.* 2013). Failure to release may have serious implications for animal welfare as the study animals are vulnerable to collar entanglement or snagging after the study period (Garshelis and McLaughlin 1998), and if the animal is young, they could also be at risk of choking as they outgrow the fixed collar (De Cena *et al.* 2011). Furthermore, despite recent developments in producing more affordable TRDs (Buil *et al.* 2019), they are still expensive and cannot be made easily by researchers due to their complexity (Rafiq *et al.* 2019).

Weak links, also known as spacers (Hellgren *et al.* 1988), breakaway devices (Garshelis and McLaughlin 1998), or degradable time-release devices (Thalmann 2013) offer an alternative option to the TRDs that is less technologically advanced but cheaper and less prone to failure to release. Weak links are often a piece of degradable material that is fitted onto the main collar strap to provide a 'weak' point. Weak links overcome the issues associated with TRDs in two ways. Firstly, the 'weak' point will result in collar detachment under increased strain, preventing snagging or entanglement both during and after the tracking period (Brian and Michael 1987; Hellgren *et al.* 1988). Secondly, weak links can achieve detachment of the collar after the study period without the need for recapture similar to TRDs but without the risk of mechanical failures of release as the material will inevitably degrade naturally (Brian and Michael 1987; Rafiq *et al.* 2019). Weak links are often made of commonly accessible materials such as cotton (Brian and Michael 1987; Hellgren *et al.* 1988), linen (Cawthen and Munks 2011), leather (Garshelis and McLaughlin 1998), latex (Cowan *et al.* 2020) or metals such as copper or magnesium (Thalmann 2013) and are usually simple in design. As a result, weak links can be cheap and easy for a non-expert to produce, which may provide an economical substitution for the TRD.

One of the biggest challenges in using a weak link is that the effectiveness of materials and designs is inconsistent within and between species and for different environments (Rayner *et al.* 2022). This is likely because the device's performance is influenced by both environmental and animal variables (Thalmann 2013). Environmental factors that influence performance can include temperature, humidity and UV exposure; animal factors include the size of the animal (which determines the strength required to break the weak link), social behaviours (such as frequent fighting) and habitat composition (e.g. dense bushland versus grassland). The duration of exposure to these factors influences the rate of degradation of the weak link material, hence it is difficult to predict when a weak link will break. This complexity makes it difficult to select a material and design for a given species and environment confidently (Rayner *et al.* 2022). Thus, field trials using weak links are critical to help guide researchers to select or design a device that is best suited for their study.

We tested a latex weak link for VHF neck collars for eastern grey kangaroos (*Macropus giganteus*) during a study on clinical progression of the disease chronic phalaris toxicity. A weak link with similar design and materials was successfully applied during tracking of western grey kangaroos (*M. fuliginosus*) (Cowan *et al.* 2020) in a previous study, with the author describing that all collars fitted with the weak link were released at the end of the study. However, the author did not discuss in detail how long the weak links remained functional or describe the mechanisms of release. The study presented here describes the design and performance of weak links in autumn and winter conditions in Victoria, Australia, to provide researchers with guidance on the use of weak links for similar species under similar conditions. Our objective was to investigate the duration that the weak link remained intact in the field, as well as its ability to achieve remote detachment following degradation in the field or during incidences of entanglement or high tension.

Materials and methods

Study site and environmental condition

The study was conducted at Plenty Gorge Parklands, Bundoora, Victoria, Australia (GPS coordinate: −37.631896, 145.104266). Eastern grey kangaroos at this location are prone to the disease chronic phalaris toxicity due to the extensive coverage of *Phalaris aquatica*, a plant that was historically used for sheep and cattle farming. This led to the current investigation of the disease and the subsequent design and deployment of the weak link VHF collars. The parkland consisted of a mixture of open grassland and grassy woodland.

From 1 May to 30 July 2022, 35 animals were captured and collared for this study; this included adults and subadults of both sexes. The time of commencement of the study coincided with the last month of autumn and the start of winter for Victoria, which has a temperate weather pattern. For the study year of 2022, the mean maximum temperature at this location ranged between 13.5°C and 16.7°C for May–August (winter), and between 17.2°C and 22°C for September–November (spring), and the mean rainfall ranged between 47.5 mm and 55.7 mm for May–August (winter) and between 58 and 66 mm for September–November (spring) (Australia Government Bureau of Meteorology 2023). This period is considered the wet season in Victoria; therefore, the weak links were expected to be functioning mostly in a cold and damp environment.

Weak link design and application

The weak links were designed to fit onto a Lotek® V6C 173C Very High Frequency (VHF) telemetry collar (Lotek, Havelock North, New Zealand). The collar weighed 130 g, and had a belt that was made of Haultain, which is a non-elastic synthetic material. The belt has a single row of 4 mm diameter fitting holes and originally came with two bolts fixed together, a washer and two self-locking nuts.

The body of the weak link was a 60 mm piece of natural latex tubing. The latex was 2 mm thick, so, when the tube was compressed together, it formed a 4 mm thick belt. The tube was then marked to indicate the spacing between two fitting holes on the belt, and 4 mm incisions were made parallel to the tube length at these locations using a craft knife in a stabbing motion (Fig. 1*a*). The incisions allowed the bolts to penetrate the tubing and a metal washer was then used to distribute the forces more evenly around the nuts. A heat shrink was then applied around the bolts and nuts to ensure

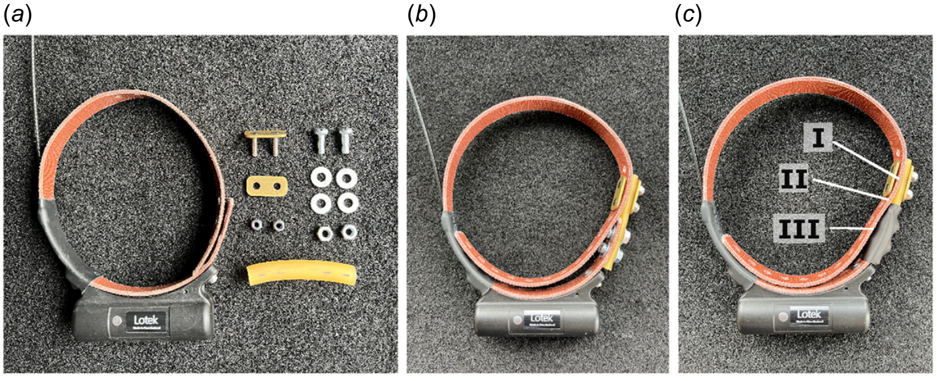

Fig. 1. Weak link design. (*a*) Before assembly, showing components of the weak link and the collar. (*b*) Assembled weak link collar. Note that the white washers were used on both sides of the belt to increase contact surface area with latex. (*c*) Assembled weak link collar with heat shrink applied to section III. Section I was not covered as this section was fitted together in the field with no access to power. Section II was not protected and was expected to be the area that degrades over time to achieve detachment.

tightness and to reduce sharp edges that may injure the animal or be caught on obstacles (Fig. 1). When the collar was fitted to the animal in the field, a pair of bolts and self-locking nuts (supplied with the collar) were used to secure the weak link. No heat shrink was used on this end of the collar as this was not practical in the field and the self-locking nuts did not produce any sharp edges.

Kangaroos were remotely sedated for the fitting process using a dart gun with a combination of xylazine (2 mg/kg, Randlab, Revesby, NSW, Australia) and tiletamine–zolazepam (1.25–2 mg/kg Zoletil, Virbac Australia, Milperra, NSW, Australia) as the sedative as described in Chen *et al.* (2024). The collar was placed at the base of the neck where it is the widest, with an additional 2 cm wide space left to prevent choking. After being collared, each animal was tracked twice per week on foot using a VHF receiver (TR-2 telonic receiver, Mesa, USA) to visually assess the condition of the collar until it was detached. Collars were retrieved when the animal was either found dead, euthanised due to animal welfare concerns resulting from significant progression of chronic phalaris toxicity, or if the collar was found detached. The collars were inspected upon retrieval for the point of breakage (e.g. at the weak link or at another point on the collar) and any damage sustained that may provide information of the reason for detachment (e.g. bite and chew marks suggestive of a predatory or scavenging cause). The duration of collar attachment was calculated from the date of fitting to the date the collar was last confirmed to be attached to the animal. The mean and the standard deviation of the duration of attachment was calculated using the data analysis program Jamovi v2.3 (The Jamovi Project 2024, Sydney, Australia, see https://www.jamovi.org/).

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Results

A total of 20 kangaroos fitted with weak link collars had these removed manually at necropsy after some animals had to be euthanised for welfare reasons from severe disease (confirmed as chronic phalaris toxicity during necropsy) ($n = 19$) and one animal drowned ($n = 1$) (Fig. 2). The duration of attachment for this group of collars ranged from 5 to 123 days, with a mean of 49.3 days (s.d. = 31.5 days).

The remaining 15 collars detached from the animal without human intervention and all broke at the weak link. Four kangaroos were found dead and their collars were retrieved nearby, with all four collars having punctures and tearing damage. The duration of collar attachment in this group ranged from 0 to 85 days, with a mean of 34 days (s.d. = 40.5 days). Eleven collars detached from animals without human intervention and were not damaged except at the weak link. All 11 animals on which these collars had been deployed were visually confirmed to be alive during subsequent monitoring. The duration of attachment for this group ranged from 0 to 208 days, with a mean of 133 days (s.d. = 55.2 days). One collar broke at the bolt and nut insertion point 2 h after being fitted onto the animal. Removing this outlier, the duration of attachment ranged from 106 to 208 days, with a mean of 147 days (s.d. = 34.8 days) with all 10 weak links breaking at the middle section not covered by the heat shrink or the washers.

Discussion

Our study demonstrated the functionality of latex weak links in a macropod field study under autumn and winter conditions in an inland temperate Australian environment. It provided evidence that when manufactured and installed correctly, for the 15 animals that were not euthanised

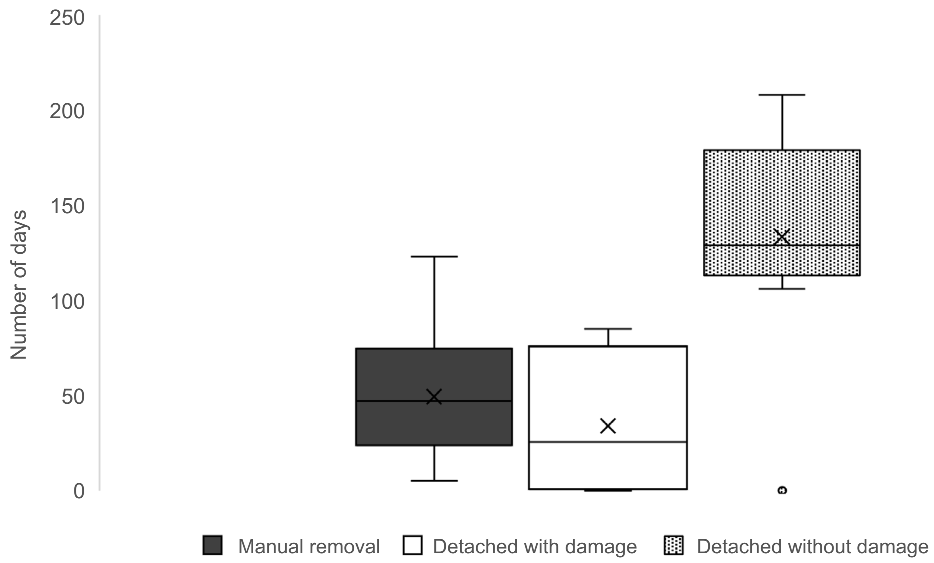

Fig. 2. Box and whisker plot of the duration (days) over which weak link collars remained attached to eastern grey kangaroos (*Macropus giganteus*) at Plenty Gorge Parklands, Victoria, Australia. Black ($n = 20$): collars that were manually removed during necropsy. White ($n = 4$): collars that detached without human intervention but had puncture and tearing damage. Grey ($n = 11$): collars that detached without human intervention and had no significant damage. Box: range between upper and lower quartile, line within box: median, x within box: mean, whisker: upper and lower extreme, dot: outlier single data point.

during the study, the weak link deployed was able to achieve 100% remote detachment of the collar, with an attachment duration of 3–7 months. This cheap and simple design may be suitable for studies that require the use of detachable tracking collars on medium to large mammals for up to 100 days in similar climatic conditions.

Each outcome category (manually removed, detached from dead animal, and detached from live animal) provided different insight into the weak link's functionality. For the collar that detached from live animals, 10 of the 11 functioned as intended, achieving remote detachment without human intervention. This finding agreed with Cowan *et al.* (2020), who reported that all latex weak link collars deployed on western grey kangaroos (*Macropus fuliginosus*) detached over a 12 month period.

The one collar that prematurely detached 2 h after deployment showed that even without degradation, the latex weak link used during the current study can still be broken without external intervention. We believe that poor installation may have contributed to the early weak link failure, with snagging on environmental objects being less likely as the collar was found in an open area. This premature detachment demonstrated the importance of proper installation and highlighted the vulnerability of such devices to human error.

Four of the 15 collars that detached without human intervention were retrieved from animals that were found dead, with the carcass showing signs of being scavenged. The collars all had puncture and tearing damage on the external surface that resembled bite marks and were broken at the weak link. It is highly probable that a predator or scavenger facilitated the removal of the collars. Similar to the premature detachment case, these results show that when the collars sustain high strain, the weak links are the points that break first in all cases.

Finally, despite being manually removed from euthanised animals, the weak links in the remaining 20 collars were all functional until the point of euthanasia, which supported the consistency in performance of the device for the duration they were deployed. In total, 34 of 35 collars in this study facilitated the collection of complete datasets on animals.

Environmental and animal factors are likely to affect the interpretation of results from our study. This study was conducted during a cool, wet winter, targeting animals living in a grassy woodland area with high abundance of vegetation that may provide protection from UV radiation. UV exposure, temperature and even certain environmental microorganisms can affect the rate of latex degradation (Varkey *et al.* 2000; Yousif and Haddad 2013; Karimi-Avargani *et al.* 2025); subsequently, the findings presented here may not apply to different environmental conditions. Furthermore, the animals tracked suffered from chronic phalaris toxicity, a neurological disease that may have influenced their behaviours such as mutual grooming, fighting or utilisation of the normal home range; this may have either increased or decreased the amount of strain applied to the weak link compared to healthy individuals. The variation of 102 days between successful weak link detachment times under the same environmental conditions highlights differences at the individual animal level, potentially based on factors such as behaviour and habitat use.

This study demonstrated that a weak link of the current design satisfied the role of a protective mechanism that prevented entrapment during deployment and recapture of the animal for collar retrieval with an expected life span of approximately 100–200 days in temperate conditions. Although the design and instalment of the weak link device is paramount to its success, it is also necessary to consider other parameters, such as weather conditions and target species affecting the success rate of deployment. Future studies applying this design in different species and conditions may provide further insight into its adaptability and performance in more variable situations.

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Data availability. The data that support this study will be shared upon reasonable request to the corresponding author.

Conflicts of interest. The authors declare that they have no conflicts of interest.

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