



Ornithological Methods

Dorsal anchoring: an alternative to the pectoral harness for the attachment of transmitters to raptors

Anclaje dorsal: una alternativa al arnés pectoral para la colocación de transmisores en rapaces

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ABSTRACT. Telemetry is a valuable tool for the study of bird behavior and ecology. However, traditional methods of transmitter attachment may cause physical discomfort, affecting the health and even the survival of the tagged birds. The present study describes a novel technique for the attachment of transmitters to free-ranging raptors, which adapts the “backpack” method. This approach was found to reduce the harmful impacts of traditional harnesses, such as skin lesions under the wings. A total of 31 raptors were tagged, including 23 Black Vultures (*Coragyps atratus*), four Harris’s Hawks (*Parabuteo unicinctus*), three White-Tailed Hawks (*Geranoaetus albicaudatus*), and one Great Black Hawk (*Urubitinga urubitinga*). The raptors were equipped with different telemetry devices: IoT Nortronic units for black vultures, and PinPoint Argos Lotek, Kite M Ecotone, and GoTel 3G Lotek transmitters for the remaining individuals. Across all species, the mean data transmission time was 86 days, with a total monitoring duration averaging 114 days, including post-recapture data. This technique should improve the monitoring of raptors and, potentially, other types of bird, by both ensuring the welfare of the animals and the accuracy of the ecological data collected using telemetry.

RESUMEN. La telemetría es una herramienta valiosa para el estudio del comportamiento y la ecología de las aves. Sin embargo, los métodos tradicionales de sujeción de transmisores pueden causar incomodidad física, afectando la salud e incluso la supervivencia de las aves marcadas. El presente estudio describe una técnica novedosa para la colocación de transmisores en rapaces en libertad, que adapta el método de “mochila”. Este enfoque demostró reducir los efectos perjudiciales de los arneses tradicionales, como las lesiones cutáneas bajo las alas. Se marcaron un total de 31 rapaces, incluyendo 23 *Coragyps atratus*, cuatro *Parabuteo unicinctus*, tres *Geranoaetus albicaudatus* y un *Urubitinga urubitinga*. Las rapaces fueron equipadas con distintos dispositivos de telemetría: unidades IoT Nortronic para *C. atratus*, y transmisores PinPoint Argos Lotek, Kite M Ecotone y GoTel 3G Lotek para los individuos restantes. En todas las especies, el tiempo medio de transmisión de datos fue de 86 días, con una duración total de monitoreo promedio de 114 días, incluyendo los datos posteriores a la recaptura. Esta técnica debería mejorar el monitoreo de rapaces y, potencialmente, de otros tipos de aves, garantizando tanto el bienestar de los animales como la precisión de los datos ecológicos obtenidos mediante telemetría.

Key Words: *Cetas; dorsal attachment; marking methods; telemetry; raptor*

INTRODUCTION

The study of birds in their natural environments is essential for the understanding of ecological processes and the effective conservation of biodiversity. Radio-telemetry is a valuable tool for the collection of different types of ecological data, in particular, in the case of large birds that are capable of flying rapidly over long distances. Telemetry can be especially useful for the analysis of home ranges and migration routes (Martell et al. 2001), habitat use (Bühler et al. 2023), and dispersal (Engler and Krone 2022).

One of the principal challenges to the use of telemetry is the adequate attachment of transmitters, to guarantee both the reliability of the data generated, and the wellbeing of the animal. The attachment of a device to any wild animal may have a series of adverse effects, ranging from behavioral alterations to physiological impacts and even death (Kenward 2001). Through meta-analysis Barron et al. (2010) found significantly higher energy expenditure and lower nesting effort in birds with

transmitters, while Bodey et al. (2018) found significant negative effects of tagging on survival, flying style, migration distance, reproduction, and parental care. Practical problems associated with the attachment of a device may also compromise the quality of the data obtained by the equipment (Longarini et al. 2023).

Several different approaches are used to attach transmitters to animals (Kenward 2001), with new options being developed as technology becomes more widespread. Backpack-type harnesses are typically used in studies of raptors (Anderson et al. 2020), although there is substantial evidence that this type of equipment causes irritation and physical discomfort, leading to an increase in preening (Booms et al. 2011, Stahlecker et al. 2015). Birds with backpacks also run the risk of getting their wings tangled in the harness, especially if it is too loose, but when a harness is too tight, it can affect the bird’s flight capacity and even cause lesions or chronic inflammation (Peniche et al. 2011). In the worst-case scenario, these problems may even threaten the life of the bird (Steenhof et al. 2006, Sunde et al. 2006).

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One other question here is the durability of the attachment. While it is essential that the device remains attached to the bird for the duration of the study period, it should, ideally, be detached once the study has ended or the transmitter has reached the end of its working life (Humphrey and Avery 2014). The double-harness backpack design, typically employed for raptors, hampers the release of the device if either one of the harnesses breaks or if the transmitter loses power (Longarini et al. 2023). Alternative techniques to harness, such as attaching devices to the dorsal and tail feathers using glue or adhesive tape, have been tested in other bird species, resulting in improved survival rates compared to birds fitted with harnesses (Fijn et al. 2024), and also allowing device removal without the need to recapture the individuals (Evens et al. 2018), however, given that the tag attachment is expected to be removed within a few days.

Given the dual objectives of minimizing the adverse effects of tagging and guaranteeing the timely release of the device, with a longer attachment duration expected, the present study describes a novel approach for the attachment of transmitters to raptors that is, in fact, an adaptation of the backpack method, using a combination of light harnesses and glue to attach the transmitter to the animal's feathers.

METHODS

The viability of this method was tested during a study of the rehabilitation and release of raptors at the Aracaju Centre for the Processing of Wild Animals (CETAS), in the Brazilian state of Sergipe. This centre is a unit of the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA). The study began in November 2022, with the testing of the attachment of non-rechargeable IoT transmitters, weighing 70 grams, to Black Vultures (*Coragyps atratus*; Bechstein 1793). A total of 23 individuals were tagged, with the IoT transmitters representing ca. 3.7% (3.0–4.1%) of the body mass of the specimens. Additionally, individuals of other raptor species - four Harris's Hawks (*Parabuteo unicinctus*, Temminck 1824), three White-Tailed Hawks (*Geranoaetus albicaudatus*, Vieillot 1816), and one Great Black Hawk (*Urubitinga urubitinga*, Gmelin 1788) - were equipped with different types of transmitters: PinPoint GPS Argos transmitters from Lotek (weighing 5 grams), the Kite M solar GSM/UHF tag from Ecotone (19 grams), and the GoTel 3G solar GSM/UHF tag from Lotek (17 grams).

Before the transmitters were attached to the birds, TESA brand 19 mm cloth insulating tape (type 51618) was fixed to the back of the devices. This tape was used to provide greater adherence for the glue, which prevented any adhesive from dripping under the feathers to reach the raptor's skin. Four 20 cm-long pieces of 1 mm-thick silk thread were then tied to the eyelets of the transmitter, leaving two threads of approximately 10 cm at each point, arranged in two pairs at the top and bottom of the transmitter (Fig. 1A).

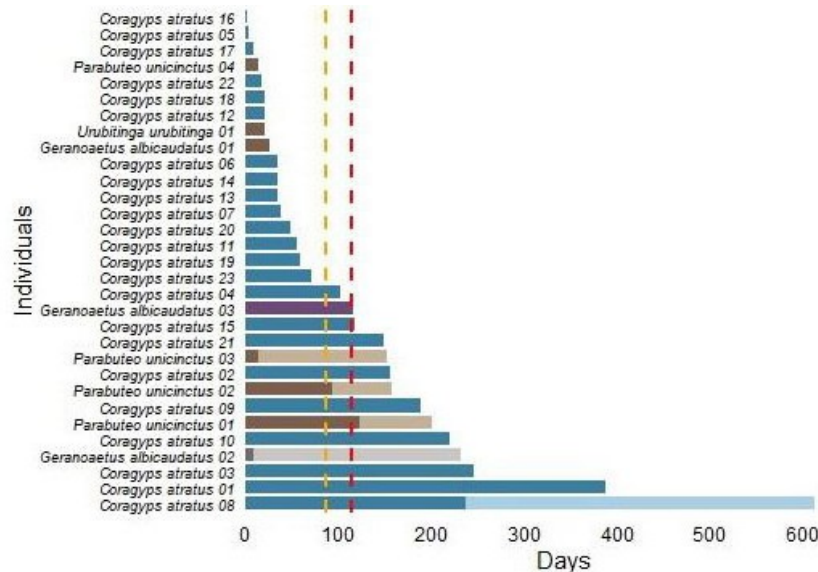
To attach the transmitter, the raptor was restrained manually by a single person, without using anaesthetic, and the transmitter was fixed to its feathers, by another person using ethyl cyanoacrylate glue (Fig. 1B) and manual pressure (Fig. 1C). The transmitters were installed in the area between the scapulae, and were aligned longitudinally along the body, with the antenna extending backward, toward the tail, and the silk laces being tied to fix the transmitter in place. The top laces were firmly tied to

Fig. 1. (A) A transmitter ready for attachment to Black Vulture, (*Coragyps atratus*), (B) application of the ethyl cyanoacrylate glue to the adhesive tape attached to the underside of the transmitter, (C) application of manual pressure to the transmitter to ensure the adhesion of the glue to the back feathers of the vulture (D) isolation of the tertiary cover feathers for the attachment of the top laces, (E) isolation of the tertiary feathers for the attachment of the lower laces, and (F) the transmitter in place prior to release.



the base of the cover feathers in the region of the scapula (Fig. 1D), and the lower laces, to the base of one or two of the tertiary feathers of the wings (Fig. 1E), which were closest to the body. Every effort was made to ensure that the plumage was arranged as naturally as possible, to ensure the fixation of the transmitter without causing the animal any discomfort. The tertiary feathers were chosen to fix the transmitters because these feathers protect the primaries and secondaries, either fully or partially, and are not considered to be flight feathers (Ferguson-Lees and Christie 2001).

Fig. 2. Time of data transmission (in days) for individual raptors equipped with different tracking devices. The bars represent the number of days each transmitter was active, separated into actual transmission period (darker color) and additional time of the transmitter fixed in the animal based on recapturing (shaded color), when applicable. Colors indicate transmitter models: IoT Nortronic (dark and light blue), PinPoint Argos Lotek (dark and light brown), Kite M Ecotone (dark and light gray), and GoTel 3G Lotek (dark and light purple). Dashed vertical lines represent the overall mean transmission time (86 days, orange) and the mean total duration including recapture-based extensions (114 days, red).



Ethylcyanoacrylate glue (TekBond from Saint-Gobain) was also applied to the knots used to tie the silk laces, to guarantee that they did not come loose during the movement of the raptor or through friction. Once the knots had been glued, the excess silk thread was trimmed off. Given these attachment procedures, this new marking method was denominated the “dorsal anchoring” technique.

Initially, the first six tagged individuals of *Coragyps atratus* were kept in a pre-release aviary for a period of five days, with the animals being monitored visually to ensure that there were no behavioral alterations or any other reaction to the harness. The other 25 birds were released as soon as the transmitter was in place, although the post-release behavior of all the raptors was monitored through a combination of visual monitoring, telemetry data and local reports. Transmission durations were systematically recorded, and raptors were recaptured, whenever possible, to evaluate transmitter attachment and the health status of the birds.

RESULTS AND DISCUSSION

The average duration of data transmission was 86 ± 91 days ($n = 31$), with the longest period reaching 387 days. A total of 11 transmitters remained active for more than 100 days (Fig. 2). The transmission duration was primarily limited by device functionality and, in the case of IoT devices, by the raptor's presence within the network coverage area. Five raptors were recovered after the transmitters had ceased functioning; in all cases, the devices remained securely attached (Fig. 2, shaded bars).

Non-systematic observations of raptors immediately after release showed no noticeable shifts in behavior or any specific reaction

to the transmitter. Except for some preening of the dorsal feathers and light pecking at the antenna, there was no damage to the birds or the transmitters. In a subsequent observational analysis of recaptured birds (also non-systematic), there was no evidence of physical damage to feathers or skin. This indicates that the birds do not exhibit an agonistic reaction to the transmitter and the marking method proposed.

All the marked raptors were observed flying and gliding in a natural manner, and the monitoring data indicate that some of these raptors traveled distances of well over 50 km. Reports from residents of towns neighboring the study area also confirm that the effects of the marking method on the movement of the raptors were negligible or non-existent. The tagged vultures were recorded in a few other municipalities in Sergipe of Brazil, including in the neighboring state of Bahia. In Sergipe, one vulture was recorded in Frei Paulo, approximately 60 km from the study area, five months and four days after being marked, while a second was registered in Nossa Senhora de Aparecida, around 70 km (in a straight line), three months and 10 days after marking. A third vulture was sighted in Estância after five months and 18 days, at approximately 30 km from the study area. In Bahia, one vulture was recorded in the municipality of Coronel João Sá, some 100 km in a straight line from the study area, four months after being marked.

In addition to the five birds recaptured after the end of the transmission period, two vultures were also recaptured during the active transmission phase (*Coragyps atratus 01* at eight months and *Coragyps atratus 03* at three months), allowing in situ verification of proper device attachment and individual condition. In neither case were any lesions or other damage found in association with the transmitters, and there is no evidence that

any deaths were caused by the attachment method. Opportunistic observations of these two vultures also indicated that these animals did not lose weight after being tagged, in fact, the body mass of the vulture recaptured after three months has increased by 100 g which further reinforces the general lack of any harmful effects that might otherwise have affected the behavior or physiology of the animals.

In comparison with the traditional backpack, which is attached by harnesses, the new type of attachment described here clearly eliminates any potential abrasions caused by the contact of the harnesses with the bird's skin. The new technique also reduces processing time, by simplifying the procedures, particularly the final adjustment of the attachments. As the device is attached to the bird's feathers, rather than to its body, the annual moult will guarantee the eventual detachment of the transmitter without the need to recapture the marked individuals. The maximum monitoring period recorded for the individuals monitored in the present study was 11 months, which was limited by the battery life, rather than the eventual detachment of the device. However, an observation was recorded of a vulture with the transmitter still partially attached, as well as the event of the device detaching and falling off one year and eight months after the attachment date. In this event there was no abnormal implications in the flight or behavior of the birds.

Overall, then, the dorsal anchoring technique satisfied the two primary objectives of the development of this new procedure, that is, (i) the avoidance of harmful impacts, and (ii) the natural detachment of the device. It is important to note that these premises, particularly the latter, apply primarily to short-term tagging studies with a shorter battery life, with a maximum expected monitoring period of one year. For longer-term studies (i.e., more than one year), however, the use of harnesses may be still necessary (Kenward 2001).

CONCLUSION

This new method guarantees not only the wellbeing of the raptors, but also the collection of reliable scientific data, as observed in the ongoing study during which this technique was developed. In fact, the study has already yielded a substantial dataset on the behavior and ecology of the focal raptor species. While the technique has proven particularly effective for monitoring vultures, it also holds significant promise for minimizing the adverse effects of transmitter deployment in other raptor species, especially those that depend on aerial hunting strategies, as well as the other monitored species. Given the successful application of this technique in the present study, it is hoped that it will be equally applicable to other birds species of different body size and activity patterns, especially through the continued research and development of the approach. The results of these trials should contribute conclusively to the advancement of the research in this field and the conservation of birds throughout the world.

Author Contributions:

ABG and JPMC conceptualized the study, collected and analyzed the data, and wrote the manuscript, with support from RB-M, JMREA, and SFF. All the authors have read and approved the final version of the manuscript and have agreed to be held accountable for all aspects of the work.

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Data Availability:

Data/code sharing is not applicable to this article because no data/code were analyzed in this study.

LITERATURE CITED

- Anderson, D., V. Arkumarev, K. Bildstein, A. Botha, C. Bowden, M. Davies, O. Duriez, N. A. Forbes, A. Godino, and R. Green. 2020. A practical guide to methods for attaching research devices to vultures and condors. *Vulture News* 78a:1-72.
- Barron, D. G., J. D. Brawn, and P. J. Weatherhead. 2010. Meta-analysis of transmitter effects on avian behaviour and ecology. *Methods in Ecology and Evolution* 1(2):180-187. <https://doi.org/10.1111/j.2041-210X.2010.00013.x>
- Bechstein, J. M. 1793. *Lathums all. Ubers. Vög.* 1 Anhanguera p. 655.
- Bodey, T. W., I. R. Cleasby, F. Bell, N. Parr, A. Schultz, S. C. Votier, and S. Bearhop. 2018. A phylogenetically controlled meta-analysis of biologging device effects on birds: deleterious effects and a call for more standardized reporting of study data. *Methods in Ecology and Evolution* 9(4):946-955. <https://doi.org/10.1111/2041-210X.12934>
- Booms, T. L., P. F. Schempf, and M. R. Fuller. 2011 - Preening behavior of adult gyrfalcons tagged with backpack transmitters. *Journal of Raptor Research* 45(3):264-267. <https://doi.org/10.3356/JRR-10-115.1>
- Bühler, R., K. Schalcher, R. Séchaud, S. Michler, N. Apolloni, A. Roulin, and B. Almasi. 2023. Influence of prey availability on habitat selection during the non-breeding period in a resident bird of prey. *Movement Ecology* 11(1):1-17. <https://doi.org/10.1186/s40462-023-00376-3>
- Engler, M., and O. Krone. 2022. Movement patterns of the White-tailed Sea Eagle (*Haliaeetus albicilla*): post-fledging behaviour, natal dispersal onset and the role of the natal environment. *Ibis* 164(1):188-201. <https://doi.org/10.1111/ibi.12967>
- Evens, R., N. Beenaerts, E. Ulenaers, N. Witters, and T. Artois. 2018. An effective, low-tech drop-off solution to facilitate the retrieval of data loggers in animal-tracking studies. *Ringing & Migration* 33(1):10-18. <https://doi.org/10.1080/03078698.2018.1521116>
- Ferguson-Lees, J., and D. A. Christie. 2001. *Raptors of the World*. Houghton Mifflin Company, New York, NY, USA.

Fijn, R. C., R. S. van Bemmelen, M. P. Collier, W. Courtens, E. E. van Loon, M. J. Poot, and J. Shamoun-Baranes. 2024. Evaluation of tag attachment techniques for plunge-diving terns. *Ibis* 166(3):1003-1022. <https://doi.org/10.1111/ibi.13306>

Gmelin, J. F. 1791. *Systema naturae: per Regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis* (Vol. 2, No. 2). Beer.

Humphrey, J. S., and M. L. Avery. 2014. Improved satellite transmitter harness attachment technique. *Journal of Raptor Research* 48(3):289-291. <https://doi.org/10.3356/JRR-13-26.1>

Kenward, R. E. 2001. *A Manual for Wildlife Radio Tagging*. Academic Press, London, UK.

Longarini, A., O. Duriez, E. Shepard, K. Safi, M. Wikelski, and M. Scacco. 2023. Effect of harness design for tag attachment on the flight performance of five soaring species. *Movement Ecology* 11(1):39-52. <https://doi.org/10.1186/s40462-023-00408-y>

Martell, M. S., C. J. Henny, P. E. Nye, and M. J. Solensky. 2001. Fall migration routes, timing, and wintering sites of North American Ospreys as determined by satellite telemetry. *The Condor* 103(4):715-724. <https://doi.org/10.1093/condor/103.4.715>

Peniche, G., R. Vaughan-Higgins, I. Carter, A. Pocknell, D. Simpson, and A. Sainsbury. 2011. Long-term health effects of harness-mounted radio transmitters in red kites (*Milvus milvus*) in England. *Veterinary Record* 169(12):311-317. <https://doi.org/10.1136/vr.d4600>

Stahlecker, D. W., T. H. Johnson, and R. K. Murphy. 2015. Preening behavior and survival of territorial adult golden eagles with backpack satellite transmitters. *Journal of Raptor Research* 49(3):316-319. <https://doi.org/10.3356/JRR-14-67.1>

Steenhof, K., K. K. Bates, M. R. Fuller, M. N. Kochert, J. O. McKinley, and P. M. Lukacs. 2006. Effects of radiomarking on Prairie Falcons: attachment failures provide insights about survival. *Wildlife Society Bulletin* 34(1):116-126. [https://doi.org/10.2193/0091-7648\(2006\)34\[116:EOPOPF\]2.0.CO;2](https://doi.org/10.2193/0091-7648(2006)34[116:EOPOPF]2.0.CO;2)

Sunde, P. 2006. Effects of backpack radio tags on tawny owls. *The Journal of Wildlife Management* 70(2):594-599. [https://doi.org/10.2193/0022-541X\(2006\)70\[594:EOBRTO\]2.0.CO;2](https://doi.org/10.2193/0022-541X(2006)70[594:EOBRTO]2.0.CO;2)

Temminck, C. J., and M. Laugier. 1824. *Nouveau recueil de planches coloriées d'oiseaux, pour servir de suite et de complément aux planches enluminées de Buffon*, Vol. 11. FG Levrault Libraire, Paris-Strasbourg, France.

Vieillot, L. J. P. 1816. *Nouveau Dictionnaire d'Histoire Naturelle, ou, Résumé et Procédé Général de tous les Phénomènes de la Nature, offerts à l'Inspection et à l'Étude; de leurs Causes et de leurs Effets; Enrichi de figures dessinées d'après Nature*. Tome 4:477. Deterville, Paris.