RESEARCH ARTICLE

A Comparison of Methods to Attach External Transmitters on the Imbricate Alligator Lizard, *Barisia imbricata* (Squamata: Anguidae)

Ailed Pérez-Pérez, Dulce Carolina Nápoles-Villanueva, Edgar de la Rosa-Silva, and Oswaldo Hernández-Gallegos, Laboratorio de Herpetología, Facultad de Ciencias, Universidad Autónoma del Estado de México, Instituto Literario #100 Centro, CP 50000, Toluca, Estado de México, México; *ailed.perez.perez@gmail.com*

The use of telemetry in studies under natural conditions provides important ecological information about the behavior of animals in their environment (Naef-Daenzer et al. 2005, White and Garrott 1990). The diverse morphology of lizards, as well as their habits and habitats, require adapting the methods of attaching external transmitters to the needs of each family or species. Thus, the principal limitation of radiotelemetry is the development of a reliable and safe fixation technique (Blomquist and Hunter 2007). Different methods to attach transmitters have been used on lizards with pronounced heads, pectoral or pelvic girdles (Riley et al. 2016) such as backpacks (*Amphibolurus muricatus*, Warner and Shine 2006, *Aspidoscelis* spp., Mundo Hernández et al. 2017), neck collars and glue (*Phrynosoma cornutum*, Miller et al. 2019), backpacks and glue (*Phrynosoma coronatum*, Richmond 1998), neck collars and backpacks (*Phrynosoma mcalli*, Fisher and Muth 1995), neck collars (*Phrynosoma orbiculare*, Martinez-Nova 2019), and pelvic girdles made from monofilament (*Cyclura* spp., Knapp and Owens 2005, *Aspidoscelis sexlineata*, Buffery et al. 2012). However, these methods are not suitable for use in Anguid lizards, as these lizards have a slender and elongated body, with small limbs that in some species are completely absent; they also lack a pronounced pectoral or pelvic girdle and possess smooth ventral scales (Canseco-Márquez and Gutiérrez-Mayén 2010). As a result, Anguid lizard morphology increases the difficulty of attaching external radio-transmitters, as they can easily slide off (Riley et al. 2016). This limits the use of telemetry for studies of mobility, home range, or habitat use in natural conditions. Only three telemetry studies have been performed in the family Anguidae, where different attachment methods have been used: glue on *Abronia campbelli* (Torres-Almazán 2012), monofilaments and glue on *Abronia graminea* (Clause 2018), and tape on *Gerrhonotus infernalis* (García-Bastida et al. 2012). We tested different external methods to attach transmitters on the Imbricate Alligator Lizard (*Barisia imbricata*).

The Imbricate Alligator Lizard is a viviparous lizard endemic to Mexico, listed as "Special Protection" (Pr) under the NOM-059-SEMARNAT-2010 (SEMARNAT 2010). We captured adult individuals of *B. imbricata* from Campus El Cerrillo, Piedras Blancas, Toluca, Estado de Mexico, México, with a weight above 20 g and Snout-Vent Length (SVL) greater than 112 mm. The lizards were captured by hand and transported to the Laboratorio de Herpetología (Facultad de Ciencias, Universidad Autónoma del Estado de México), so that a radiotransmitter (Telenax TXC-006G with battery life 80 or 170 days, weight 1.8 g) with an external whip antenna (13 cm), could be attached through three distinct methods. The lizards were kept in the laboratory for 24-48 hours for observation before being released, and then monitored 2-3 times per week using a receiver (Telenax RL-TLX) and yagi antenna.

Methods to Attach Transmitters

Collar + kinesiotape—Similarly to techniques used on *Phrynosoma mcalli* (Fisher and Muth 1995) and *Tiliqua rugosa* (Price-Rees and Shine 2011), we used a rectangle 1.5 cm × 3.5 cm of kinesiotape (cotton tape with acrylic glue) on which the transmitter was affixed with a 7-10 cm of pediatric feeding tube (with nylon thread placed inside; Fig. 1a). The tape was then folded in half to cover the transmitter and the feeding tube. The device was placed around the animal's neck, tied with a knot, and then a drop of superglue was applied. The transmitter was attached to the animal's body/back using kinesiotape (1 cm wide and 7 cm long; Fig. 1b, 1c).

Adhesive tape + kinesiotape—Based on the technique used by García-Bastida et al. (2012) as well as Madrid-Sotelo and García-Aguayo (2008), the transmitter was attached by adhesive tape to the back of the lizards. We looped the tape to the body, and then the transmitter was glued to the back using UHU® glue. A second loop with the tape was attached to further secure the transmitter (Fig. 1d, 1e). Due to the white color of the tape, a piece of camouflage-colored kinesiotape was placed on the back to avoid attracting the attention of predators (Fig. 1f).

***Sports Tape®* (*Ruban Hockey Tape*)**—We made a modification to the technique of adhesive tape + kinesiotape, using SportsTape® (gripply, tightly woven poly-cotton cloth, black in color; Fig. 1g). We looped the tape to the body, then placed the transmitter on the back. Afterwards, we applied tape again in a second loop, then added a drop of UHU® glue in between the transmitter and the tape to further secure the transmitter (Fig. 1h, 1i).

The use of telemetry in studies under natural conditions provides important ecological information about the behavior of animals in their environment (Naef-Daenzer et al. 2005, White and Garrott 1990). The diverse morphology of lizards, as well as their habits and habitats, require adapting the methods of attaching external transmitters to the needs of each family or species.

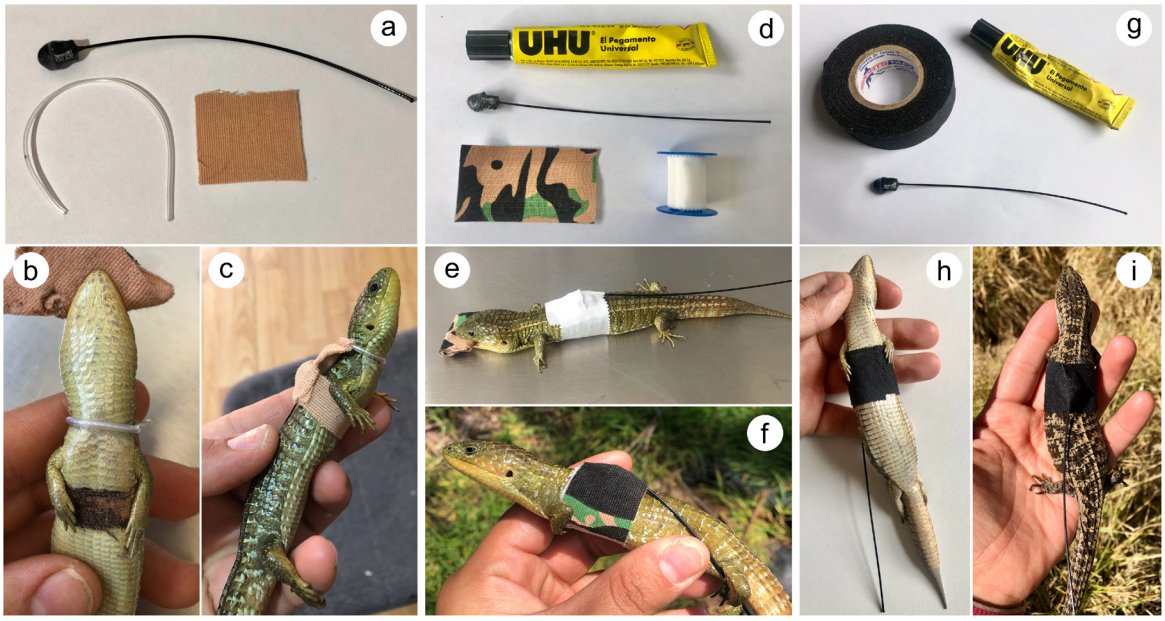

Fig. 1. Methods and materials used to attach transmitters in *Barisia imbricata*. **a)** Material used in collar + kinesiotape method, **b)** ventral view, and **c)** lateral view of collar + kinesiotape method; **d)** material used in adhesive tape + kinesiotape, **e)** lateral-dorsal view of adhesive tape with transmitter, **f)** camouflage-colored kinesiotape covering the adhesive tape, **g)** material used in Sports Tape® method, **h)** ventral view, and **i)** dorsal view using Sports Tape® (Photographs by Ailed Pérez-Pérez).

Results

Collar + kinesiotape—The average weight of the devices was 6.28% of the body weight (range 4.8-8.4% body weight). The mean time the transmitters remained attached was 6.3 days (range 4-8 days). Three lizards were equipped with this method. Once they were released in the field, two of the devices slipped off completely from the lizards, and we found only the transmitter (Fig. 2a). The other lizard was recaptured twice with the collar on its body (Fig. 2b). Each time, the device was readjusted and reattached, and the lizard released. Unfortunately, after we attempted to locate the lizard for the third time, only the transmitter was found.

Adhesive tape + kinesiotape—The average weight of these devices was 5.49% of the body weight (range 4.8-8.4% body weight). Seven lizards were equipped with this method. The mean time the transmitters remained attached was 11 days (range 1-41 days). Of the devices attached, two were found completely detached for the next search, one more was replaced before shedding, and in five of the lizards (twice for one), the tape was replaced because it became rolled up, causing some constriction in the abdomen (Fig. 2c).

***Sports Tape®* (*Ruban Hockey Tape*)**—With this method, the lizards had a mean body weight gain of 7.22% (range 4.3-9.3% body weight). The average duration of the devices was 25.1 days (range 3-106 days). Thirteen lizards were equipped with this method (we employed it a total of 25 times). During the period where we employed this method, five transmitters ran out of battery, so they were not located again; three lizards had their transmitters replaced, as they had only a few days of battery life left; the tape was replaced on 4 different occasions, in different lizards, because it started to wear out or the transmitter could slip out of the tape. The transmitters of two lizards were found in the field due to shedding, and the transmitters had detached (Fig. 2d). Subsequently, we checked the onset of shedding in equipped lizards. Due to this, the tape was removed in 6 individuals, which were then transported to the laboratory and, once the shedding was complete, the tape and transmitter were reattached, and the lizards were released again. Two lizards (a male and a gravid female) were found dead in the field. We could not determine the cause of death of the male, however, when the female was dissected in the laboratory, it was found that two follicles had burst, causing the demise of the lizard. One more gravid female was predated upon, so we only located the transmitter (Fig. 2e). There are scant reports on the death of animals equipped with transmitters during scientific spatial studies. In one study, the survivorship of translocated wild-caught Texas Horned Lizards was low (Miller et al. 2019), and although the number of animals is small, it is still important to make the report, as this variable should be considered in future studies, even if the causes of death are not directly related to the use of transmitters.

Discussion

Of the techniques tested for attaching transmitters, we consider that the most appropriate for *Barisia imbricata* and the one that may be the most feasible

Of the techniques tested for attaching transmitters, we consider that the most appropriate for *Barisia imbricata* and the one that may be the most feasible for other species of the Anguidae family is the use of Sports Tape®, since it was the one that remained adhered the longest and presented the least difficulties.

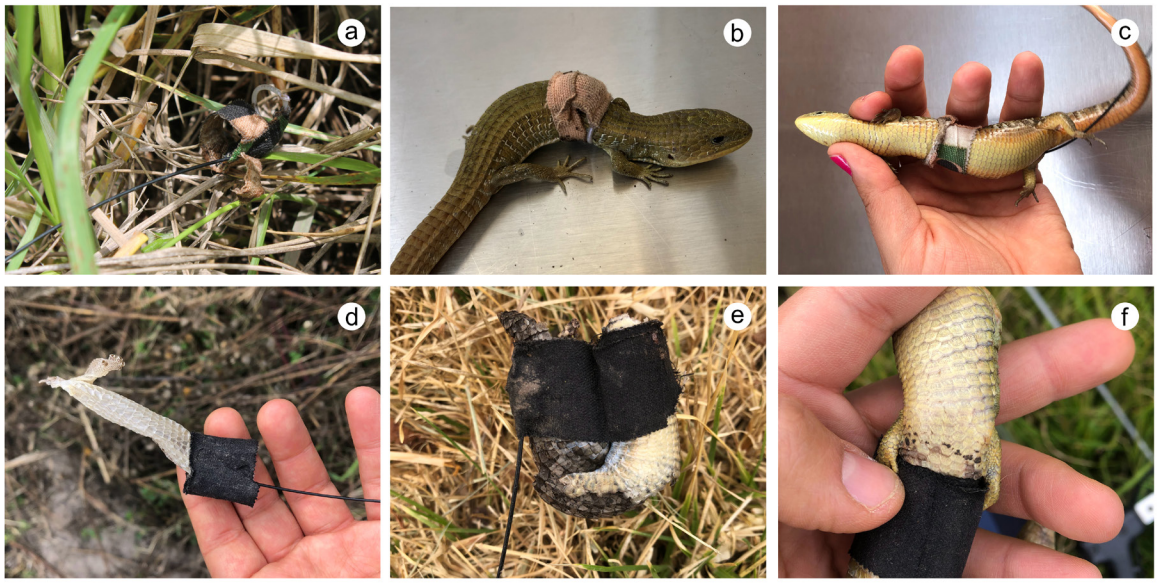

Fig. 2. Complications recorded with different transmitter attachment methods in *Barisia imbricata*. **a)** Detached transmitter found in the field, **b)** collar slipped on the abdomen, **c)** adhesive tape rolled up in the abdomen, **d)** transmitter detachment by shedding, **e)** lizard with transmitter depredated, and **f)** slight abrasions of the scales during the use on the Sports Tape® method (Photographs by Ailed Pérez-Pérez).

for other species of the Anguidae family is the use of Sports Tape®, since it was the one that remained adhered the longest and presented the least difficulties. As for the other procedures, due to the morphology of *Barisia imbricata,* the main difficulty with the collar + kinesiotape method was that the collar tube slipped into the body of the lizard, causing constriction in the abdomen.

The sampling period was carried out during a part of the rainy season, so the humidity of the environment and microhabitats contributed to the adhesive tape + kinesiotape method not remaining attached for very long, since the glue diluted. García-Bastida et al. (2012) mentioned that it can be a viable option in dry seasons, but in environments with high humidity or rain, it is not a suitable option since the risk of detachment of the devices is high. A great advantage of using Sports Tape® (Ruban Hockey Tape) is that the glue is more resistant to rain and humidity, and once the tape becomes wet and dries again, the glue does not lose adherence. This is important, as it allows for the tracking of animals without losing the transmitters due to detachment, even during the rainy season.

Due to the low weight of lizards, lightweight and short-lived transmitters must be used, so it is important to maximize sampling time (Refsnider et al. 2015) and avoid losses due to detachment; loss of devices due to shedding has been reported by Price-Rees and Shine (2011) and García-Bastida et al. (2012), so researchers must keep in mind that when using methods that stick directly to the skin, it is paramount to pay attention to the onset of shedding during sampling to minimize the loss of devices.

With the use of Sports Tape®, no issues were observed during lizard movement, though we detected slight scale abrasions in some individuals (Fig. 2f). Such minor damage, however, did not jeopardized the life of the lizards. In addition, it did not interfere with reproduction, as during the sampling, males with bites and gravid females were observed.

The average weight of the devices in the three methods used remained below that proposed by Knapp and Abarca (2009), which suggests not exceeding 7.5% of body weight in lizards. We also did not record any lizards trapped in the vegetation at any time during the sampling.

It is important to continue adapting transmitter attachment methods to the morphology and activity of the species under study. The use of telemetry in the Anguidae family involves a great challenge to keep the transmitters in place, so it is important to continue analyzing and discovering methods to use telemetry in these species, since the information obtained through telemetry can help us to improve conservation efforts in this family, via better understanding of their activity and habitat use, as little is known about these topics.

The average weight of the devices in the three methods used remained below that proposed by Knapp and Abarca (2009), which suggests not exceeding 7.5% of body weight in lizards. We also did not record any lizards trapped in the vegetation at any time during the sampling.

Acknowledgments—We thank Kenia Itzel Octaviano and Martin Rivera for their help in the field. We thank COMECyT for the financial support, and to the staff of the Facultad de Ciencias Agricolas de la Universidad Autónoma del Estado de México, especially Dr. Aaran Aquilino Morales Pérez.

Literature Cited

Blomquist, S.M., and M.L. Hunter. 2007. Externally attached radio-transmitters have limited effects on the antipredator behavior and vagility of *Rana pipiens* and *Rana sylvatica*. Journal of Herpetology 41:430-438.

Buffey, Jr. L.D., T. Yoder-Nowak, and E. Szuch. 2012. Radio-transmitter attachment method for a small burrowing lizard. Herpetological Review 43:572-574.

Canseco-Márquez, L. and G.M. Gutiérrez-Mayén. 2010. Anfibios y reptiles del Valle de Tehuacán-Cuicatlán. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) Fundación para la Reserva de la Biósfera Cuicatlán; Puebla. Benemérita Universidad Autónoma de Puebla, México.

Clause, A. 2018. Multi-national conservation of Alligator lizards: applied socioecological lessons from a flagship group. Ph.D. Thesis. University of Georgia, Athens, GA.

Fisher, M., and A. Muth. 1995. A backpack method for mounting radio transmitters to small lizards. Herpetological Review 26:139-140.

García-Bastida, M.C., A. Madrid-Sotelo, and D. Lazcano. 2012. Evaluation of a simple method of externally attaching radio-transmitters to the Texas Alligator Lizard, *Gerrhonotus infernalis*. Herpetological Review 43:410-412.

Knapp, C.R., and J.G. Abarca. 2009. Effects of radio transmitter burdening on locomotor ability and survival of iguana hatchlings. Herpetologica 65:363-372.

Knapp, C.R., and A.K. Owens. 2005. An effective new radio transmitter attachment technique for lizards. Herpetological Review 36:264-265.

Madrid-Sotelo, C.A., and A. García-Aguayo. 2008. A simple method for externally attaching radio-transmitters to snakes. North-Western Journal of Zoology 4:335-338.

Martinez-Nova, N.A. 2019. Uso de hábitat y ámbito hogareño de *Phrynosoma orbiculare* (Squamata: Phrynosomatidae). Bachelor´s Thesis. Universidad Autonoma del Estado de México. Toluca, México.

Miller, K.J., D.R. Erxleben, N.D. Rains, J.C. Martin, H.A. Mathewson, and J.M. Meik. 2019. Spatial use and survivorship of translocated wild-caught Texas horned lizards. The Journal of Wildlife Management 84:118-126.

Mundo-Hernandez, V., M. Martinez-Haro, M.A. Balderas-Plata, X. Antonio-Nemiga, and J. Manjarrez-Silva. 2017. Use of backpack radio-transmitters on lizards of the genus *Aspidocelis* (Squamata: Teiidae). Mesoamerican Herpetology 4:219-221.

Naef-Daenzer, B., D. Fruh, M. Stalder, P. Wetli, and E. Weise. 2005. Miniaturization (0.2 g) and evaluation of attachment techniques of telemetry transmitters. Journal of Experimental Biology 208:4063-4068.

Price-Rees, S.J., and R. Shine. 2011. A backpack method for attaching GPS transmitters to bluetongue lizards (*Tiliqua*: Scincidae). Herpetological Conservation and Biology 6:142-148.

Refsnider, J.M., S. Des Roches, and E.B. Rosenblum. 2015. Evidence for ecological release over a fine spatial scale in a lizard from the white sands formation. Oikos 124:1624-1631.

Richmond, J.Q. 1998. Backpacks for lizards: a method for attaching radio transmitters. Herpetological Review 29:220-221.

Riley, J.L., J.H. Baxter-Gilbert, and J.D. Litzgus. 2017. A comparison of three external transmitter attachment methods for snakes. Wildlife Society Bulletin 41:132-139.

SEMARNAT (Secretaría de Medio Ambiente y Recursos Naturales). 2010. Norma Oficial Mexicana NOM-059-SEMARNAT-2010, Protección ambiental-Especies nativas de México de flora y fauna silvestres - Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-Lista de especies en riesgo. Diario Oficial, jueves 30 de diciembre de 2010(Segunda Sección). *https://www.profepa.gob.mx/innovaportal/file/435/1/NOM_059_SEMARNAT_2010.pdf*

Torres-Almazán, E. 2012. Historia Natural y Estado de Conservación de la lagartija arboricola *Abronia campbelli* Brodie y Savage (Squamata: Anguidea) en Potrero Carrillo Jalapa. Bachelor's Thesis. Universidad del Valle de Guatemala, Guatemala.

Warner, D.A., J. Thomas, and R. Shine. 2006. A simple and reliable method for attaching radio-transmitters to lizards. Herpetological Conservation and Biology 1:129-131.

White, G.C., and R.A. Garrott. 1990. Analysis of Wildlife Radio-tracking Data. Academic Press, New York, NY. 383 pp.