

Leg-loop harness for passerine tag attachment

1. SCOPE AND FIELD OF APPLICATION

The 'leg-loop', or 'figure-8' harness, first described by Rappole and Tipton (1991), is an appropriate method of tag attachment for long distance migrants that will go through some body mass fluctuations over the course of the study. It can be used on a variety of small bird species, as long as they have long, external thighs (thus, this method is not appropriate for ducks, doves, swifts, and most shorebirds, for example). Specifics of harness design vary greatly with materials and tag design, but the basic premise is always the same. Leg-loop harnesses are ideal for studies requiring longer-term (over one month) retention that cannot always be reliably achieved with glue attachment techniques (Raim 1978; Johnson et al. 1991; Woolnough et al. 2004). Many studies have success with tags staying on for more than 1 year using this method, but it depends on the specifics of harness construction; shorter-term (up to 2 month) attachments are achieved with elastic sewing thread, and longer attachments achieved with jewelry cord (see Section 4). Longer-term attachments should be used for geolocators and GPS tags, which generally need to be retrieved by the researcher to access the data.

The "Streby harness" is modeled after the figure-8 leg-loop harness first described by Rappole and Tipton (1991), but with modifications to the harness material and preparation to minimize weight (Streby et al. 2015b). In particular, the Rappole and Tipton (1991) leg-loop harness can consist of ligature materials that are ~1 mm in diameter, whereas the Streby harness uses very thin (~0.5 mm) thread/cord and can attach to a marking device with no loops, tubes, or other manufacturer add-ons. Moreover, the Streby harness is meant to be tight enough to the bird's body to prevent movement of the harness and therefore abrasion. This harness can be used to attach radio transmitters, geolocators, or GPS tags, and has been used on adult passerines weighing as little as 9 g with no negative effects observed; however, effects may vary between species, so caution should be used when applying this method to a new species (Taff et al. 2018). This attachment method can be particularly useful for attaching stalkless geolocators to small birds, as the harness elevates the tag slightly, ensuring that the back feathers do not cover the light sensor (Peterson et al. 2015).

Tags with eyelets or tubes tend to be best for studies that require tags to stay on indefinitely, or used in studies where each harness may need to be fitted individually.

2. PURPOSE

To provide instruction for the preparation of leg-loop harnesses to attach tracking devices to birds and provide guidelines for deployment.

3. CONSIDERATIONS

Methods will differ if using 1) preconstructed or adjustable harnesses, and if using 2) the gluing or Streby method for harness preparation, or the tags to be used include eyelets or tubes.

3.a. Non-adjustable harness

Harnesses will need to be sized to the specific species that you are working with, as the methods described herein will make a harness that cannot be adjusted at the time of deployment. Some guidance is supplied in Rappole and Tipton (1991) and Naef-Daenzer (2007), but those resources should be used only as starting points, and determining appropriate sizing will require some initial testing. Multiple harness sizes should be prepared and available during tagging. A guide to some average sizes that have been successfully deployed is available on the Motus Wildlife Tracking System website (<https://motus.org/tag-harness-sizes/>). Please consider contributing any new information to this reference.

Application of tracking devices with a preconstructed leg-loop harness can be performed by one person, and can generally be completed in less than one minute, with minimal negative effects on birds post-release (Suedkamp Wells et al. 2003; Davis et al. 2008; Rae et al. 2009; Gow et al. 2011; Bell et al. 2017). Using harness attachments on nestlings has led to adults removing tagged individuals from the nest in some cases, so these methods are best applied to adults or fledglings and should only be used on nestlings with caution (Mattsson et al. 2006; Fisher et al. 2010).

3.b. Adjustable harness

Eyelet or tubed tags can be fit to a bird in the field. Applying adjustable harnesses on birds in the field should be performed with two people and can take longer to complete than pre-fitted harnesses (>5 minutes).

Migratory Bird Permits (CWS) are required, with specific permissions related to attaching tracking devices to birds. Additional permissions will be needed if the study species is a Species at Risk. We strongly recommend that the fitter practice deploying this type of harness before attempting it on a live bird.

4. MATERIALS AND EQUIPMENT

4.a. Non-adjustable harness

Glued harness:

- ~1mm elastic thread (e.g. sewing essential elastic thread; best for smaller birds, or those with high seasonal fluctuations in weight/fat loads) or varying thicknesses of plastic necklace cord "Stretch Magic". Elasticized thread has much more play and is easier to place on a bird than stretch magic. One may wish to use lighter or thicker thread depending on the species.
- Gel-style super glue (e.g. LePage Ultragel Super Glue)
- Scissors, razor or scalpel blade (to bevel the thread)
- Ruler
- Permanent marker
- Crochet hook or surgical probe

- Strip of paper or plastic (with width approximately equal to that of the tag) to deploy solar-powered tags or light-level geolocators over feathers
- Tags and activator

Harness for eyelet or tubed tags:

- All materials listed under *Glued harness*
- Silver crimp beads
- Needle-nose pliers with smooth edges
- Battery powered soldering iron (if soldering Stretch Magic)
- Eyelet or tubed tags

Streby harness:

- 0.5 mm elastic sewing thread (for retention up to 2 months), or 0.5 mm jewelry cord (e.g. Stretch Magic; for retention of at least a year), with inclusion of a weak link of rubber band or other soft material for a shorter deployment time.
- Gel-style super glue (e.g. LePage Ultragel Super Glue)
- Scissors
- Ruler
- Strip of paper or plastic (with width approximately equal to that of the tag) to deploy solar-powered tags or light-level geolocators over feathers
- Crochet hook
- Tags and activator

4.b. Adjustable harness

- All materials listed under *Harness for eyelet or tubed tags*

5. PROCEDURES

5.1 Preparation of harnesses

5.1.a. Non-adjustable harness

Glued harness:

- Determine the leg loop size for your species (see Section 3, above).
- Cut lengths of thread to specified measurements, making sure to add extra length to overlap thread with the tag.
- Mark thread with permanent marker where it will be glued to the tag (black sections in Fig 1a).

E.g. Blackpoll Warbler:

Black = 4mm (or width of transmitter)

Blue = 33-36 mm, depending on size

- Place a generous drop of glue in the centre of the tag on the side that doesn't show a tag label, and be sure to avoid the activation area or solar panel of certain tags. Gluing in the centre of the tag helps to keep the tag balanced and helps to avoid flipping or twisting.
- Let the glue set for 30-60s before applying the thread. This will help the harness threads to set more quickly.
- Place the centre of the thread into the drop of glue and allow to set. Before the glue dries, wrap the loose ends of the threads above and below the glued centre thread, and glue to the tag (Fig 1a). Gluing the loose ends towards the distal ends of the tag helps keep the antenna straight on the bird and minimizes twisting (Fig 1b).
- When the thread is in place on the tag, put a small drop of glue on top of the glued sections of thread and spread it around to cover the ends for added security.
- When the glue is dry, measure harness again to make sure it did not get malformed during gluing – this is most easily done by stretching the harness (until the slack is gone, but not beyond taut) between two pencils along a ruler (Fig 2).

Harness for eyelet or tubed tags:

- Determine the leg loop size for your species. Depending on how the loops or eyelets are positioned, you may or may not need to take the tag width into consideration. You'll want to leave up to 5mm to overlap the threads to apply a crimp.
- Cut thread at an angle so that it will easily slip into the crimps.
- Run the thread through the anterior eyelets or loop. Guide one of the ends of the thread through a crimp bead, then through the posterior eyelets or tube. Guide the other end of the thread through the same posterior eyelets or tube and the crimp bead.
- Squeeze crimp bead into place with needle-nose pliers. It is best to place the crimp within a tube, or in a place where it won't rest on the back of the bird.
- Care should be taken to ensure that the tag does not shift to one side; this can be done by applying a small drop of glue to each eyelet/tube to hold the harness in place.
- Some studies using Stretch Magic have successfully 'welded', or melted the loose ends of the thread together using a battery powered soldering iron, but this can be finicky.

Streby harness:

- Determine the leg loop size for your species (see Section 3, above)
- Cut >10cm of elastic thread (more for larger birds), and make a loop from ~1/3 of the segment (Fig 4).
- Wrap the long end of the elastic around the loop (Fig 5a), and pull the long end through, as if you were tying a shoe, to end with two loops (Fig 5b). Leave the knot somewhat loose until you have adjusted the loops to approximately the correct length for your species. Trying to adjust the loops after the knot is tight can result in the loops twisting, which will cause issues when fitting the bird (Fig 5c).
- Adjust the loops to approximately the right size (within 1-2 mm), and tighten the knot. Check sizing by placing the end of one loop around the end of a thin ruler and measuring the length of each loop (from end to knot) when the loop is pulled taught, but not stretched (Fig 6). Remove the harness from the ruler and adjust and re-measure each loop as necessary.
- Place a bead of glue on the midline (between the battery and the transmitter) of the bottom of the transmitter (side that goes against the bird) (Fig 7). The harness must be attached in the middle of the transmitter, to prevent the transmitter from flipping over once deployed.
- Place the knot on the dab of glue with the loops perpendicular to the transmitter, and let the glue dry (Fig 8). If the loops are at any other angle, the antenna will angle off-center, which might affect the bird.
- Flip the transmitter over. Place another bead of glue on the top of the transmitter, and wrap the loose ends of the harness around the transmitter and across the bead of glue (Fig 9a-b). Once the glue is dry, cut the loose ends of the harness (Fig 9c). **Note:** if your transmitter label will be covered at this step, make sure the tag is otherwise labeled so the proper tag details can be recorded at deployment.

5.1.b. Adjustable harness

- Determine the approximate leg loop size for your species.
- Cut thread at an angle (so that it will easily slip into the crimps), leaving a length that leaves an extra 10-20 cm on either end.
- Insert the elastic thread in the anterior tube or eyelets of the transmitter.
- Add a crimp along both ends of the thread.
- Pass one end of the thread through the posterior tube of the transmitter.
- Insert the second end of the thread through the posterior tube of the transmitter.
- Pass each end of the thread through the crimps.

- Make a knot at the ends of the thread to prevent the crimps from sliding off when deploying the transmitter on the bird while in the field (Fig 10).

5.2 Tag deployment

Attachment methods differ if the harness is not preconstructed, and must be fit to individuals in the field.

5.2.a. Non-adjustable harness

- Activate tag and record tag number alongside your other banding data
- Harnesses with more stretch:
 - With the bird in the bander's grip, bring the first leg loop over the foot and over/around the thigh to rest the transmitter on the lower back. The antenna should be hanging off the bird's rump, the tag label should be facing up, and the elastic threads should be on the bottom, resting on the bird (Fig 11a-3d).
 - While gently holding the tag in place, bend the free leg and slip the second leg-loop from back to front over the bird's foot then up past its knee (Fig 11e). The leg loop should now be loosely around the second leg.
 - While still holding the tag in place to keep the first leg loop secure, slide the second leg loop up and over the thigh (straightening the leg a bit often helps), keeping the tag centered on the back (Fig 11f). A crochet hook can help with this step, and with removing a tag if necessary.
- Harnesses with less stretch (a video of this method is available online, see Appendix 2)
 - With the bird in the bander's grip, bring the first leg loop over the foot to the tibiotarsal joint (but not above the knee). If deploying a solar-powered tag or light-level geolocator that should sit on top of the back feathers, place a long, thin strip of paper or plastic on the bird's back (i.e. from the neck to the tail, covering the synsacrum), and gently pull the tag across the bird's back to place the tag over the feather barrier.
 - Gently pass the second loop over the tibiotarsal joint then over the foot and toes. The first leg should be free to move during this step, and will have enough natural flexibility to allow the second loop to be placed.
 - Slide both leg loops up over the knees so they rest between the thighs and the body (Fig 12).
 - If using a feather barrier, pull this out from under the tag towards the tail. If some feathers are still sitting over the tag (so may obscure the light sensor or solar panel), run the feather barrier under the tag again, from front to back, which should place the remaining feathers under the tag.

- Ensure that both leg loops are properly placed; it is critical that the leg loops are over the thighs to ensure the tag won't slide off. Proper placement can be checked by blowing feathers out of the way around each thigh.
- With the exception of solar-powered tags or light-level geolocators, adjust the feathers so that none are stuck beneath the harness or tag. The bird will preen it themselves, but you want to make sure that the feathers maintain their function as best as possible.
- Tags should be snug to the body, but not tight. The harness should be tight enough that they do not stretch beyond 1-2mm of play. You should not be able to pull the tag back down and over the bird's rump, or flip the tag over easily without it flipping back into place on its own.

5.2.b. Adjustable harness

- **Holder:** hold the bird in the bander's grip, facing away from the fitter.
- **Fitter:** lace the loop without the crimp bead over the bird's foot and over/around the thigh.
- **Fitter:** place the tag in position on the bird's back.
- **Fitter:** place the loop with the crimp bead over the bird's other leg.
- **Fitter:** pull both ends of stretch magic through the crimp bead to tighten the harness. Ensure the loops are over and around the bird's thighs so they rest between the thighs and body and will not slip down the legs or restrict the bird's normal movement.
- **Holder:** once the fitter feels they have the correct tension for the harness, hold the stretch magic tails in place with the same hand you are using to hold the bird so the tension does not slip.
- **Fitter:** ensure the loops are correctly positioned around the hips.
- **Fitter:** check the tension by lifting the bottom of the tag (where the antenna joins the tag body). If you cannot move it at all, it might be too tight and restrict movement or blood flow. If you can flip the tag, it is too loose. The elastic capacities of the thread will accommodate the various weights of the bird according to the season.
- **Fitter:** pull the feathers from under the thread before making the final adjustment.
- **Holder:** make sure the bird's legs can move freely.
- **Fitter:** once the tension is appropriate, ensure the crimp bead is directly next to the tag and crimp the bead once, then rotate your pliers a quarter turn and crimp again. The crimp should look flattened. Pull the thread to check that the attachment is secure and strong.
- **Fitter:** cut the stretch magic tails off with scissors.

- **Fitter:** slide the crimp bead into the tag tube if possible to prevent abrasion.
- **Fitter:** you can place a tiny dab of glue on each tube/eyelet to keep the tag centered on the back of the bird and prevent it sliding to the side.

5.3 Ensure proper fit, and release bird

- Check that the feet are able to perch on your fingers, and that the wings are free.
- When holding the bird in the photographer's grip the tag should sit high on the bird's back in line with their spine, free of feathers (if solar-powered, or has a light sensor), with the antenna falling straight down the bird's tail (Fig 13, Fig 14). The bird will tend to preen them into place and cover them with feathers over time.
- Tug lightly on the tag to check movement: if you can easily slide the tag forward and backward, or side to side, without stretching the harness, it is probably too loose. If the harness pulls one or both of the bird's legs out from under the body, it is too tight.
- Release the bird very low to the ground, in case it refuses to fly. On occasion, passerines may initially refuse to fly, but will resume normal behaviour after some time passes. The newfound pressure on their back will sometimes cause the birds to resist flying. If the tag is too tight, they'll feel more pressure on their back.
- Watch the bird to ensure it acclimates to its tag after release; the bird can be left once it appears to have returned to normal behaviour.
- If the bird refuses to fly within a minute or two, the tag should be removed by carefully cutting the leg loops. One person should hold the bird, while another pulls gently on the tag to create a gap where the scissors can be safely maneuvered to cut the harness near the tag. The bird can then be released as described above.

6. CATEGORY OF INVASIVENESS

- C – Minor stress or pain of short duration (e.g. capture using methods with little or no potential to cause injury and marking of animals for immediate release; short periods of restraint beyond that for simple observation or examination, but consistent with minimal distress). Category selected based on the *Categories of invasiveness in animal experiments* outlined by Canadian Council on Animal Care (CACC 1991).

7. REFERENCES (INCLUDING POLICIES)

BELL, S.C., M.E. HAROUCHI, C.M. HEWSON and M.D. BURGESS. 2017. No short- or long-term effects of geolocator attachment detected in Pied Flycatchers *Ficedula hypoleuca*. *Ibis* 159: 734–743.

- DAVIS, A.K., N.E. DIGGS, R.J. COOPER and P.P. MARRA. 2008. Hematological stress indices reveal no effect of radio-transmitters on wintering Hermit Thrushes. *Journal of Field Ornithology* 79: 293–297.
- FISHER, R.J., K.M. DOHMS and S.K. DAVIS. 2010. Removal of nestling radio-transmitters by adult Sprague's Pipit (*Anthus spragueii*). *Journal of Ornithology* 151: 749–753.
- GOW, E.A., T.W. DONE and B.J.M. STUTCHBURY. 2011. Radio-tags have no behavioral or physiological effects on a migratory songbird during breeding and molt. *Journal of Field Ornithology* 82: 193–201.
- JOHNSON, G., J. PEBWORTH and H. KRUEGER. 1991. Retention of transmitters attached to passerines using a glue-on technique. *Journal of Field Ornithology* 62: 486–491.
- MATTSSON, B.J., J.M. MEYERS and R.J. COOPER. 2006. Detrimental impacts of radiotransmitters on juvenile Louisiana Waterthrushes. *Journal of Field Ornithology* 77: 173–177.
- NAEF-DAENZER, B. 2007. An allometric function to fit leg-loop harnesses to terrestrial birds. *Journal of Avian Biology* 38: 404–407.
- PETERSON, S.M., H.M. STREBY, G.R. KRAMER, J.A. LEHMAN, D.A. BUEHLER and D.E. ANDERSEN. 2015. Geolocators on Golden-winged Warblers do not affect migratory ecology. *The Condor* 117: 256–262.
- RAE, L.F., G.W. MITCHELL, R.A. MAUCK, C.G. GUGLIELMO and D.R. NORRIS. 2009. Radio transmitters do not affect the body condition of Savannah Sparrows during the fall premigratory period. *Journal of Field Ornithology* 80: 419–426.
- RAIM, A. 1978. A radio transmitter attachment for small passerine birds. *Bird-Banding* 49: 326–332.
- RAPPOLE, J.H. and A.R. TIPTON. 1991. New harness design for attachment of radio transmitters to small passerines. *Journal of Field Ornithology* 62: 335–337.
- STREBY, H., T.L. MCALLISTER, S.M. PETERSON, G.R. KRAMER, J.A. LEHMAN and D.E. ANDERSEN [online]. 2015a. Figure-eight harness design and transmitter attachment. University of Minnesota Digital Conservancy. <<http://hdl.handle.net/11299/183647>> (4 February 2019).
- STREBY, H.M., T.L. MCALLISTER, S.M. PETERSON, G.R. KRAMER, J.A. LEHMAN and D.E. ANDERSEN. 2015b. Minimizing marker mass and handling time when attaching radio-transmitters and geolocators to small songbirds. *The Condor* 117: 249–255.
- SUEDKAMP WELLS, K.M., B.E. WASHBURN, J.J. MILLSPAUGH, M.R. RYAN and M.W. HUBBARD. 2003. Effects of radio-transmitters on fecal glucocorticoid levels in captive Dickcissels. *The Condor* 105: 805–811.

TAFF, C.C., C.R. FREEMAN-GALLANT, H.M. STREBY and G.R. KRAMER. 2018. Geolocator deployment reduces return rate, alters selection, and impacts demography in a small songbird. PLOS ONE 13: e0207783.

WOOLNOUGH, A., W. KIRKPATRICK, T. LOWE and K. ROSE. 2004. Comparison of three techniques for the attachment of radio transmitters to European Starlings. Journal of Field Ornithology 75: 330–336.

8. DOCUMENTATION (E.G. ANY FORM ASSOCIATED WITH THIS SOP)

9. REVISION HISTORY

10. APPENDICES

Appendix 1. Figures

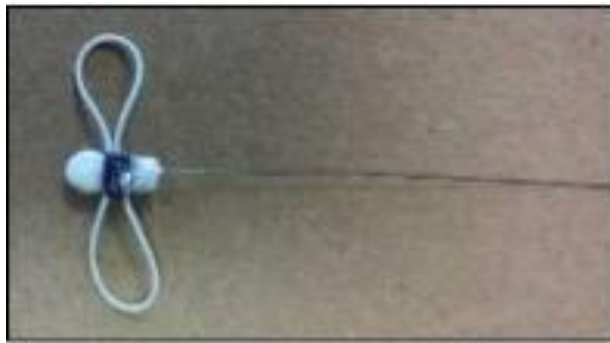


Figure 1a. Harness glued to underside (non-label side) of a radio tag

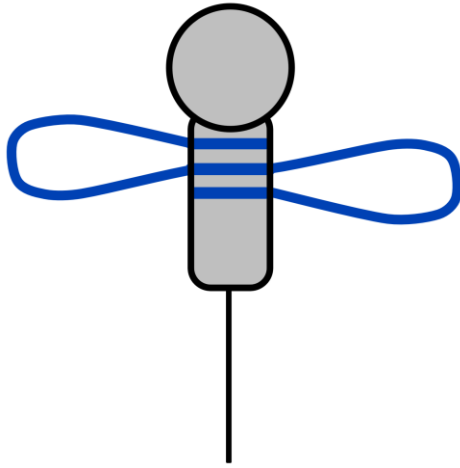


Figure 1b. Diagram of harness arrangement, with center of harness (blue) glued closest to battery, and ends glued subsequently towards distal ends of tag. Lengths not to scale.



Figure 2. Measuring finished harness by holding loops taut (but not stretched) along a ruler, to ensure leg loops are the proper size.

Figure 3.

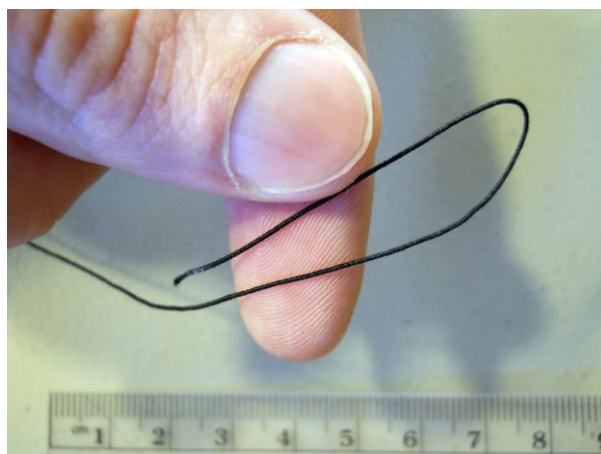


Figure 4. The first loop is made using approximately 1/3 of the harness material.

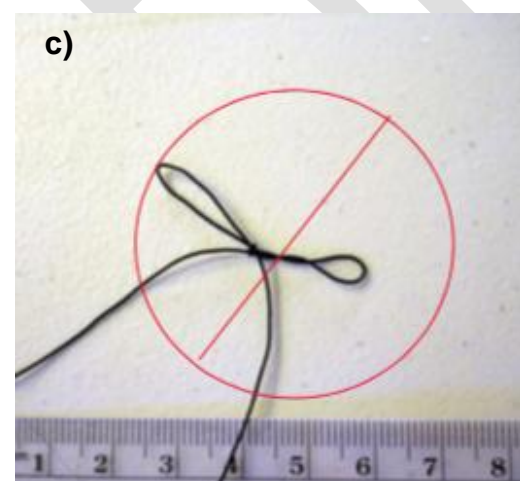
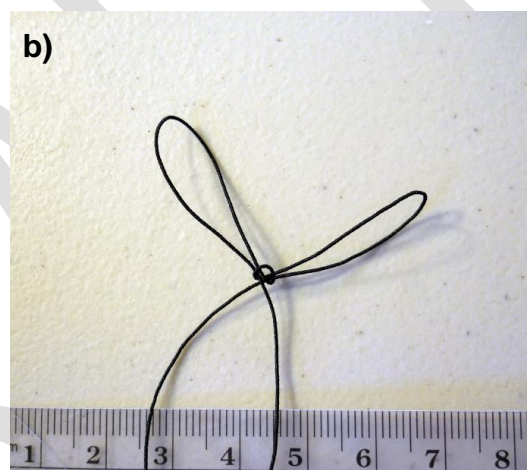
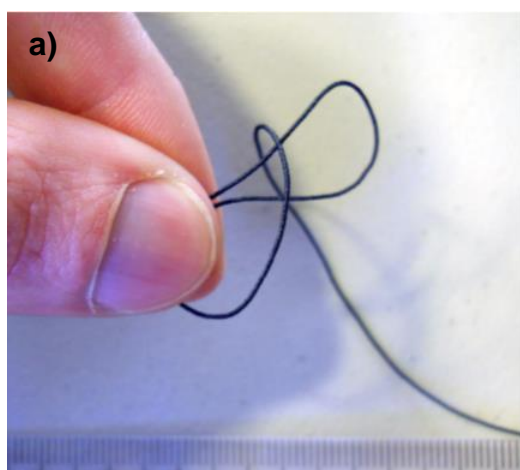


Figure 5. The long end is wrapped around the existing loop (a), then pulled through, as if tying a shoe, to make two loops (b). Adjust loop length with a loose knot; attempting to adjust the length with a tighter knot may result in twisted loops that can cause problems at deployment (c).



Figure 6. Measuring the length of each leg loop by pulling taut (but not stretching) on a ruler.



Figure 7. Placement of glue at the midline of the underside of the transmitter.



Figure 8. Harness placed on the bead of glue, with loops perpendicular to the transmitter





Figure 9. With transmitter flipped over, placement of another bead of glue on top of the transmitter (a), and free ends of harness wrapped over the glue (b), and ends cut (c).



Figure 10. Adjustable leg-loop harness

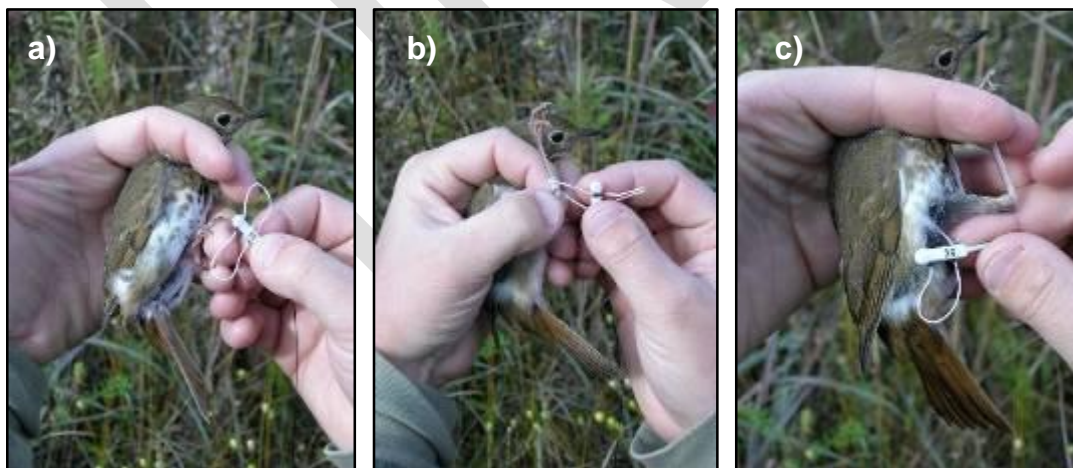




Figure 11. Tag deployment: Placement of first leg loop over one of the legs (a-c), so the tag sits on the rump with the antenna extending down the tail (d). Sliding second leg loop over other leg from heel to foot while holding tag in place (e), and final tag placement (f).



Figure 12. Leg loops placed over the knee joint, between the thigh and the body

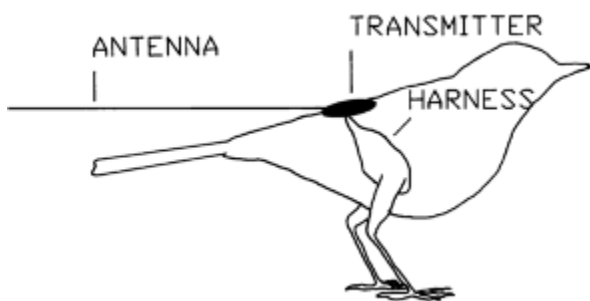


Figure 13. Final placement of harness and tag. Diagram from Rappole and Tipton (1991)



Figure 14. Northern Wheatear tagged in Helgoland Kringel. Photo Credit to Harro H. Müller.

Appendix 2. Videos

Video of geolocator deployment on a small passerine, using the Streby harness made of a material with lower elasticity: https://youtu.be/YDZJHA_fmIl