A transmitter attachment method for terrestrial turtles, designed to protect the radio module from mammalian chewing

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Various methods for attaching radiotransmitters to turtles have been described and reviewed (Belzer and Reese 1995; Boarman et al. 1998; Renaud et al. 1993; Resources Inventory Committee 1998; Wilson et al. 2003). Modifications are usually needed to address special aspects of a study’s species, habitat, goals, or duration (cf., Resources Inventory Committee 1998). Our NW Pennsylvania studies of eastern box turtles, Terrapene carolina carolina, span decades (Belzer and Seibert 2009), and so require repeated radiotransmitter replacements.

Removing transmitters epoxied directly to the turtle’s scute can be tedious, time consuming, and risks damage to the scute (Belzer and Reese 1995). In the early
1990’s we therefore developed a rubber transmitter holder that enabled quick transmitter replacement in the field without the risks and stress to the turtle that attend separating a transmitter from epoxy on a scute (Belzer and Reese 1995). However, mammals began to chew the rubber. The damaged rubber sometimes allowed transmitters to fall off, with consequent loss of the turtle from our telemetered population. Incidence of such chewing escalated during the next 3 years. Gnawing often went beyond the rubber holder and destroyed the radio module. By the 1996 season, 38% of our rubber transmitter holders had suffered some amount of gnawing. We therefore began to design and test more rigid transmitter housings with coatings of abrasive grit and/or 8-methyl-N-vanillyl-6-nonenamide (capsaicin, the burning irritant found in hot chili peppers and pepper-spray) that might discourage gnawing.

We field tested and refined several prototypes before arriving at the housing and attachment procedure described in this paper. After this 2-day, one-time, indoor attachment procedure we release the turtle with little likelihood that its habitat-use will ever again need to be interrupted. Fabricating the components before the turtle’s arrival minimizes its absence from the field. For 10 years, now, the technique detailed below has given us good results.

Steps in constructing the transmitter housing (cap).—(1) To begin the construction of the cap (which will protect the transmitter) cut a 4.0–4.5 cm diam. ring from the equatorial region of a plastic egg or plastic golf ball. (2) Then take a 24 cm length of narrow (2.5 cm wide) Kevlar ribbon (Fibre Glast Development Corp.,
Brookville, Ohio) and fasten one end to the plastic ring with a size 8 (1.25 cm long) sequin pin (Prym-Dritz Corp., Spartansburg, South Carolina) (Fig. 1). Next (as indicated in Fig. 2) loop the Kevlar up and over, back under, and then over the ring again to create a Kevlar dome. The width of the Kevlar in Fig. 2 is drawn proportionally narrow, to more clearly illustrate the pattern of looping over the plastic ring. Make tucks in the Kevlar loops and secure them to each other with sequin pins and hot glue (Adhesive Technologies, Hampton, New Hampshire) so
that the dome becomes relatively smooth (Fig. 3). (5) After contouring the Kevlar dome, coat the inside and outside surfaces with Devcon 2 Ton® Clear Epoxy (ITW Performance Polymers, Riviera Beach, Florida). (6) Then sprinkle coarse (#30 – #60), dark aluminum oxide grit (Kramer Industries, Piscataway, New Jersey) over the epoxy on the outside of the cap. Once the grit-embedded epoxy hardens, the dome is fairly rigid (but light in weight) and presents an abrasive surface to confront mammalian teeth (Fig. 4). This abrasive cap will later be held on the turtle.

Fig 3 Kevlar dome contoured with sequin pins and hot glue.

Fig 4 The Kevlar surface of right-hand dome is coated with 2 Ton epoxy and embedded abrasive grit. A relief-notch model #2000 U-nut lies in front.
of an exposed portion (onto which the U-nut will later be slipped) of the plastic base.

by screws from two anchoring flaps epoxied to the turtle’s carapace (see Fig. 8 and fabrication steps below).

Steps in fabricating anchoring flaps.— To fabricate a Kevlar anchoring flap,

1. take an 8 cm length of 2.5 cm wide Kevlar, fold it at its midpoint to create a 4 cm long 2-layer tab, and slip a #6 flat washer (InStock Fasteners, Buffalo Grove, Illinois) inside the folded end. Push a thin wire through the Kevlar and washer orifice to keep the washer from slipping out of the fold. Also stitch a short wire down the length of Kevlar so you can put a small bend in its washer end that will hold its shape when epoxy is added to the flap fabric (Fig. 5).

2. Coat about 1.3 cm of the Kevlar flap (inside and outside surfaces) at its bent end with 2 Ton epoxy.

3. When the epoxy hardens, the bent end enclosing the washer serves as a rigid flange (Fig. 5) that will abut against a U-nut to be fastened (see next procedure) to
the base of the cap.

*Determining attachment sites for anchoring flaps.*— In preparation for attaching anchoring flaps to the turtle’s carapace, (1) slip 2 U-nuts (relief-notch model #2000, from ACS Manufacturing Inc, South Elgin, Illinois) over each of 2 exposed plastic sections along the base of the cap (Fig. 6A and 6B). (2) Alternately holding an anchoring flap to each of the cap’s U-nuts with your fingers, and sliding the U-nuts into different trial positions along the plastic base of the cap, identify prospective U-nut locations that will permit the flexible end of each flap, when attached to a cap’s U-nut, to lie on suitable scutes (anterior for females, so the cap won’t impede mating; anterior or posterior for males) on the turtle’s carapace. (3) After selecting U-nut locations, bore a hole through each U-nut orifice and its underlying plastic segment of the cap. (4) Attach an anchoring flap to each U-nut by threading a #6 x 1.27 cm sheet metal screw (InStock Fasteners, Buffalo Grove, Illinois) through the
flap’s washer and cap’s U-nut (Fig. 7). Next, hold the cap/flap assembly on the
carapace surface, and try small changes in its position to find a location where the
flexible end of each of the cap’s anchoring flaps will, after trimming with scissors,
end on the center of a scute.

Attaching anchoring flaps to the carapace.— We use PC-7® Heavy Duty Paste
Epoxy (Protective Coatings Co., Allentown, Pennsylvania) to attach the anchoring
flaps to the turtle’s carapace. Belzer and Reese (1995) and Belzer (1997)
summarized the safety and other advantages of using this epoxy rather than
quick-setting alternatives (cf., Renaud et al. 1993). Before applying any epoxy to
the carapace, cover the sutures on all sides of the chosen scutes with masking
tape (3M Corp., St Paul, Minnesota) to keep epoxy off of the sutural growth zones
(Fig. 8). Then work PC-7 onto the keratin exposed within the taped perimeter
(Fig. 8). It is important to work the epoxy thoroughly into all available irregularities
Fig 8 Male turtle’s carapace with masking tape covering of the perimeter growth zones of two selected attachment scutes, and PC-7 epoxy worked into the center of each attachment scute. The distal end of each anchoring flap that secures the transmitter cap is affixed to the PC-7 epoxy on each attachment scute.

on the keratinous surface so that the epoxy will gain a good hold. (3) Next, work PC-7 into the trimmed ends of the anchoring flaps that are attached to the cap. Then hold the entire cap/flap assembly on the carapace, and press the epoxied ends of the flaps into the epoxy previously worked onto the scutes (Fig. 8). (5) Finally, take long strips of masking tape (2 cm, 4.5 cm, and 7.5 cm wide) and liberally layer them over the epoxy, cap, flaps and shell so that the cap/flap assembly will be held firmly in place during the ensuing 24 – 48 h curing period. We wrap some of the narrowest tape completely around the carapace and plastron at the hinge zone for even greater stabilization during epoxy curing. (6) Once the epoxy has cured, remove the layers of tape covering the cap and shell, and then (by
unthreading the screws) release the cap to expose the taped sutures (Fig. 9).

Fig 9 View of anchoring flaps epoxied to carapace. Cap has been removed by unthreading the flaps’ screws, so that the masking tape can be peeled from the growth zones.

Peel the tape from the sutures.

Now that the flaps are securely affixed, place a transmitter under the cap, feed the transmitter’s antenna through an opening in the cap’s dome, and secure the cap with screws through the anchoring flaps. Replacement of transmitters thereafter is a simple procedure that can quickly be done in the field without interrupting the turtle’s habitat-use.

For our adults (450 – 700 g) this 30 g package (epoxy, flap, cap, and transmitter) is well under the 10% body weight limit proposed in Heyer et al. (1994) for attached objects, and also meets or approaches smaller maximum limit suggestions discussed for some species (Resources Inventory Committee 1998).
We use Holohil (Carp, Ontario) R1-2B radiotransmitters (15 g) that last 2 years before replacement is needed. To prevent attachment screws from rusting to cap U-nuts, we replace the screws each spring and fall.

During the 10 years since we replaced our rubber holders with these caps, radio module destruction from mammalian chewing has never recurred. Sometimes the exposed section of an antenna still gets chewed (Fig. 10); but that

![Chewed portion of antenna that extended beyond the transmitter cap.](image)

has not caused loss of transmitter function. Our prototype tests did not indicate that adding capsaicin to the cap coating noticeably enhanced a gritty surface’s capability to deter mammalian chewing. We therefore use only abrasive grit in our caps’ coating.

If a flap’s epoxy detaches from the scute, the transmitter can slip from under the loosened cap. On 9 occasions (all involving subadults) we have lost track of a
turtle for varying periods of time because of such detachment. Three of those 9 instances were repeat detachments for individuals that had been located and refitted with a new flap after their original transmitter-loss (i.e., we lost track of only 6 different turtles due to flap detachment). Both flaps detached and the cap itself fell off for 4 of those 6 turtles. The scutes on young (and very aged) turtles tend to be smooth and provide poor purchase for the epoxy. An advantage of our method is that 2 attachment points secure the cap. The second anchoring flap retained the cap and transmitter on 18 other turtles (14 subadults, 4 adults) after one flap had detached. In those 18 instances we located the turtle and replaced its loose flap before it was lost from our telemetered population. If you wrap a ring of tape around the antenna’s basal portion where it emerges through an opening, the antenna is thickened at its juncture with the cap’s outer surface. That thickening can prevent the antenna from slipping in through the cap’s opening, and the transmitter sliding out from under a loose cap. The anchoring flaps on our other 127 (84%) turtles have never detached. The PC-7 epoxy has securely held the flaps and cap on some of our adults for 10 years now.

While this transmitter housing provides advantages, it also poses some mortality risk. Such a bulky, if light, prominence on the turtle’s carapace might frustrate a turtle’s attempt to right itself from an inverted orientation, or get snagged by long weeds. During 10 years of use (on 151 different turtles), one death (a 270 g juvenile) was probably caused by the presence of the cap assembly (hyperthermia from prolonged sun exposure in a turtle unable to right
itself). This lone mortality incidence attended 670 turtle-seasons (or ca. 16,000 ambulatory weeks) of transmitter cap use among our 151 telemetered turtles. Although non-telemetered turtles might find themselves unable to right themselves, it’s reasonable to attribute this instance of lethal hyperthermia to the attached cap.

During the same decade, we found 9 others of our telemetered juvenile (ca. 300 g) turtles upside down, but we righted them before injury had occurred. Two instances were repeat cases (i.e., only 8 of 80 different juveniles have so far suffered this circumstance). If an inverted turtle is not in the sun it can survive for an extended period. We locate each turtle approximately once a week to determine its location and welfare. Our not finding larger turtles stranded upside down suggests that their longer necks enabled adults to successfully right themselves despite the transmitter housing.

During this decade we also found 2 subadult turtles encumbered by weeds tangled around their antenna or cap. We found and released them from the hindrance before climate or predator injured them. Those antenna tangles (4 years apart) both occurred in late September when weeds in our habitat are tall and dense. Getting snared in vegetation under water would pose a much greater mortality risk and so this housing is not acceptable on aquatic species. For terrestrial turtles the risk seems to be very low and the cap protects the transmitter from the teeth of inquisitive mammals. The ease with which transmitters can be replaced in the field is a decided asset in long-term studies.
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Literature Cited


