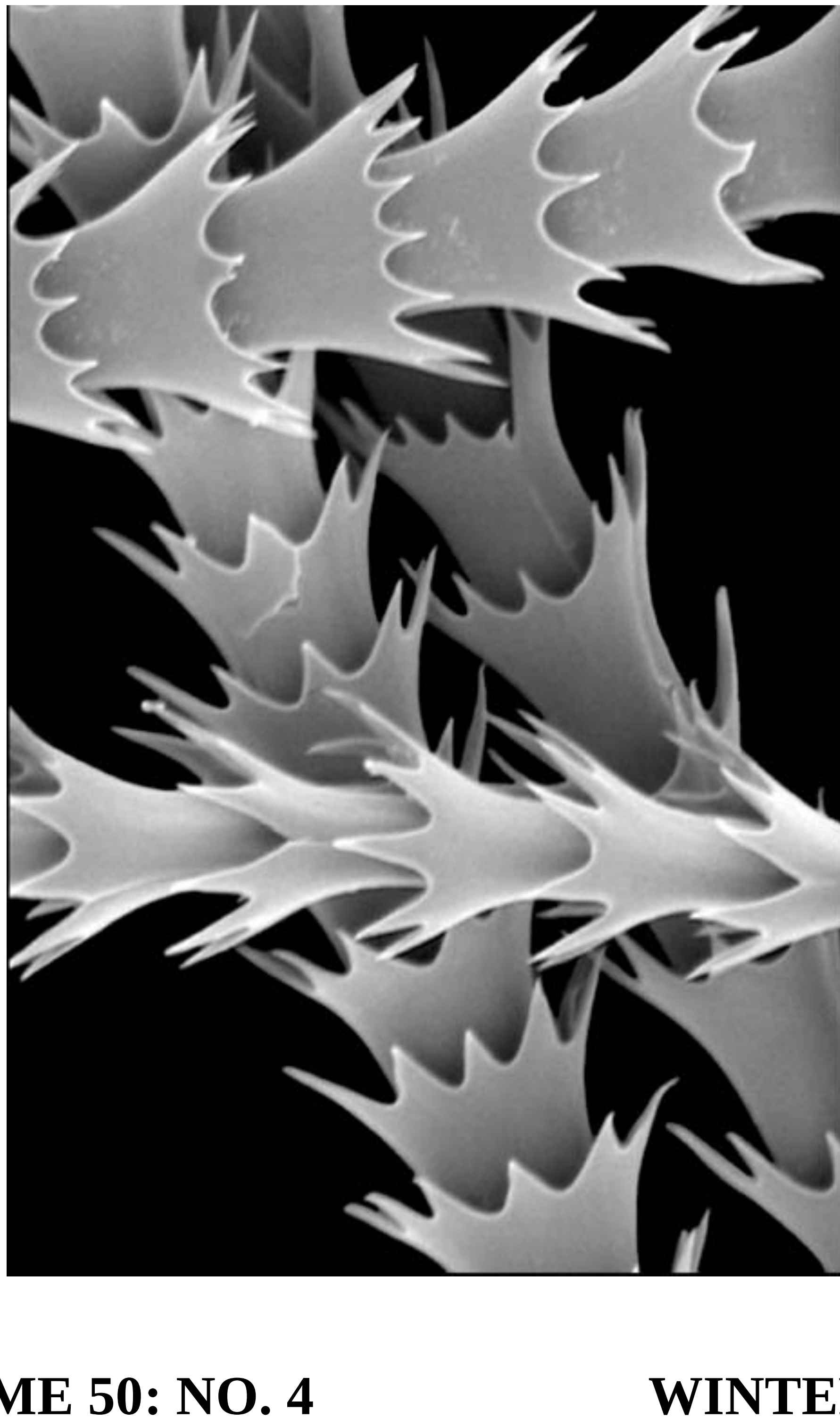
BAT RESEARCH NEWS



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A Field- and Laboratory-based Comparison of Adhesives for Attaching Radiotransmitters to Small Insectivorous Bats

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Introduction

Radiotransmitters are a valuable tool for studying numerous aspects of chiropteran behavior (Campbell et al., 2006; Chruszcz and Barclay, 2004; Willis and Brigham, 2004), physiology (Park et al., 2000; Turbill et al., 2003; Willis and Brigham, 2003), and ecology (Heithaus and Fleming, 1978; Murray and Kurta, 2004; Neubaum et al., 2006; Nicholls and Racey, 2006; Perry et al., 2007). There are various methods for attaching transmitters, but rubber-based surgical adhesives (e.g., Skin-Bond, Smith & Nephew, Inc., Largo, Florida) frequently are used to glue the transmitter to the skin between the scapulae (Aldridge and Brigham, 1988; Brigham, 2008). Although some aspects of applying transmitters to bats are unique, the manufacturer's general directions for using these adhesives are similar for most brands and apply for use with bats. After trimming the fur close to the skin, the biologist applies a thin layer of adhesive to both the bat and the transmitter. When the adhesive is tacky, the transmitter is positioned on the bat, and the fur often is folded over the transmitter to finish the application (Brigham, 2008; Carter, 2009).

The original formula of Skin-Bond (hereafter referred to as old Skin-Bond) was the most popular and widely used adhesive for bats (Brigham, 2008), but since its discontinuation, an alternative adhesive is needed. The replacement formula of Skin-Bond (hereafter referred to as new Skin-Bond) was not considered acceptable by all workers, and this new formulation also was discontinued within a year of its release. Some researchers recommended Torbot Bonding Cement (Torbot Group, Inc., Cranston, Rhode Island), which is a latex-based surgical adhesive, as a replacement. We tested characteristics of these and other adhesives to evaluate their performance compared to the benchmark set by old Skin-Bond. Specifically, we assessed performance with four metrics: transmitter retention time, adhesive waiting time, adhesion strength, and re-adhesion strength.

Materials and Methods

Field test.—Three types of surgical adhesives (old Skin-Bond, new Skin-Bond, and Torbot) were tested in the field by placing transmitters on three species of *Myotis* (*M. sodalis*, *M. lucifugus*, and *M. septentrionalis*) at sites in southern Indiana, Illinois, and northern Kentucky and tracking each bat using telemetric equipment. We documented how many days each transmitter remained attached to the animals. Transmitters were considered attached if we located the bat in a new roost tree each day or if we documented that the bat was flying (variable versus constant signal during the night). If we failed to locate the animal, the transmitter still may have remained attached. Therefore, our estimate represents the minimum number of days that a transmitter remained on an animal. Although conservative, any bias should be equal among treatments (types of adhesive).

Laboratory tests.—In addition to old Skin-Bond, new Skin-Bond, and Torbot, three other brands—Osto-Bond (Montreal Ostomy Products, Vaudreuil, Quebec, Canada), Perma-Type Surgical Cement (Perma-Type Company, Inc., Plainville, Connecticut), and LashGrip Eyelash Adhesive (American International Industries, Los Angeles, California)—were tested in a controlled laboratory environment. Each adhesive underwent tests to assess waiting time, adhesion strength, and re-adhesion strength. First, each adhesive was applied to a clean glass slide in the same manner as it would be applied to a bat. The time it took for the adhesive to become tacky was recorded. This represented the time that a biologist should wait before applying a transmitter (Brigham, 2008). The transmitter was deemed tacky after visual confirmation of bubbles and tactile confirmation of a sticky surface that did not transfer any glue to a finger when lightly touched.

To measure adhesion strength, each adhesive was applied to both the flat side of a transmitter and to a clean glass slide. The slide and transmitter were left apart until the adhesive became tacky. Then, the adhesive-coated transmitter was applied to the adhesive on the slide, and the adhesive was allowed to cure. After 24 h, the transmitters were pulled parallel from the glass-slide by gripping the antennae with a spring-scale (Pesola AG, Baar, Switzerland). Adhesion strength was defined as the loading (g) at which the bond failed. Each adhesive was tested on 10 slides with 10 different transmitters.

The test for re-adhesion strength occurred immediately after the initial 24-h strength test. After a transmitter became detached, it was immediately reapplied to the same slide, without any modifications, and adhesion strength was immediately remeasured with the spring scale. This procedure tested the ability of the adhesive to re-adhere (re-adhesion strength) and simulated re-attaching a transmitter to a bat after the transmitter had been subjected to some stressing force or partial removal. In the field, this rebonding ability presumably helped prevent loss of transmitters and increase retention time.

Statistics.—Retention time, adhesion, and re-adhesion strength were compared using one-way analyses of variance and Tukey's multiple comparison tests. Because tackiness is based on a person's judgment and there is no good way to quantify tackiness, we report our observations for this measure but do not statistically analyze them. All means are presented ± 1 sd.

Results

Field test.—New Skin-Bond, old Skin-Bond, and Torbot were applied to 5, 30, and 17 bats, respectively. There was a significant difference in length of time that a transmitter was retained ($F = 5.57$; d.f. = 2, 46; $p = 0.007$). Although number of days of attachment for new Skin-Bond (17.6 ± 7.6 days) was not significantly different from that of old Skin-Bond (16.9 ± 6.1 days), both formulations of Skin-Bond held significantly longer than Torbot (10.9 ± 4.5 days).

Laboratory tests.—Old Skin-Bond needed 5–10 min to become tacky. After curing for 24 h, old Skin-Bond required a load of 330 ± 76 g to pull the transmitter from the slide (Table 1). With immediate reapplication and testing, a load of 318 ± 98 g resulted in adhesive failure. After 24 h, the adhesive was still tacky.

New Skin-Bond had a waiting time of less than 5 min. After curing for 24 h, new Skin-Bond required a load of 565 ± 63 g to pull transmitters free from the slides. When the transmitters were retested, a load of 496 ± 63 g was needed for adhesive failure. After 24 h, new Skin-Bond also was still slightly tacky.

Torbot dried to a tacky state in 2–2.5 min. After curing for 24 h, a load of 270 ± 144 g was required to cause adhesive failure. After immediate reapplication, Torbot failed under

Table 1. Range of time to tackiness and mean (± sd) adhesion strength and re-adhesion strength of different adhesives used for attaching radiotransmitters to bats.

Adhesive	Time to tackiness (min)	Adhesion strength (g)	Re-adhesion strength (g)
New Skin-Bond	<5	565 ± 63	496 ± 63
Perma-Type Surgical Cement	3–4	465 ± 102	392 ± 94
Old Skin-Bond	5–10	330 ± 76	318 ± 98
LashGrip Eyelash Adhesive	>20	276 ± 74	0
Torbot Bonding Cement	2–2.5	270 ± 144	154 ± 88
Osto-bond	<2	254 ± 171	153 ± 69

a load of 154 ± 88 g. After 24 h, the adhesive was not tacky.

Time to tackiness for Osto-Bond was less than 2 min. Adhesion strength at 24 h was 254 ± 171 g, and re-adhesion strength was 153 ± 69 g. Osto-Bond was not tacky after 24 h.

Perma-Type Surgical Cement became tacky in 3–4 min. This cement had an adhesion strength of 465 ± 32 g at 24 h and a re-adhesion strength of 393 ± 94 g. The cement was slightly tacky after 24 h.

LashGrip Eyelash Adhesive took more than 20 min to become tacky. The 24 h adhesion strength was 276 ± 74 g, and the adhesive had no ability to re-adhere after 24 h and was not tacky.

There was a statistical difference in adhesion strength among the adhesives ($F = 12.73$; d.f. = 5; 54, $p < 0.001$). New Skin-Bond was stronger than all other adhesives, except Perma-Type. Perma-Type, in turn, was stronger than Osto-Bond, Torbot, and LashGrip. Results were similar for re-adhesion strength ($F = 54.87$; d.f. = 5, 53; $p < 0.001$). New Skin-Bond had a stronger re-adhesion strength than all other adhesives except Perma-Type. Perma-Type and old Skin-Bond were stronger than Osto-Bond, Torbot, and LashGrip. LashGrip had no re-adhesion ability and was significantly weaker than all other adhesives.

Discussion

Although laboratory tests are no substitute for real-world field tests, they can eliminate many confounding factors likely to influence the performance of adhesives used to affix transmitters to bats. Laboratory tests are useful for eliminating the variability caused by numerous biotic and abiotic factors (e.g., animal behavior and weather) and also factors likely to influence probability of detection (e.g., topography, road density, and property access), which can affect measures of retention time. Using field and laboratory tests and the worldwide-accepted use of old Skin-Bond as a benchmark, we evaluated the other adhesives.

Although initial strength of an adhesive is certainly important, it is not the only consideration. Our tests and field observations also identified a large disparity in waiting time (time to tackiness) among brands of adhesives. Although amount of time an adhesive takes to reach the tacky state does not appear related to its ultimate adhesion strength (e.g., Old and New Skin-Bond have very different time to tackiness but have similar strength; Table 1), it is an important factor affecting how long bats must be held while transmitters are applied.

Additionally, age and consistency of the adhesive are factors that contribute to waiting time and, therefore, length of time that bats are held. We observed in preliminary tests that, within a brand, the more viscous the adhesive (generally older bottles), the greater the amount of adhesive that must be applied, which results in added weight, longer drying times, and weaker bonds. Most adhesives that we tested use a hexane-based solvent as a thinning ingredient. As that solvent volatilizes, the adhesive thickens and eventually dries. Old bottles of Skin-Bond, Torbot, and similar adhesives can be returned to original consistency by mixing with small amounts of hexane. This procedure allows less adhesive to be used with each application, thus improving performance and maximizing number of applications per bottle.

Even with these similar patterns of drying time versus consistency across adhesives, some brands apparently reach the tacky state more quickly than others (Table 1). Although not analyzed statistically, our observations indicate that the time required for old Skin-Bond to become tacky is much longer than for the other adhesives. Researchers who are accustomed to old Skin-Bond will have to change their current time-management and work-flow patterns due to the shorter waiting times of many alternative adhesives. A benefit, however, is that these new adhesives allow for faster processing of animals and greatly reduced holding times. We were able to release bats in 10 min or less after using new Skin-Bond and Torbot, compared to a typical 20–30 min with an older bottle of old Skin-Bond. However, some adhesives, such as Torbot, dry so fast that steps to expedite the process of applying transmitters may be needed. Occasionally, by the time that we were ready to apply a transmitter, the Torbot had almost completely dried, rendering it considerably less effective. In these cases, a new, thin layer of Torbot was applied, and the process was restarted.

We noticed a seeming disparity in the performance of old Skin-Bond between field and laboratory tests. Although retention time and adhesion strength should have some correlation, the performance of old Skin-Bond seemed much better in the field than in the laboratory. We believed that this is a consequence of old Skin-Bond having a better ability to re-adhere than alternative products. New and old Skin-Bond and Perma-Type had re-adhesion strengths that equaled 90% or more of their initial values. Re-adhesion strengths of Torbot and Osto-Bond averaged ca. 70% of initial adhesion strengths.

We advocate that re-adhesion strength is important, because it allows both Skin-Bond formulations and presumably Perma-Type to maintain a stronger hold over time, as bats actively work to remove transmitters or the bond is exposed to passive stressors. These adhesives can essentially reattach after partial removal, which should increase length of time a transmitter stays attached. The differences in re-adhesion strength may be related to the ingredients used. Both formulations of Skin-Bond and Perma-Type are rubber-based adhesives, whereas Torbot and Osto-Bond are latex-based cements.

During early stages of this work, we intended to suggest new Skin-Bond as a replacement for old Skin-Bond, because the newer formulation is generally superior to other alternatives (Table 1). However, because new Skin-Bond is no longer sold, we now recommend Perma-Type Surgical Cement. It is similar in characteristics to both formulations of Skin-Bond and is the best available adhesive based on our laboratory tests (Table 1). Torbot and Osto-bond are also acceptable for applications where maximum time of transmitter retention is not needed. Additionally, we believe that Osto-bond is the same product as Torbot, just relabeled. The packaging and ingredients are identical, and results of our laboratory tests are virtually identical for all metrics (Table 1).

Lastly, woodworking contact cement (e.g., Weldwood Contact Cement, DAP, Inc., Baltimore, Maryland) has been used in some countries to affix transmitters to bats

(Brigham, 2008). It has been described as performing well in wet conditions (F. Anderka, pers. comm.), and our preliminary tests suggest that strength and re-adhesion may be greater than other adhesives. However, even though contact cement has ingredients and material safety data sheets (MSDS) similar to those of Skin-Bond, the U.S. Fish and Wildlife Service (Field Office, Bloomington, Indiana) has rejected it for use with endangered bats because, unlike the adhesives described in this paper, woodworking products are not designed for direct contact with skin.

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