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Revista Brasileira de Ornitologia, 16(2):131-136
junho de 2008

A comparison of five techniques for attaching radio-transmitters to tropical passerine birds

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Recebido em: 25/07/2007. Aceito em: 23/07/2008.

RESUMO: Comparação de cinco técnicas de fixação de radiotransmissores em pássaros tropicais. Foram comparados cinco métodos para fixar radiotransmissores em três espécies de pássaros tropicais de pequeno tamanho corpóreo (20-34 g) da Mata Atlântica para determinar diferenças no tempo de retenção dos radiotransmissores. Um total de 96 Tangará-dançarinos *(Chiroxiphia caudata),* 38 Olhos-de-fogo-do-sul *(Pyriglena leucoptera)* e 27 Vira-folha-vermelhos *(Sclerurus scansor)* foram capturados, sendo fixado com radiotransmissores. Um radiotransmissor também foi fixado em um canário-doméstico *(Serinus canária f. domestica).* Transmissores com pesos entre 0,54 e 0,64 g (~1,5-2,9% do peso dos pássaros) foram fixados nos indivíduos com um dos seguintes métodos: nas penas da cauda, como uma mochila (com alças ao redor do encontro da asa) e com três tipos diferentes de cola diretamente nas costas dos indivíduos. O tempo da retenção dos transmissores variou conforme a espécie e o método de fixação. O método utilizando cola de cílios postiços contendo látex foi o que apresentou maior tempo de retenção; em média, esses transmissores ficaram fixos por um período de 15,5 dias para *P. leucoptera* (Olho-de-fogo-do-sul) e 32 dias para *S. scansor* (Vira-folha-vermelho); o maior tempo observado foi de 197 dias para *C. caudata* (Tangará-dançarino). Os radiotransmissores apresentaram menor tempo de fixação nos indivíduos de *P. leucoptera,* provavelmente por causa das características morfológicas (costas sem penas, bico comprido). A cola de cianoacrilato e a cola de cílios postiços sem látex tiveram menor tempo de retenção. A mochila teve, aparentemente, efeitos negativos sobre o comportamento dos pássaros. A fixação dos transmissores nas penas da cauda foi um método melhor, mas o fato de ser dependente da muda, o torna um método insuficientemente confiável, visto que a época de muda é variável ente os indivíduos de pássaros tropicais. A nossa recomendação é a utilização de cola de cílios postiços contendo látex, visto que não ocorre qualquer irritação à pele das aves.

PALAVRAS-CHAVE: pássaros tropicais, fixação de radiotransmissores, radio telemetria, Mata Atlântica, Brasil.

ABSTRACT: We compared five methods for attaching radio transmitters to three species of tropical passerines (20-34 g) in the Atlantic Rainforest of Brazil to determine differences in retention time. Ninety-six Blue Manakins *(Chiroxiphia caudata),* 38 White-shouldered Fire-eyes *(Pyriglena leucoptera),* and 27 Rufous-breasted Leaftossers *(Sclerurus scansor)* were captured and tagged. We also tested two attachment methods on a captive canary *(Serinus canaria f. domestica).* Transmitters weighing 0.54 to 0.64 g (~1.5-2.9% of each bird's body mass) were either tail mounted, attached with a backpack harness, or back mounted with three different types of glue (cyanoacrylate-based, latex-based eyelash, or latex-free eyelash glue). Transmitter retention times differed between species and methods. Back mounts with the latex-based eyelash glue lasted the longest; mean retention times were between 15.5 days in White-shouldered Fire-eyes and 32 days in Rufous-breasted Leaftossers, with an observed maximum of 197 days in Blue Manakins. The shorter retention time in White-shouldered Fire-eyes was possibly influenced by body features (i.e., featherless lower back, strong elongated beak). Retention times were shortest with back mounts of cyanoacrylate-based and non-latex-based glue. The backpack harness apparently disturbed the birds. Tail mounts had fewer behavioral effects, but due to molt birds may lose their transmitters prematurely. The timing of molting periods between individuals of tropical bird species is variable. We recommend as attachment method for radio transmitters to tropical forest passerines a latex-based non-skin-irritating glue that is manufactured by the cosmetics industry to attach artificial eyelashbands.

KEY-WORDS: tropical passerine birds, transmitter attachment, radio telemetry, Atlantic Rainforest, Brazil.

Recently, radio-telemetry has provided a method of gathering valuable information on ecology and behavior of wild animals. Data on movement patterns, territoriality, habitat use and survival as well as dispersal rates have been collected for inconspicuous and difficult to observe species (Jacob and Rudran 2003). Nowadays, with transmitters weighing less than 1 g, telemetry studies of small passerines are possible. Different transmitter attachment techniques have been described for birds, including tail-mounts (Wiktander *et al.* 2001), back mounts (Raim 1978, Johnson *et al.* 1991) and harnesses (Nicholls and Warner 1968, Rappole and Tipton 1991, Hill *et al.*

1999). Advantages and disadvantages are well described (Kenward 2001), and several studies compare attachment techniques for larger birds (Wheeler 1991, Rotella *et al.* 1993, Hubbard *et al.* 1998, Bowman *et al.* 2002). However, species-specific variation in the suitability of transmitter attachment methods for passerines is less well documented (Johnson *et al.* 1991). For example, Sykes *et al.* (1990) evaluated the comparative effectiveness of eyelash glue, velcro, and the loop harness for the durability of transmitter attachment on captive Common Yellowthroats *(Geothlypis trichas).* Woolnough *et al.* (2004) compared cyanoacrylate adhesive with harness methods and with tail mounts on captive European Starlings *(Sturnus vulgaris).*

Here we report results from a study on free-ranging passerines radio-tracked in the Atlantic Rainforest of Brazil. We compared five techniques of radio transmitter attachment in birds weighing 20 to 40 g: Blue Manakin *(Chiroxiphia caudata),* White-shouldered Fire-eye *(Pyriglena leucoptera),* and Rufous-breasted Leaftosser *(Sclerurus scansor).* The techniques used were a backpack harness (Hill 1998, modified), a back mount using cyanoacrylate glue (Bowman *et al.* 2002, modified), a tail-mount (Wiktander *et al.* 2001), and back mounts based on two types of eyelash glue (Raim 1978, modified).

STUDY AREA

Study sites are on the Atlantic Plateau of Ibiúna in southeastern Brazil, about 40 km west of the city of São Paulo (23°35'S-23°50'S; 46°45'W-47°15'W). The climate type was classified as temperate – warm and rainy (Köppen 1948). Maximum temperatures averaged 27°C (February) and minimum temperatures 11°C (July). Mean annual rainfall was ~1400 mm, with a marked dry season from June to August (SABESP 1997). While experimenting with the different methods weather conditions changed randomly and were unlikely to bias the results.

Birds were captured and radio-tagged in two sites of a contiguous, large forest area (10.000 ha, Reserve of Morro Grande) and in seven similar sites in an adjacent fragmented landscape of approximately the same size as the reserve. The forest in the reserve was of intermediate to old secondary growth and structurally connected to a large forest track (> 760.000 ha) of the Paranapiacaba Serra (Metzger *et al.* 2006). The same type of forest was scattered over the fragmented landscape as patches of < 1 ha to 280 ha and comprised 31% of the landscape. Young secondary forest comprised 6%, and the surrounding matrix consisted of agricultural fields, Eucalyptus plantations, horticulture, and urban settlements (Uezu *et al.* 2005). For a more detailed description of the study area see also Metzger *et al.* (2006) and Silva *et al.* (2007).

Species

We chose three species of tropical forest passerines endemic to the Atlantic Rainforest (Ridgely and Tudor 1994, Stotz *et al.* 1996, Sick 1997). Blue Manakins (*Chiroxiphia caudata,* Pipridae), White-shouldered Fire-eyes *(Pyriglena leucoptera, Thamnophilidae),* and Rufous-breasted Leaftossers *(Sclerurus scansor, Furnariidae).*

Transmitter attachment

Between February 2003 and February 2005 we captured birds using mist-nets for 2-4 days at each site. The nets were opened at sunrise and checked at least every hour. Captured individuals of the target species were measured, banded with aluminum leg bands (CEMAVE; Brazilian governmental agency responsible for bird banding in Brazil), fitted with transmitters using one of the five methods and released at the site.

We used PIP2 and PIP3 radio transmitters (0.43 g-0.64 g, depending on the battery and attachment type) from Biotrack Ltd. (Dorset, United Kingdom) with life expectancies of three to five weeks. Tags weighed 1.5%-2.15% of a bird's body mass; only the tags attached with a backpack harness reached 2.7%-2.9% of a bird's body mass.

In all cases, transmitters were placed on top of a bird's back or tail, not affecting the uropygial gland, and with the antenna pointing backwards.

In addition to assess harassment of the birds caused by the transmitter unit, we used two techniques (backpack harness and back mount with latex-based glue) on one captive canary *(Serinus canaria f. domestica)* which is comparable in size to the Blue Manakin. While experimenting with the different methods weather conditions changed randomly and were unlikely to bias the results.

Harness mounted backpack – We placed backpack harnesses (following Hill 1998, Kenward 2001) with two types of elastic: the first 1.5 mm thick covered by synthetic fiber and the other only 0.5 mm thick covered with cotton. We attached both to a 0.64 g transmitter, using Superbonder® on top of the transmitter and a cotton thread on the bottom. The cotton thread served as a weak-link that would degrade and break with time to detach the unit (Hill 1998).

Glue mounted backpack – We glued transmitters with Superbonder® on the feathers of the lower back using 0.54 g (for Blue Manakins) and 0.61 g (for White-shouldered Fire-eyes) transmitters, respectively. A small piece of gauze fixed underneath the unit was coated with Superbonder® and placed on top of the feathers. We did not

drop this glue directly onto the skin, since it can have irritating effects (Göth and Jones 2001).

Tail-mount – To attach the tail-mounted transmitter to the bird, a drop of cyanoacrylate-based glue (Superbonder®) was dropped into a crevice on the transmitter, and the shaft of one central tail feather was placed into it. Wiktander *et al.* (2001) used two tail feathers, but we found it stable enough to fix the transmitter to one feather. In addition, the unit was secured by dental floss tied around it and an adjacent supporting feather and secured with a drop of Superbonder®.

Eyelash glue – We used eyelash glue as recommended by Raim (1978), since it is not skin-irritating, and tried both a latex-based glue designed to attach eyelash bands and a latex-free glue designed to attach single eyelashes. There are several manufacturers (e.g. Fing'rs Wimp'rs®, Artdeco®, Eylure®) that sell both adhesives.

Latex-based glue – We used the latex-based glue and mounted 0.4 g and 0.61 g radio transmitters. A piece of gauze that had been attached to the transmitter was coated with eyelash glue that was left dry for a few minutes. Before attaching the transmitter to Blue Manakins and Rufous-breasted Leaftossers, a few feathers on the bird's lower back were cleaned with alcohol and clipped to create a spot of bare skin where the radio unit was placed. White-shouldered Fire-eyes have a naturally bare spot on their back, so we did not have to clip feathers; we only cleaned the skin with alcohol. The glue was left to dry for a few minutes before we released the bird. The length of the drying period depended on weather conditions; on humid days it took longer. During the drying period birds were kept in cotton bags.

Latex-free glue – We used the non-latex-based eyelash glue and mounted 0.4 g and 0.61 g radio transmitters. The attachment procedure was the same as for the latex-based glue.

We used three categories to measure success for back-mounted transmitters (Table 1): (A) attachment was successful, (B) attachment was not successful, and (C) unknown, because of reasons independent of attachment. Attachment was considered successful, if the transmitter remained with the bird until the end of the telemetry bout (21 to 40 days) or until the battery power was exhausted (≥ 16 days). Attachment was considered unsuccessful, if the transmitter had detached and we were able to recover it. The category *unknown* included transmitters that could not be found, but the signal continued from the same location, lost signals of birds that presumably had left the area and we could no longer monitor them, or death (when we found the dead bird or parts of it together with the transmitter).

Data analysis

We evaluated the efficiency of the attachment methods by calculating the percentage of successful tagging for each one of the five methods, having:

$$Efficiency = \frac{number\ of\ success\ of\ method\ i}{total\ number\ of\ tags\ attached\ with\ method\ i}$$

To test whether the five attachment methods were equally good, we performed a Kruskal-Wallis-Test. We further produced two cross tables to verify whether methods and success categories, and species and success categories are independent from each other.

Results obtained from observations of the captive canary were merely observational and were not included in any analysis.

RESULTS

Backpack harness – We tested the backpack construction with the thicker elastic on the captive canary. During the first hours after attachment the bird seemed to be bothered by the harness, but then stopped trying to remove it. The bird's movements appeared slightly hindered, but it was still able to fly. We removed the backpack after three days. When fitted with the harness with the thinner elastic, the canary kept pulling it for several hours – obviously feeling uncomfortable – until it managed to strip off the transmitter unit. Thus, we decided not to use the thinner elastic on wild birds.

Of the five Blue Manakins outfitted with the thicker elastic on the backpack two lost the transmitters after four and six days, respectively. We found one backpack undamaged on the forest floor, the other with the elastic destroyed, possibly by a predator. Two birds carried the transmitters until the batteries stopped working (23 and 29 days, respectively). One individual was recaptured after 20 months; it had lost its backpack.

TABLE 1: Success categories of back mount transmitters fixed with latex-based glue on Blue Manakins *(Chiroxiphia caudata),* White-shouldered Fire-eyes *(Pyriglena leucoptera),* and Rufous-breasted Leaftossers *(Sclerurus scansor).* More than half of the fixed tags in *C. caudata* and *S. scansor* were successful.

		C. caudata		*P. leucoptera*		*S. scansor*	
		n	**%**	**n**	**%**	**n**	**%**
A	Successful	38	55.5	8	22.0	16	69.5
B	Unsuccessful						
	Detached 1-9d	3	4.3	7	28.0	1	4.3
	Detached 10-19d	9	13.0	3	12.0	2	8.7
	Detached > 20d	5	7.2	1	4.0	1	4.3
C	Unknown	14	20.2	6	24.0	3	13.0
	Total	**69**		**25**		**23**	

Back mount with Superbonder® – 18 individual birds (16 Blue Manakins and 2 White-shouldered Fire-eyes) were outfitted with the cyanoacrylate based glue. Within the first three days after attachment we found eleven transmitters on the forest floor attached to several feathers. Three were located on the ground eight days after attachment. The fate of other three was unknown, due to lost of signal. Only one individual kept the transmitter more than 23 days.

Tail-mount – This method was used in six individuals. Three Rufous-breasted Leaftossers retained their transmitters until the end of the telemetry bout or until the battery stopped working (36/38 and 28 days, respectively). One White-shouldered Fire-eye retained the transmitter for more than 29 days while another individual dropped the transmitter the day after attachment. One transmitter had an unknown fate.

Latex-based eyelash glue – Of 69 Blue Manakins with transmitters attached with the using latex-based glue, 38 retained the transmitter for more than 21 days. Two individuals still wore their transmitters when recaptured after 197 days, but the antennae were broken. 17 birds lost their transmitter within the first 20 days and 14 transmitters had an unknown fate. During direct observations at lek sites of Blue Manakins we noticed no behavioral differences between tagged and untagged individuals.

Of the 25 White-shouldered Fire-eyes fitted with transmitters using the latex-based glue, five were followed until the end of the telemetry bout. Six transmitters were lost within the first nine days after attachment, four of these in the rainy season. Twenty-three Rufous-breasted Leaftossers were radio-tagged with the same method. Ten transmitters remained attached until the end of the telemetry bout. One bird was recaptured after 169 days with the unit still attached and the antenna unbroken. The captive canary was also tagged using the latex-based glue. During the first few days after attachment its behavior was dominated by preening, focusing on its lower back, where the transmitter was placed. Then it became accustomed and returned to normal preening. It lost the transmitter during molt after five months. No skin irritation or irregular growth of feathers was seen.

The latex-based glue lasted the longest of all attachment methods; hence, as the other methods were not appropriate enough, the sample sizes of the other methods remained small. Table 2 gives an overview of all used attachment methods and the recorded maximum number of days transmitters were attached to wild birds.

Latex-free eyelash glue – Six Blue Manakins were outfitted with latex – free glue. Three of these lost the transmitter within the first six days, and only one transmitter remained attached for more than 29 days. Six of eight White-shouldered Fire-eyes dropped the transmitter within the first five days, one kept it for 25 days, and of one the signal was lost a day after attachment. The only Rufous-breasted Leaftosser tagged with latex-free glue lost its transmitter after nine days.

The Kruskal-Wallis test revealed, that the five methods were significantly different (asymptotic approximation of KW test, df = 4, $\chi^2 = 39.572$, $p < 0.001$). The tail mount had the highest rank and the latex-based glue the second highest. Table 2 shows the efficiency values of the five methods.

The cross tables revealed that the success categories and the five attachment methods were independent from each other (df = 8, Pearson $\chi^2 = 26.461$, $p = 0.001$), and the success categories were also independent from the species (df = 4, Pearson $\chi^2 = 13.205$, $p = 0.010$).

DISCUSSION

We tested five radio transmitter attachment methods on 161 individual birds of three species. The results show that not all methods used on other larger species of birds are applicable for forest dwelling tropical passerines. Except for the captive canary, and in contrast to previous studies, all data were gained from wild free-ranging birds under natural conditions. Some birds moved out of the monitorable range, some individuals were predated, and possibly heavy tropical rains, dense understory, and other unpredictable causes were responsible for the loss of tags. Statistical robustness was not the main goal of this study, but results reflect which method was best during field work under tropical conditions for understory passerines.

TABLE 2: Efficiency of the five transmitter attachment methods. It was calculated as success/n. All 161 individuals of the three study species are included

Method	n	Success	Failure	Unknown	Efficiency
Backpack harness	5	2	2	1	0.400
Glue mounted backpack	18	1	14	4	0.056
Tail mount	6	4	1	1	0.667
Latex-based glue	117	59	29	28	0.504
Latex-free glue	15	2	10	3	0.133

The latex-based glue was the most reliable method; retention time of the transmitter was longest, and we had no indication that the birds were hindered in their normal behavior. The two Blue Manakins recaptured after 197 days with the transmitter still in place had been captured and tagged during the dry season. The dry weather conditions might have facilitated the glue to fasten quickly and firmly (Sykes *et al.* 1990). Eyelash-glue is harmless if applied to the skin (Raim 1978), and neither the canary nor the recaptured wild birds showed signs of skin irritation. Following Sykes *et al.* (1990) the amount of preening in birds outfitted with this type of glue is not significantly higher than in birds of a control group. The captive canary in our study showed higher preening activities only during the first few days after tagging, than returned to a normal behavior.

The handling procedure stressed the Blue Manakins. However, compared to the backpack harness that we tried, or an implantation (Korschgen *et al.* 1996, Hubbard *et al.* 1998), or the suturing of the transmitter (Martin and Bider 1978, Wheeler 1991), the back mount has less severe effects. We do not exclude a bias in behavioral data (Rappole and Tipton 1991), since the backpack harness might cause reduced mobility (movements of the captive canary appeared slightly hindered). Entanglement of a bird's bill in the harness (Rappole and Tipton 1991, Hill *et al.* 1998) is rather unlikely, since Blue Manakins have relatively short beaks, but getting caught in vegetation might be a problem for understory birds. We did not observe this, but nevertheless for above mentioned reasons we do not recommend a backpack harness for passerines of this body size.

The radio signal was lost before the battery stopped working on some individuals. Such birds might have left the area, but it is also possible the antennas broke, and therefore signals became weak. This might have happened through interactions with other individuals or the bird itself might have damaged the antenna (Johnson *et al.* 1991).

Applying latex-free glue did not have sufficient elasticity and could not withstand a bird's movements, thus, it dropped off easily. Tail-mount appears to be an appropriate method for birds like White-shouldered Fire-eyes and Rufous-breasted Leaftossers with strong tail feathers. We agree with Woolnough *et al.* (2004) that this method is not very harassing; tagged individuals did not show obvious signs of stress and kept the transmitter during the telemetry bout. One molting individual however lost the transmitter instantly. Molt in Neotropical birds is not directly related to breeding activities (Sick 1997) and individuals of the same species might vary in changing their plumage up to six months (Stutchbury and Morton 2001). For this reason we think that the latex based glue method gains upon the tail mount method. Because of the high efficiency of the latex based glue that we observed during fieldwork, we finally abandoned the tail – mount method.

Back mounting the transmitter with Superbonder® failed for both Blue Manakins and White-shouldered Fire-eyes, because the feathers were too weak to support the transmitter unit.

White-shouldered Fire-eyes usually lost the units fixed directly on the skin prematurely, while most Blue Manakins and Rufous-breasted Leaftossers retained the transmitter to the end of the telemetry bout. The back of White-shouldered Fire-eyes is naturally featherless; only the interscapular feathers cover it. Maybe this featherless skin excretes substances that hinder the glue from attaching firmly to the bird's back. Also, White-shouldered Fire-eyes might be able to remove the transmitter unit with their elongated beaks (Johnson *et al.* 1991, Woolnough *et al.* 2004).

We conclude that tail-mount and back mount with a latex-based glue have the least adverse effects on tagged passerines. However, we do not recommend tail-mounts for tropical passerines, since there is no specific molting season. The eyelash glue method resulted in practical transmitter attachment; but it is important that this skin-friendly glue contains latex to maintain its flexibility.

ACKNOWLEDGMENTS

This study was supported by the German BMBF (Federal Ministry of Education and Research) that financed the program BIOCAPSP within the framework of the Brazilian-German cooperation "Mata Atlântica" (Förderkennzeichen 01LB0202 (Teilprojekt D3)). We thank all our committed and patient field helpers for their invaluable help and their mental input. We especially thank the Biotrack team who provided us with the radio-tags and advice on several topics concerning transmitters. We further thank J. P. Metzger for coordinating the overall collaboration and R. Iartelli for helping us with the catching permits. Comments of I. Storch and J. Bissonette improved an earlier draft of the manuscript.

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