

A SOLUTION TO LEG BAND INJURIES IN WILLOW FLYCATCHERS

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Abstract. Leg injuries caused by colored plastic leg bands have been reported in Willow Flycatchers (*Empidonax traillii*) in Oregon, California, and Arizona. Based on a five-year banding study of Southwestern Willow Flycatchers (*E.t. extimus*) in southern California, our observed band injury rates were lower than those reported elsewhere. We believe our injury rates were lower because we used modified celluloid bands that were: (a) resized to better fit the flycatcher's tarsus and to avoid slipping over the tarsometatarsal joint; (b) smoothed around the upper and lower edges to minimize abrasion; and (c) sealed to additionally reduce the amount of potentially abrasive surface and to maintain a prescribed inside diameter. Our overall observed injury rate was 2.9%, and declined to 0% over the last three years of the study after we switched from four bands to two bands per individual and eliminated the use of certain bands. We believe that the rate of band-related leg injuries is related to the number of bands applied, physical condition of bands, and use of improperly sized bands. Even the smallest commercially available celluloid leg bands are too large for Southwestern Willow Flycatchers. Moreover, we found that inside diameter of plastic bands varied widely, and were typically larger than advertised. To minimize band-caused leg injury, we recommend using a band of $2.0 \text{ mm} \pm 0.1$ inside diameter for Southwestern Willow Flycatchers. Unaltered "0A" and "0" bands from the U.S. Geological Survey Bird Banding Lab are suitably sized and have physical characteristics appropriate for use on Willow Flycatchers; plastic color bands, if correctly modified, are also suitable. Banders must take the responsibility to examine the propriety of bands they apply to live specimens, and to attempt recapture and treatment of injured individuals.

Key Words: banding; color bands; *Empidonax traillii extimus*; injury; Southwestern Willow Flycatchers

Comparative data on band-related injuries in birds are limited and vary widely. Published studies report band-related injury rates ranging from 0.4% (Gratto-Trevor 1994) to 50% (Salzert and Schelshorn 1979). However, much of the literature on band injuries comes from studies of shorebirds and may have limited application to passerines. Nevertheless, it appears that band type, size, and application technique may contribute significantly to injury rates in a host of species (Amat 1999, Bailey et al. 1987, Nisbet 1991, Rothstein 1979). Sedgwick and Klus (1997) recorded an overall leg injury rate of 9.6% in a long-term band and recapture study of Willow Flycatchers (*Empidonax traillii*). Similar injuries have been noted in some Southwestern Willow Flycatcher (*E.t. extimus*) banding studies in Arizona (M. Sogge, pers. comm.) and California (M. Whitfield, pers. comm.); injuries in *E.t. extimus* are of particular concern due to the endangered status of this subspecies.

During the course of a five-year Southwestern Willow Flycatcher research project, we noted a plastic band-related leg injury rate lower than that reported by Sedgwick and Klus (1997). This led us to investigate the level and nature of band-related injuries in our banded population, and the factors that may contribute to these injuries. We hypothesized that band-related injury may be the result of application of improperly sized bands and/or bands with physical characteristics conducive to abrading flycatcher tarsi or

constriction of the foot. It is also possible that the weight of more than one band per leg further exacerbates the potential for leg injury. To determine if improper band size or physical characteristics may contribute to injuries, we compared measurements of Willow Flycatcher lower tarsometatarsus diameter (tarsus) and distal tarsometatarsal joint (distal joint) width to the inside diameters of federal aluminum bands and commercially available plastic color bands.

METHODS

BAND MEASUREMENTS

Celluloid bands are produced in a variety of colors and three primary color schemes: solid (uniform color throughout), two-colored narrow striped, and two-colored broad striped. We used a dial caliper (with 0.05 mm resolution) to measure the inside diameter and wall thickness (gauge) of 100 size XF plastic color bands (manufactured by A. C. Hughes). We randomly selected and measured inside diameter and gauge of 40 solid color bands from a population of 400, 20 two-colored narrow striped bands from a population of 200, and 40 two-colored broad striped bands from a population of 400. We also measured the inside diameter and gauge of 100 size 0 and 100 size 0A federal numbered aluminum bands.

WILLOW FLYCATCHER CAPTURE, BANDING, AND LEG MEASUREMENTS

We conducted our field study from 1996 to 2000 on a breeding population of Willow Flycatchers along the upper San Luis Rey River (San Diego Co., California), approximately 1 km downstream of Lake Henshaw.

TABLE 1. BAND-RELATED INJURIES IN SOUTHWESTERN WILLOW FLYCATCHERS (1997 TO 2001) AT THE UPPER SAN LUIS REY RIVER, SAN DIEGO COUNTY, CA

Year banded	Year and age recaptured	Sex	Injury/symptoms	Treatment/outcome
1996	1997 Third year	Female	Celluloid band (thin-striped) slipped over distal joint of left foot; joint slightly abraded; loss of foot use	Removed plastic bands from left leg; treated with povidone-iodine and released. Observed on territory for remainder of breeding season, use of foot restored. Individual not observed in following years.
1996	1998 Fourth year	Male	Severe abrasion: raw, swollen tissue below bands on left leg	Removed plastic bands from left leg, treated with povidone-iodine; released. Recaptured June 1999, minimal evidence of injury (slight scarring observed with 10-power hand lens).
1996	1998 Third year	Male	Raw, swollen tissue at joints above and below bands (thin-striped) on left leg	Removed plastic bands from left leg, treated with povidone-iodine; released. Remained on territory through season; not observed in subsequent years.
1997	1999 Fourth year	Male	Raw, swollen tissue at joints above and below bands on right and left legs	Removed all bands, treated with 10% povidone-iodine; released. Remained on territory through season. Unknown if observed in subsequent years.

Note: All birds were originally banded with two bands per leg.

We used mist-nets to capture summer resident flycatchers, and banded each individual with a numbered size 0A federal aluminum band and from one (1998–2000) to three (1996–1997) plastic colored leg bands; the size XF celluloid bands were re-sized and modified to a 2.0 mm \pm 0.1 inside diameter (details below). For this study we used a dial caliper (with 0.05 mm resolution) to measure the maximum diameter of the tarsus and width of the distal joint in 65 live adult (\geq second year) flycatchers.

DETERMINATION OF LEG INJURIES

We derived our band injury data from banding, recapture, and resighting data of birds banded between 1996 and 2000 ($N = 168$) and re-sighted and/or recaptured at least one year later (i.e., 1997 to 2001, $N = 139$). We thoroughly inspected the tarsi of each newly captured and recaptured flycatcher, and visually inspected (through binoculars) the leg condition of each flycatcher that was resighted.

RESULTS AND DISCUSSION

TARSAL MEASUREMENTS

Tarsal diameter of 65 Southwestern Willow Flycatchers ranged from 1.65 to 1.90 mm (mean = 1.80 mm, $SD = 0.04$). Diameter (maximum width) of the distal joint ranged from 2.05 mm to 2.45 mm (mean = 2.20 mm, $SD = 0.07$).

BAND MEASUREMENTS

Advertised as having an inside diameter of 2.30 mm, celluloid XF color band inside diameter ranged from 2.35 to 2.65 mm (mean = 2.45 \pm 0.06 SD). Because all Willow Flycatchers we measured had distal joints of 2.05 mm or larger,

bands of 2.00 mm inside diameter are unlikely to slip over the distal joint. Forty of the 65 flycatchers had distal joint widths of 2.30 mm or less; thus, unmodified plastic XF bands had the potential to slide over the distal joint of more than 60% of the flycatchers.

Size 0A and 0 aluminum bands were more consistent in dimensions than were all other bands we measured. Mean inside diameter of size 0A bands was 2.05 mm ($SD = 0.05$, range = 1.90–2.15). Mean inside diameter of size 0 aluminum bands was 2.1 mm ($SD = 0.06$, range = 2.05–2.30). Therefore, all size 0A bands were large enough to fit around the flycatcher tarsi and small enough to avoid slipping over the distal joint. Size 0 bands had smaller inside diameters than the distal joints of 57 (88%) of the flycatchers we measured; however, there is potential for slippage over some flycatcher distal joints (8 of 65 flycatchers had a distal joint width less than 2.15 mm).

BAND-RELATED INJURY RATES

We banded 168 Southwestern Willow Flycatchers between 1996 and 2000, and recaptured/resighted 139 (not including birds re-sighted within the season in which they were banded). We have detected four (2.9%) band-related injuries (Table 1). Injuries included tarsal abrasions above and/or below the plastic bands ($N = 3$) and plastic band slippage over the distal tarsal joint ($N = 1$). All four injuries occurred to birds on which we had placed four bands (two bands per leg), two (50%) of the four injuries

involved birds with thin-stripped color bands adjacent to the distal joint. Of 168 birds banded, only 17 (10%) had thin-stripped bands in the position directly above the distal joint. Thus, 50% of our injuries occurred in a small subset of banded individuals (i.e., the thin-stripped group), yielding in this small sample an observed injury rate of approximately 12%. We observed no leg injuries in birds with one band per leg; however, none of these had been banded with thin-stripped bands. Our observed injury rates declined to 0% over the last three years of the study after we switched from four bands to two bands per individual and eliminated the use of thin-stripped bands.

Although our injury rates were lower than those reported by Sedgwick and Klus (1997), the nature of injuries was similar and a potential cause for concern. Because there is a paucity of published data on leg injury rates in passerines, it is difficult to determine whether the Willow Flycatcher is particularly susceptible to band-related injury as compared to other species. Band-related injuries have been reported in other *Empidonax* and some *Contopus* flycatchers (M. Gustafson, pers. comm.), which may suggest that the tarsi of these genera may be susceptible to abrasion injuries, at least with improperly sized or physically unrefined bands. Injury data reflect only evidence from birds that were injured but survived long enough to be recaptured and re-sighted. It is probable that band-related injury rates are actually higher than can be observed and therefore reported, especially for more serious injuries that prevent a banded individual from surviving between breeding seasons.

POSSIBLE MECHANISMS FOR INJURY

Sedgwick and Klus (1997) describe a potential route for abrasive injury to flycatcher tarsi: sharp edges on the rims of color bands irritate the tarsus, leading to open wounds that become infected. Predicating that bands are not affixed too tightly, we believe that there are two additional injury mechanisms: (a) oversized bands may slip over the flycatcher distal joint, and (b) sharp lower edges and offset corners where the plastic band is split may cut into the fleshy flycatcher distal joint. Therefore we believe that some leg injuries may be related to the use of improperly sized and/or unsealed bands.

Federal aluminum 0A and 0 bands are associated with low rates of injury (Sedgwick and Klus 1997; M. Whitfield, pers. com.) and contributed to no injuries observed in this study. Our measurements indicate they are a better fit to the Willow Flycatcher tarsus than are unmod-

ified plastic bands, and therefore less likely to slide along and abrade the tarsus. An over-sized band moves easily around and along the tarsus, and would therefore be more likely to cause abrasion than bands of more appropriate fit. In addition to abrasion injuries, oversized bands can slide over the distal joint severely restricting use of the foot, and can circumscribe the distal joint to cause ischaemic injury (a deficiency of blood as a result of functional constriction). This would ultimately lead to tissue necrosis and loss of part or all of the extremity, possibly amplified by self-mutilation. Privation of foot use and foot loss are potentially serious enough to preclude survivorship through an entire annual cycle. Unmodified federal bands probably rarely slide over the distal joint, reducing their potential to cause injury.

Other band features that probably contribute to abrasion are sharp or rough edges, including unsealed edges, improper seal (e.g., resulting in offset edges), and band gauge. The gauge of thin-stripped bands in our study was smaller (mean = 0.40 mm \pm 0.03 SD, range = 0.35–0.45) than solid and broad-stripped celluloid bands collectively (mean = 0.50 mm \pm 0.03 SD, range = 0.45–0.55). Being relatively narrow, the lower rim of the thin-stripped bands we used during the initial years of our field study (prior to discontinued use due to the aforementioned injuries) may have acted like a cutting edge, especially under the weight of a second band. Although it was not possible to test this, we have not detected band-caused injuries subsequent to eliminating this type of band and reducing the number of bands per leg from two to one.

Trapping of debris and mud under the band contributes to leg injuries in shorebirds (Amat 1999), and trapped plant debris has been implicated in impairment of foot function and occasional foot loss in Least Bell's Vireos (*Vireo bellii pusillus*; B. Kus, pers. comm.). Although we have found plant material imbedded in and wrapped around the tarsi of a small number of flycatchers during initial and subsequent capture (N = 1 banded, N = 3 unbanded), we have seen no injuries that appear related to these plant materials.

RECOMMENDATIONS

BAND SIZE

Based on tarsus and distal joint measurements, we recommend use of size 0A federal aluminum bands on Southwestern Willow Flycatchers. We have no data to indicate harmful effects to flycatchers resulting from use of the slightly larger size 0 band, but size 0A bands

would seem to preclude the possibility of slippage over the distal joint. Because tarsal diameter and width of the distal joint may vary between subspecies of the Willow Flycatcher, we recommend the determination of leg size prior to banding. If color marking Southwestern Willow Flycatchers, celluloid color bands should be resized to $2.0 \text{ mm} \pm 0.1$ inside diameter.

BAND MATERIAL

A few studies have reported that the federal aluminum bands have a low frequency of band injury (Sedgwick and Klus 1997; M. Sogge and M. Whitfield, pers. comm.; W. Haas, pers. obs.). We believe the low incidence of leg injury from federal bands is due to their gauge, weight, and their smooth surfaces that lack sharp edges. Metal bands can be colored to provide auxiliary marking schemes, and we recommend that any such metal color bands mimic the federal Size 0A bands in size (including inside diameter), weight, and edge characteristics. Bands should be inspected for appropriate thickness and smooth, rounded edges prior to entering the field; sharp, acute, and/or rough edges should be repaired using sandpaper, file, emery board, or other similar abrasive agent.

Plastic color bands are inexpensive, commercially available in a large number of colors and color combinations, and maintain color throughout the typical 3 to 5-year Southwestern Willow Flycatcher lifespan. Although they can cause leg injuries if used "as purchased," we found that celluloid bands can be safely used on Southwestern Willow Flycatchers if (a) re-sized, (b) smoothed to remove sharp edges (see below) and to provide a continuous seal at the butt-ends, and (c) closed with acetone or other appropriate sealing agent to reduce the amount of potentially abrasive surface and maintain a prescribed inside diameter. Although correctly modified plastic color bands are suitable for use, thin-walled celluloid bands (e.g., the thin-striped bands from our study), bands with rough or sharp edges, and incorrectly sized bands are not appropriate for use on Willow Flycatchers.

BAND MODIFICATION

We used the following techniques to re-size and modify the XF celluloid color bands used in our study. We removed sufficient material to create a band of approximately 2.0 mm inside diameter by filing down the butt-end of each band. We filed rather than cut the edges to create a more porous and nearly parallel surface that enhances later bonding by increasing available surface area; cutting with scissors or nail clipper can compress the butt ends and reduce bonding surface area. Once altered, the bands

were temporarily re-closed and measured to assure we had reached the proper inside diameter. We then inspected the upper and lower edges of the bands, and used an emery board, file, or application of acetone to smooth and round all rough edges. In the field, after applying the band to the bird's tarsus, we inspected the band's fit to ensure that it would not slide over the distal joint. After ascertaining the band was the correct size, we bonded the ends of the band with acetone or an alternate adhesive. Note that small celluloid bands do not maintain plastic "memory" and do not easily regain their original circular conformation without time-consuming heating and re-conforming (Haas and Fisher 1999). Sealing the bands after placement is thus mandatory. After bonding, we re-inspected the band to be sure it did not adhere to the tarsus or present other physical risk.

TREATMENT OF INJURIES

Because it is impossible to conduct banding activities with 100% certainty that no band-related injuries will occur (see Marion and Shamis 1977), it is important to design banding studies that include sufficient time and efforts to look for band-related injuries. When an injured bird is found, we recommend an attempt to re-capture the bird, replace or remove any worn, improperly sized, or otherwise flawed bands, and administer to the injury. In our study, we removed the offending bands (but generally maintained the federal numbered band) and treated the wounds with a full strength 10% povidone-iodine solution, then released the bird at the point of capture; if the band injury was sufficiently serious we removed all bands. Abrasive band injuries appeared to heal after band removal and treatment with this antibiotic solution (Table 1).

COMMERCIAL MANUFACTURE OF BANDS

For the Willow Flycatcher and other small passerines (e.g., California Gnatcatcher, *Poiloptila californica*; Least Bell's Vireo), commercially manufactured plastic bands may not be suitable for use without time-consuming modification. A preferred alternative would be to have appropriately-sized bands manufactured to the correct specifications. Also, we feel there is a need for improved quality control so that inside band diameter is less variable than we found in this study. We also suggest that commercial manufacturers specify the approximate weight and gauge of their bands, allowing banders a clear choice when deciding which bands to order for their specific needs.

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