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Notes

Retention of Riveted Aluminum Leg Bands by Wild Turkeys

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17 **Abstract**

18 A critical assumption of mark-recapture models so they provide unbiased estimates of population
19 parameters is that uniquely identifying tags or marks are not lost. We double-banded male and
20 female wild turkeys with aluminum rivet bands and estimated the probability that a bird would
21 be recovered with both bands <1–225 weeks since banding (\bar{x} = 51.2 weeks, SD = 44.0). We
22 found that 100% of females (n = 37) were recovered with both bands. For males, we recovered 6
23 of 188 turkeys missing a rivet band for a retention probability of 0.984 (95% CI = 0.96–0.99). If
24 male turkeys are double-banded with rivet bands the probability of recovering a turkey without
25 any marks is <0.001. We failed to detect a change in band retention over time or differences
26 between adults and juveniles. Given the low cost and high retention rates of rivet aluminum
27 bands, we believe they are an effective marking technique for wild turkeys and, for most studies,
28 will minimize any concern about the assumption that marks are not lost.

29 Keywords: aluminum, *Meleagris gallopavo*, New York, Pennsylvania, retention, rivet band, wild
30 turkey

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Introduction

46 No loss of marks is a critical assumption of mark-recapture models so they provide unbiased
47 estimates of population parameters. For wild turkeys (*Meleagris gallopavo*), butt-end aluminum
48 leg bands have typically been used to mark birds but these bands were found to have retention
49 probabilities <1.0 (Diefenbach et al. 2009, Butler et al. 2011). Diefenbach et al. (2009) reported
50 retention probabilities differed between adults and juveniles and declined to <0.233 after 15
51 months. Butler et al. (2011) reported no differences in retention among sex-age classes, but
52 retention probability was 0.864 15 months after banding.

53 One approach to account for tag loss is to have a sub-sample of animals fitted with a
54 permanent mark so that loss rates can be estimated and incorporated into the estimator (Laake et
55 al. 2014). However, a better solution is to use marks that have retention probabilities close to 1.0
56 as long as they are inexpensive and easy to apply. Diefenbach et al. (2009) and Diefenbach et al.
57 (2012) used rivet bands to mark wild turkeys and assumed the retention probability of these
58 bands was 1.0. Our objective was to estimate the retention of rivet aluminum leg bands on wild
59 turkeys.

60

Study Area

61 The study area encompassed the range of wild turkeys in New York and Pennsylvania. We
62 captured male turkeys throughout upstate New York (except Essex and Rensselaer counties)
63 north of Rockland and Westchester counties as part of a study of harvest rates (Diefenbach et al.
64 2012). Captures in Pennsylvania occurred throughout the state for a study of male harvest rates
65 (Diefenbach et al. 2012), but most captures (of both male and female wild turkeys) occurred in
66 central Pennsylvania in wildlife management units 2C, 2E, 4A, 4B, 4D, 2F, 2G, and 2H for a
67 study of female harvest rates
68 (<http://www.portal.state.pa.us/portal/server.pt?open=514&objID=619923&mode=2>, accessed 27
69 October 2015).

70 **Methods**

71 We baited capture sites with cracked corn and used rocket nets to capture turkeys (Delahunt et al.
72 2011). During December 2008–March 2009, we captured male turkeys in New York and
73 Pennsylvania, although all but one capture occurred January–March. Beginning in August 2012
74 and ending October 2014, we captured male and female turkeys in central Pennsylvania during
75 August–October and January–March .

76 We determined age of turkeys (ad: >1 yr old; juv: <1 yr old; Delahunt et al. 2011) and
77 fitted them with an aluminum rivet band (National Band and Tag, Newport, KY) below the spur
78 on each leg. We fitted females with rivet band model 1242FR8 and males with model 1242FR9.
79 Each band was imprinted with a unique alphanumeric sequence and listed a toll-free number for
80 reporting recovery of a band.

81 We conducted analyses with R.3.1.2 (R Development Core Team 2012, [www. R-
82 project.org](http://www.R-project.org), accessed 31 Oct 2014) and used conditional logistic regression (package `mrds`,

83 <http://cran.r-project.org/web/packages/mrds/>, accessed 29 June 2015) to estimate the proportion
84 of rivet bands retained. The analysis was equivalent to distance sampling double-observer
85 surveys where the probability of an object being detected (i.e., each band being retained) is
86 estimated conditional on at least one observer detecting the object (i.e., at least one band being
87 retained; Burnham et al. 2006). We investigated models in which band loss was related to age of
88 turkeys at time of banding (ad and juv), weeks between banding and recovery, and an intercept-
89 only model. We used Akaike's Information Criterion adjusted for sample size (AIC_c) to identify
90 the best model (Burnham and Anderson 2002).

91 **Results**

92 We obtained recoveries of 188 males (40 ad, 148 juv) and 37 females (19 ad, 17 juv). Recoveries
93 occurred between <1 and 225 weeks since banding ($\bar{x} = 51.2$ weeks, $SD = 44.0$). All females
94 were recovered with both rivet bands present so we conducted no further analyses on these data.
95 For males, 6 of 188 turkeys were recovered missing one band 15–91 weeks after banding ($\bar{x} =$
96 42.3 weeks, $SD = 12.0$).

97 The model with the lowest AIC_c value was the intercept-only model, although models
98 that included age ($\Delta AIC_c = 1.96$) or time ($\Delta AIC_c = 1.52$) were competitive. However, the age
99 model indicated greater retention by adults (slope coefficient = 0.31, $SE = 1.11$), which was
100 opposite of what was reported by Diefenbach et al. (2012). The time model indicated increased
101 retention over time (slope coefficient = 0.008, $SE = 0.011$), whereas both Diefenbach et al.
102 (2009) and Butler et al. (2011) reported increased band loss over time. Consequently, we
103 selected the intercept-only model (intercept = 4.105, $SE = 0.4149$) as the best model because
104 results of the other models were contrary to our expectations (i.e., other studies have found lower

105 retention rates for adults and reduced retention over time) and the slope coefficients were not
106 different from zero. We estimated the retention probability of a single rivet band for males was
107 0.984 (95% CI = 0.96–0.99).

108 **Discussion**

109 The loss of butt-end bands on wild turkeys reported by Butler et al. (2011) indicated band-
110 recovery models would exhibit negative bias in survival rates of –4% to –6%. We observed
111 100% retention in females ($n = 37$) and 98.4% retention in males ($n = 188$) and suggest that use
112 of rivet bands on wild turkeys would introduce little bias in dead-recovery models using this
113 marking technique. The highest retention scenario modeled by Nelson et al. (1980), which was
114 lower than what we estimated for rivet bands, indicated bias of –2% to –0.4% depending on the
115 length of the study.

116 In contrast to previous studies of loss of butt-end bands by wild turkeys (Diefenbach et al.
117 2009, Butler et al. 2011), the model that estimated band loss as a function of time (weeks)
118 suggested that retention increased over time. Although the effect was small, the model suggested
119 that a rivet band was 1.03 times more likely to be retained for every 4 weeks the band was on the
120 turkey (95% CI = 0.99–1.08). Another explanation for this result is that failure in rivet bands
121 occurs soon after being deployed but otherwise they are retained. If this interpretation of the time
122 model is correct, it further supports the use of the estimated loss probability of 0.984 for most
123 mark-recapture studies.

124 The objectives of a given study, however, will determine an acceptable loss rate for
125 marks. Therefore, if researchers need to further minimize the probability of a wild turkey losing
126 its mark (using a rivet band) then birds could be double-banded. If we assume loss of each rivet

127 band were independent (*sensu* Diefenbach and Alt 1998), by double banding wild turkeys the
128 probability of recovering a banded bird with both bands missing would be near zero ($0.0003 = [1$
129 $- 0.984]^2$). We were not able to test for independence of loss of bands, such that loss of one band
130 would mean loss of a second band is more likely, but dependence is unlikely to be a concern
131 with so few bands lost (Diefenbach and Alt 1998, Laake et al. 2014).

132 Butler et al. (2011) suggested that there was enough variability among turkey populations
133 that data from some banding programs based on butt-end bands might be useful for population
134 monitoring. We believe the results of analyses that rely on recaptures of wild turkeys banded
135 with butt-end bands with the assumption that marks are not lost should be interpreted with
136 caution. A better alternative would be to conduct a pilot study and band a sample of birds with
137 rivet and butt-end bands to estimate the loss rate of butt-end bands (e.g., Diefenbach et al. 2009).
138 Such an approach could allow for an ad hoc adjustment for bias introduced in the estimator. A
139 preferred approach is to use estimators that incorporate tag loss directly into the estimator when a
140 subsample is permanently marked (Conn et al. 2004, Laake et al. 2014). However, such models
141 are advantageous only when it is not possible to permanently mark all animals because of cost or
142 logistics.

143 **Archived Material**

144 **Text A1.** Code (for program R using the package *mrds*) to estimate band retention in wild
145 turkeys (*Meleagris gallapavo*) double-banded with rivet bands in Pennsylvania, USA, 2008-
146 2014. . Archived in Dryad Digital Repository: <http://dx.doi.org/10.5061/dryad.8433>

147 **Text A2.** Data of band retention for male and female wild turkeys (*Meleagris gallapavo*) double-
148 banded with rivet bands in Pennsylvania, USA, 2008-2014. . Archived in Dryad Digital
149 Repository: <http://dx.doi.org/10.5061/dryad.8433>

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