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SHORT COMMUNICATIONS

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LONGEVITY OF BALD EAGLES FROM AUTUMN CONCENTRATIONS IN GLACIER NATIONAL PARK, MONTANA, AND ASSESSMENT OF WING-MARKER DURABILITY

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KEY WORDS: *Bald Eagle*; Haliaeetus leucocephalus; *eagle longevity*; *mortality*; *wing markers*; *marker durability*.

We present data collected subsequent to the publication of McClelland et al. (1994). In that study, 303 Bald Eagles (*Haliaeetus leucocephalus*) were banded with U.S. Fish and Wildlife Service pop-rivet aluminum leg bands between 1977 and 1993, in Glacier National Park, Montana (GNP). Wraparound patagial wing markers were placed on 121 of the 303 eagles and 66 were equipped with battery-powered VHF transmitters (55 tail mounts and 11 backpacks). With few exceptions, Bald Eagles at autumn concentrations in GNP came from summering areas in northwestern Canada en route to wintering sites south and west of GNP. The eagles stopped in GNP to feed on spawning kokanee salmon (*Oncorhynchus nerka*). The kokanee population collapsed in the late 1980s; consequently, there no longer are autumn concentrations of Bald Eagles in GNP (Spencer et al. 1991).

Herein, we assess eagle longevity and marker durability from sightings of live eagles and from eight dead eagles recovered after the 23 reported in McClelland et al. (1994).

METHODS

At the time of banding, each eagle's age was estimated based on a hatching date in June (thus, June is 0 mo, July is 1 mo, etc.; Klimkiewicz 2002) and on plumage criteria described by McCollough (1989). Eagle sex was judged using a formula based on morphological measurements, described in McClelland et al. (1994:11). Reports of dead eagles came from the U.S. Geological Survey Bird Banding Laboratory (BBL), Patuxent, Maryland, and from the public. Three of five dead, transmitter-equipped eagles were located by following the radio signals. Monitoring of wing-marked eagle A-38 was conducted by experienced observers who searched the eagle's previously known wintering area, south of GNP, each winter after 1999.

We conducted an assessment of whether the presence of wing markers influenced the reporting rates or survival of eagles found dead. We did not use data from radiotelemetry because of insufficient samples. Throughout analyses of marker data, we assumed marker loss was negligible. However, in reality, marker loss commonly occurs and could have influenced survival estimates. We observed loss as early as 2 wk and as long as 22 yr post-marking; Kochert et al. (1983) reported 40% loss of markers on Golden Eagles (*Aquila chrysaetos*) after 20 mo.

We used the joint live/dead model described by Burnham (1993) in Program MARK (White and Burnham 1999). We used Akaike's Information Criteria (AIC; Akaike 1973, Shibata 1989) to find a balance between overfitting a model (adding parameters to a model to decrease bias) and underfitting (reducing the number of parameters to increase precision of the estimates). Thus, AIC seeks to find the most parsimonious model that has a sufficient number of parameters to explain variation in the data (Burnham and Anderson 2002).

The ''best'' model (i.e., with the lowest AIC) included a group effect (i.e., wing markers or not) for survival (S) and resighting probability (p) of live birds, but no group effect for recovery probability (r) or fidelity (F). In this context, F is defined as the probability of fidelity to the sampling region, i.e., remaining in the sample, and 1 - F is the probability of permanently emigrating (Burnham 1993). We assumed that F did not differ by time, eagle age, or between eagles with and without wing markers.

RESULTS AND DISCUSSION

Dead Eagles and Marker Effects. Between 1994 and 2000, we received reports on eight additional dead Bald Eagles (Table 1); four were males. Overall in this study, 52% of dead eagles ($N = 31$) and 56% of all eagles banded ($N = 303$) were males (χ^2 test of independence = 0.234, df = 1, $P = 0.629$), suggesting sex of eagles did not influence mortality. The estimated ages of the eight eagles when recovered ranged from 2 yr 8 mo to 22 yr 6 mo (mean = 12 yr 2 mo). Ten percent of the 303 banded eagles now have been reported dead (Table 2), with a mean age at

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Table 1. Migrating Bald Eagles banded and marked at autumn concentrations in Glacier National Park (GNP), Montana, and subsequently recovered in 1990–2000. Eagles are listed by increasing age at death (Addendum to Table 13 in McClelland et al. 1994).

Eagle[a]	Marker/ Transmitter[b]	Date		Time Between Marking and Recovery yr (mo)	Estimated Age at Death yr (mo)	Recovery Location	Distance from GNP (km)	Circum-stances[d]
		Marked	Recovered[c]					
JuvM	B-T	16 Nov 87	Feb 90	2 (3)	2 (8)	Near Twin Bridges, MT	352	unknown
JuvM		11 Nov 88	21 Mar 97	8 (4)	8 (9)	Near Hyrum, UT	822	poisoning
AdF19(2)	W	25 Nov 88	Nov 93	5 (0)	9 (6)[e]	Pincher Creek, Alberta	111	unknown
JuvF26(2)	W, T-T	16 Oct 86	Apr 96	9 (6)	9 (11)	Fox Creek, Alberta	682	injured, died
JuvF[f]		6 Nov 86	5 Mar 97	10 (4)	10 (9)	Near Billings, MT	532	unknown
AdM74(2)[g]	W, B-T	30 Nov 86	24 Apr 95	9 (5)	13 (11)[e]	Near Condon, MT	113	hit by vehicle
JuvM[f]		7 Oct 80	22 Jan 00	19 (3)	19 (7)	Near Idaho Falls, ID	600	unknown
SubF		27 Oct 80	7 Dec 99	19 (1)	22 (6)[e]	Near Condon, MT	113	hit by vehicle

[a] Age class on banding date grouped using McCollough's (1989) criteria: Juv (Juvenal Plumage), Sub (Subadult; Basic I, II, and III Plumages), and Ad (Adult; Basic IV and Definitive Plumages); Sex (M = male, F = female); wing-marker number (e.g., 19); (2) code reused after previous eagle died.

[b] All eagles leg-banded; W = wing markers; T-T = tail-mount transmitter; B-T = backpack transmitter.

[c] If eagle was recovered long after death, estimated month of death is shown.

[d] D = All eagles except JuvF26 found dead.

[e] Minimum age estimate because of variable plumage characteristics.

[f] Reported by the National Eagle and Wildlife Property Repository (Commerce City, CO), which received the eagles from U.S. Fish and Wildlife Service special agents. Dates of actual recoveries, precise locations, and identification of finders were not available. Dates of recoveries were estimated as 5 mo prior to Repository receipt dates.

[g] At recovery, still equipped with a backpack transmitter, 9 yr 5 mo after marking.

Table 2. Recoveries of Bald Eagles ($N = 31$) banded and marked ($N = 303$) at autumn concentrations in Glacier National Park, Montana, 1977–2000 (update to Table 14 in McClelland et al. 1994).

		EAGLES BANDED AND MARKED		KNOWN DEAD	
GROUP NO.	METHOD	NO.	PERCENT OF TOTAL BANDED	NO.	PERCENT DEAD
1	Leg band	176	58.1	9	5.1
2	Leg band and wing markers	61	20.1	10	16.4
3	Leg band, wing markers and tail-mount transmitter[a]	54	17.8	3	5.6
4	Leg band and wing markers without tail-mount transmitter (Group 3 after central-rectrix molt)[a]	51	–	7[b]	13.7
5	Leg band, wing markers, and backpack transmitter	6	2.0	1	16.7
6	Leg band and tail-mount transmitter	1	0.3	0	0
7	Leg band and backpack transmitter	5	1.7	1	20.0

[a] Because all tail-mount transmitters were shed at the next central rectrix molt, no eagles remained in Group 3 after that molt; all that were still alive become part of Group 4. It is not known how many actually were alive at that time ($N \leq 51$).
[b] Seven of the eagles originally equipped with tail-mount transmitters ($N = 54$) were found dead after the transmitters were shed in a molt prior to the year of death.

death of 7 yr 1 mo (range = 7 mo–22 yr 6 mo). Eagles banded and equipped with wing markers (excluding those also equipped with transmitters) were more likely to be reported dead (16.4%, 10 of 61) than eagles with only a standard aluminum leg band (5.1%, 9 of 176; $\chi^2 = 7.82$, df = 1, $P = 0.005$).

Calculation and statistical analyses of percent of dead eagles with tail-mount transmitters were complicated by feather molt and resultant change in status of these eagles after marking. Specifically, because eagles shed the central rectrices and transmitter during the first molt, it was not known how many of these birds survived post-molt (i.e., group 4, Table 2). Retention time for rectrices is not well documented for wild Bald Eagles. In a 15-yr study of captive Golden Eagles, Ellis and Kéry (2004) found that tail-feather retention was usually 2 yr, with alternating loss of left and right central rectrices. In wild-caught Golden Eagles, Bloom and Clark (2001) reported that: ''Tail molt is often not symmetrical and becomes less symmetrical as eagles increase in age.'' All tail-mount transmitters we recovered ($N = 11$) had been shed during the first spring/summer after marking, with the transmitter still attached to the two central rectrices. If left and right central rectrices normally are molted in alternating years, the mass of the transmitter apparently induced loss of the remaining feather after the first was molted.

We found some evidence that both survival and reporting rates differed between eagles with and without wing markers (i.e., banded only). Annual survival rates were estimated as 0.88 (±0.03 SE) and 0.98 (±0.01 SE) for eagles with and without wing markers, respectively. Resighting probability (p) of live eagles was estimated as 0.27 (±0.03 SE) and 0.004 (±0.002 SE) for eagles with and without wing markers, respectively. Low resighting of eagles without wing markers was expected; to be identified, eagles with only leg bands must be recaptured or perched close enough for an observer to read the band code with a spotting scope.

Based on either AIC or a likelihood ratio test ($\chi^2 = 0.008$, df = 1, $P = 0.927$) the estimation of a separate reporting rate (r) of dead eagles was not warranted ($\hat{r} = 0.16 \pm 0.04$ [SE] and 0.06 ± 0.02 for eagles with and without wing markers, respectively). The lack of statistical significance of these differences may be attributed to the low number of eagles reported. We suspect that eagles with brightly colored markers (orange and yellow in our study) were much easier to see in concealing vegetation than an eagle with only a leg band. It should also be noted that the reporting rate assumes all dead eagles were reported with equal probability. The inducement to make a report may be stronger when a dead eagle has a wing marker than when it has only a leg band. Parameterizations that distinguish retrieval and reporting exist for hunted species, but are not available for Bald Eagles, for which additional ancillary information will be necessary (Brownie et al. 1985). We found no studies that addressed this reporting disparity and a BBL contact knew of no such study (K. Klimkiewicz pers. comm.).

The dangers posed by wing markers and transmitters are well documented (McClelland et al. 1994, Steenhof et al. 2006). However, we have no evidence that any of the 31 recorded eagle deaths in our study were a result of a marker or transmitter. Cause of death was known for only two of 10 banded, unmarked eagles: one poisoned and one hit by vehicle. Cause of death was known for 10 of 22 marked eagles: four shot, two poisoned, one hit by vehicle, one hit by train, one porcupine (*Erethizon dorsatum*) quill in throat, and one unspecified injury.

Compared to a permanent (penetrating) patagial marker, the potential loss of a wraparound wing marker, although a disadvantage to the researcher may provide a safety advantage to the bird. If a wraparound marker

becomes snagged on a branch or wire, the eagle's wing may simply slip out of the marker (see McClelland 1994). A marked nestling may be more vulnerable to hooking a marker in a manner that precludes extricating itself (Gerrard et al. 1978).

Backpack transmitters have an inherent disadvantage for the bird compared to tail-mount transmitters. In a recent study at Birds of Prey National Conservation Area, Idaho, Prairie Falcons (*Falco mexicanus*) equipped with satellite transmitters had significantly lower survival than untagged falcons (Steenhof et al. 2006). A tail-mount transmitter, shed in the first central-rectrix molt (a disadvantage to the researcher), has a shorter hazard period than a backpack transmitter. Some backpacks remain on eagles for years, long after operation has ceased, even when biodegradable thread is used to affix the harness (e.g., Eagle AdM74 carried a backpack for 9 yr 5 mo). Additionally, even the attachment method for backpacks may influence degree of potential harm to an eagle (Buehler et al. 1995). In projects where auxiliary markers have distinct advantages to researchers, a decision to use them must be justified recognizing potential negative impacts (including death) to marked raptors.

Rehabilitation of an Injured, 22-yr-old Eagle. U.S. Bureau of Land Management Biologist S. Robinson (pers. comm.) reported that an adult Bald Eagle (11657) was found alive, but injured, on the ice of Lake Coeur d'Alene, ID U.S.A., on 28 December 2001. It had been banded 6 December 1981 in GNP, 217 km from the encounter site. After treatment by a veterinarian and rehabilitation, the eagle was released in the Coeur d'Alene area on 16 January 2002. At banding, the eagle was classified as a male. Basic II Plumage (McCollough 1989) indicated it was 2 yr 6 mo old. Thus, at the time of release in Idaho, it was approximately 22 yr 7 mo old.

Observations of Wing-marked Eagle A-38 (Marker Longevity). Eagle A-38 was tagged with two wraparound wing markers in GNP on 2 November 1979. This eagle was reported during winters 1987–90 near Lolo, MT U.S.A., 122 km south of the capture location (McClelland et al. 1994). On 2 January 1999 (19 yr 20 mo. post-capture), coauthor M. McFadzen, K. Newlon, and M. Burcham observed the eagle about 18 km west of Lolo. The markers (TXN-18) vinyl-coated nylon (Cooley, Inc., Pawtucket, RI U.S.A.) were faded, but easily identified as international orange. The edges were somewhat curled, but did not obscure the slightly faded code characters (black silkscreen ink). The markers had not rotated, as had been the case with two marked eagles we had observed previously.

On 28 November 1999, A-38 was again observed near Lolo Creek, in the same black cottonwood (*Populus balsamifera*) grove in which it had been seen the previous winter. On a 5 March 2000 sighting, A-38 had lost the left wing marker. On 2 March 2001, this eagle was observed (right marker, code read) at the same location. Our final observation of A-38 was on 2 January 2002, when the eagle's remaining marker had been in place for 22 yr 2 mo (eagle age 22 yr 7 mo). Searches for A-38 during the winters of 2002–03 and 2003–04 and late autumn 2004 were unsuccessful.

This observation of a wraparound patagial marker still in place on a Bald Eagle after 22 yr 2 mo appears to represent the maximum longevity so far reported for this type of marker. In a Saskatchewan study, two Bald Eagles with wraparound patagial markers were last seen 21 yr after marking (G. Bortolotti pers. comm.). Kochert et al. (1983) reported that Golden Eagles retained wraparound patagial markers for 10 yr in a southwestern Idaho study.

Eagle Longevity. The BBL web site currently lists 29 yr 7 mo as the longevity record for Bald Eagles (Klimkiewicz 2002). That eagle was banded and recovered in Michigan (J. Holt, Jr. and S. Postupalsky pers. comm.). On the BBL recovery record, all eagles older than 22 yr were banded east of the Mississippi River. Encounters and sightings do not enter the BBL records unless they are reported directly to the BBL; the BBL does not process records from publications. For example, the record of a 28 yr 0 mo old Bald Eagle recovered in Alaska, published by Schempf (1997) is not on the current BBL list. Harmata et al. (1999) reported recovering no Bald Eagle older than 12 yr in a Greater Yellowstone Ecosystem study.

Based on our review of recovery data from the BBL, the two 22 yr 7 mo old eagles (wing-marked eagle A-38 and rehabilitated eagle 11657) and 22 yr 6 mo old dead eagle 08001 appear to be the oldest wild Bald Eagles banded west of the Mississippi River in the contiguous United States, reported to date.

Addendum: In May 2006, the BBL informed us that a new longevity record of 30 yr 9 mo had been confirmed for Bald Eagles (Klimkiewicz pers. comm.). The eagle was banded in Ontario, Canada, by J. Grier (pers. comm.) and recovered in Iowa.

LONGEVIDAD DE *HALIAEETUS LEUCOCEPHALUS* EN CONCENTRACIONES DE OTOÑO EN EL PARQUE NACIONAL GLACIER, MONTANA, Y EVALUACIÓN DE LA DURABILIDAD DE LAS MARCAS COLOCADAS EN LAS ALAS

RESUMEN.—Presentamos datos recolectados con posterioridad a la publicación de McClelland et al. (1994). En ese estudio, 303 águilas de la especie *Haliaeetus leucocephalus* fueron marcadas en las patas con anillos del U.S. Fish and Wildlife Service en el Parque Nacional Glacier, Montana, entre 1977 y 1993. Además, se colocaron marcadores en el patagio de las alas en 121 de las 303 águilas, y a 66 de éstas se les acoplaron transmisores de VHF. Las edades estimadas de ocho águilas encontradas muertas tras la publicación de McClelland et al. estuvieron entre 2 años y ocho meses, y 22 años y seis meses. Observamos un águila con una marca patagial aún intacta, con el código legible 22 años y dos meses después de haber sido marcada. Tres de las águilas para las que presentamos

datos (dos de 22 años y siete meses y una de 22 años y seis meses de edad) parecen ser registros récords de longevidad para individuos de esta especie anillados al oeste del Río Mississippi en los Estados Unidos continentales.

[Traducción del equipo editorial]

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