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MOLTING SEQUENCE AND AGING OF BALD EAGLES

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ABSTRACT.—Photographs of 135 wintering Bald Eagles (*Haliaeetus leucocephalus*) of known age were examined to document plumage changes. Criteria were established to age ½-year (Juvenile Plumage), 1½-year (Basic I), 2½-year (Basic II), and 3½-year (Basic III) eagles; primarily from head plumage and iris, beak, and cere color. Body plumage varied among individuals and was not a reliable aging characteristic. Definitive plumage was observed on 4 of 17 4½-year (Basic IV) and all 5½-year (Basic V) eagles; however, individuals up to 8½ years-of-age were observed with gray or brown flecking in the head plumage. Photographs of wintering eagles demonstrated that yearly body molt was not complete. *Received 24 Apr. 1987, accepted 19 Oct. 1987.*

The age at which Bald Eagles attain “adult” plumage (the “definitive plumage” of Palmer 1972) has not been documented clearly. Most authors have described a similar progression of plumage changes that were assumed to be associated with age (Bent 1927; Southern 1964, 1967; Sherrod et al. 1976); however, these descriptions were based on wild birds and study skins of unknown ages. Gerrard et al. (1978), Clark (1983), and Bortolotti (1984) each has named his own general plumage classes of subadult Bald Eagles derived from observations of a small number of known-age wild birds. The purpose of this paper is to document maturation of a large sample of known-age Bald Eagles from Maine and the Canadian Maritime Provinces, describe the characteristics associated with distinct plumages in traditional molt terminology, and provide distinguishing characteristics for aging young eagles in the field.

METHODS

From 1976 to 1985, 428 eaglets (>95% of those known produced) were banded in Maine. Known-age banded Bald Eagles from ½ to 8½ years-of-age subsequently were photographed

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Juvenal Plumage
1/2 Year



Basic III Plumage
3 1/2 Year



Basic I Plumage
1 1/2 Year



Basic IV Plumage
4 1/2 Year



Basic II Plumage
2 1/2 Year



Definitive Plumage

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Plumage classes of Bald Eagles. Both dark and light variations in head plumage of Basic III plumage are illustrated.

A known-age Bald Eagle with "pre-definitive" plumage at 7-1/2 and 8-1/2 years of age (bottom right) is also illustrated.

while perched on the ground at winter feeding stations in Cobscook and Frenchman Bay during the winters of 1984–85 and 1985–86 (McCollough 1986). The age, identity, and origin of the birds were determined by reading the U.S. Fish and Wildlife Service (FWS) band or supplementary color bands and tags with an 80× telescope. A series of photographs were taken of each eagle from a blind 20 to 30 m from the eagles using a 600-mm lens. Plumage characteristics and bill, cere, and iris color were recorded from the photographs.

RESULTS

Photographs of 135 known-age eagles were examined. One-hundred-fourteen of the eagles were banded in Maine, 12 in New Brunswick, 5 in Nova Scotia, 3 in Prince Edward Island, and 1 in Ontario. Twenty-three eagles were photographed in both winters.

Six plumages were delineated corresponding to age (terminology after Palmer 1972, Fig. 1). Bald Eagles have one plumage per year, and sexes are similar in feathering. The juvenal plumage is the first covering of true contour feathers acquired in the nest and is succeeded by basic plumages in subsequent years. Basic plumages are acquired by molts that are initiated each spring and completed in the late fall and retained through the following winter (Stalmaster 1987). Two captive Maine eagles initiated molt for basic plumages in April and completed molt in October.

A Bald Eagle in definitive plumage has a white head, tail, and upper and lower tail coverts. Definitive plumage was first observed in eagles 4½ or 5½ years-of-age (Basic IV and V plumage). Flecks of brown or gray were common on the head and tail of birds in definitive plumage. Distinguishing characteristics of plumages are illustrated in the Frontispiece. Characteristics useful in distinguishing age classes are discussed below. Color descriptions are from Palmer (1962:5–6). Sample size following each plumage denotes N_x = total number of birds photographed of the designated age (x) and N_{x+1} = number of these birds photographed again in the following winter.

Juvenal plumage (½ year, $N_{0.5} = 36$, $N_{1.5} = 3$).—Juvenal plumage was completed at 11 to 14 weeks of age and was a uniform blackish-brown. By winter, prolonged exposure to the sun had bleached the crown to a buffy-brown contrasting with the blackish-brown auriculars. Buff-brown to smoke-gray coloration was restricted to the chin of 32 birds but extended down the throat of the other four individuals. A good field characteristic was the uniform blackish-gray beak and cere. The interior of the nares was blackish-gray in 30 birds and light cream in 6 birds. The iris was sepia.

The belly and underparts were generally buffy-brown and variably mottled with dark brown in contrast to the dark brownish-olive breast feathering with faint buffy-brown tips. The basal portions of the nape feathers and contour feathers were whitish (Fig. 2) and gave the appearance of

Age in half years	1/2	1-1/2	2-1/2	3-1/2	4-1/2	5-1/2	
Calendar year	First	Second	Third	Fourth	Fifth	Sixth	
Plumage	Juvenile	Basic I	Basic II	Basic III	Basic IV	Basic V	
Molt	Prebasic I	Prebasic II	Prebasic III	Prebasic IV	Prebasic V		
Southern (1967)	A B, B/C Immature	C C/D Belly	D	E, F?	F	G	
Clark (1983)	Dark Immature	White Belly	Mottled	Transitional		Adult	
Bortolotti (1984)	Young immature	Old immature	Subadult		Adult		

FIG. 1. Characterization of plumage and molt sequence for Bald Eagles, including comparisons of plumage descriptions of Southern (1967), Clark (1983), and Bortolotti (1984).

white mottling in a strong breeze or when the feathers were wet and matted.

All wing coverts were dark brown and sometimes had smoke-gray or buffy-brown margins. Primaries and secondaries were sooty-black. Wing linings and axillars were mottled white. The distal $\frac{1}{3}$ of the rectrices were sooty-black, and the inner vanes were mottled pale gray and sooty-black. This tail pattern resembled that of a juvenile Golden Eagle (*Aquila chrysaetos*); however, the terminal brown band was not as broad and distinct from the sooty-gray proximal $\frac{2}{3}$ of the rectrices.

The shape of the juvenal contour feathers, wing coverts, nape feathers, and secondaries were noticeably different from the basic plumages (Fig. 2). The juvenal belly and chest feathers and primary, secondary, and middle coverts were longer and had more acute apices. The nape feathers were shorter with a more obtuse apex and became more lanceolate in the basic plumages. Eagles in juvenal plumage had longer secondaries with cuspidate apices that gave a serrated trailing edge to the wing that could be observed in flight.

Basic I plumage (1½ year, $N_{1.5} = 35$, $N_{2.5} = 9$).—The distinguishing characteristics of this plumage were in the head, beak, cere, and iris. The tan crown was noticeably lighter than in the juvenal plumage and thus sharply contrasted with the blackish-brown auriculars. The beak was predominantly blackish-gray. Thirty birds had buffy-yellow restricted to the base of the beak next to the cere or at the curve of the beak. All Basic I eagles had a blackish-gray cere with buffy-yellow interior of the nares and the lining of the nares. The iris lightened to buffy-brown in all but one individual which had advanced to light cream typical of 2½-year eagles.

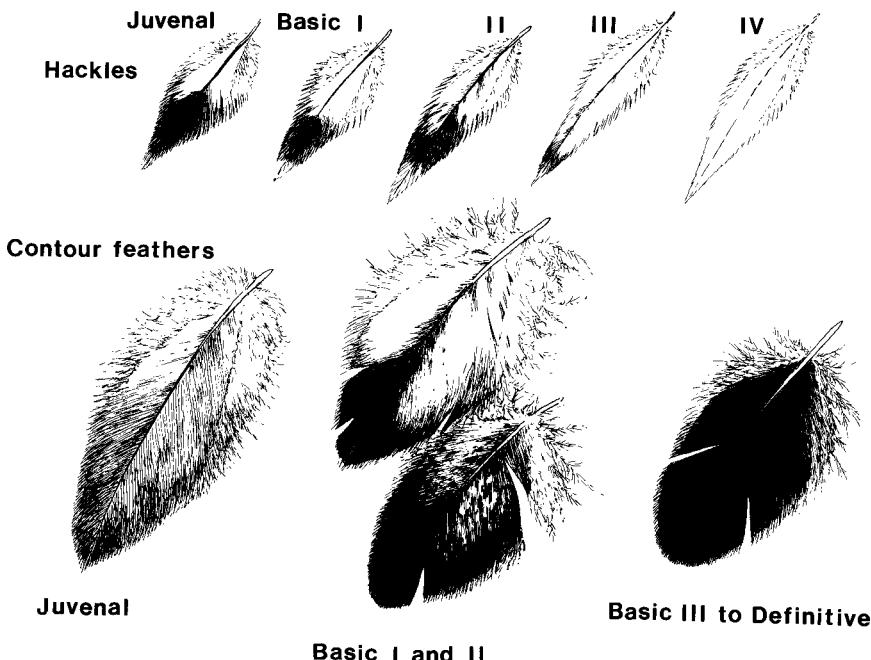


FIG. 2. Variation in nape feathers and contour feathers of Bald Eagles collected from known-age eagles. Nape feathers depicted were from the back of the head immediately posterior from the eye. Contour feathers depicted were from the base of the sternum (drawing by author).

The breast was 70–100% brownish-olive with variable white mottling but was always darker than the belly, giving the appearance of a bib. The belly and underparts were extremely variable and ranged from dark brown to nearly pure white. The extent of brown in the breast and belly depended on the amount of pigmentation of the contour feathers (Fig. 2). A white-mottled inverted triangle was distinct on the mantle of 31 birds. Four birds retained a dark brown mantle.

The middle and greater wing coverts were brownish-olive and variably mottled white. The rectrices were dark-tipped, but somewhat lighter than the juvenal plumage. Primaries, secondaries, and rectrices of Bald Eagles decrease in length with increasing age (Bortolotti 1984). Retention of some of the longer, pointed juvenal secondaries into the Basic I plumage was particularly noticeable in flight and produced an uneven trailing edge to the wing. Also, the outer rectrices of the 1½-year eagles were more rounded instead of blunt-ended as in the juvenal plumage.

Basic II plumage (2½ year, $N_{2.5} = 29$, $N_{3.5} = 3$).—The distinguishing characteristics of this plumage were in the head, beak, cere, and iris. The auriculars retained the appearance of a broad, brown band that extended through the eye but was flecked with light tan or smoke-gray. The crown was a light smoke-gray, and the throat lightened to an extensive white or buffy-white patch that started at the corner of the mouth and extended down the throat to the top of the breast. This coloration gave an “Osprey-like” (*Pandion haliaetus*) appearance to the bird. All 29 birds had a blackish-gray beak variably mottled with buffy-yellow at the base and as a line extending forward from the nares or from the tip of the upper mandible extending backward. The lower mandible was buffy-yellow at the distal end and faded to blackish-gray at the proximal end. The cere was predominantly buffy-yellow mottled with gray. The iris color was light cream, although one bird retained the light buffy-brown typical of 1½-year eagles.

At this age, there was a tendency for the belly and chest to be considerably darker, but body plumage varied among individuals. Twenty-seven birds had a predominantly brown belly and chest with little (<30%) white flecking. Three eagles had an entirely brown belly and chest; however, two birds retained a mostly (60%) white belly and white mottled chest. The mantle was darker than Basic I plumage, with a less distinct inverted white triangle. Two birds had a completely brown mantle.

The greater and middle coverts were all brown in 9 eagles, but the others retained some feathers with white mottling from the previous plumage. The distal ⅓ of the rectrices was mottled brown and was smoke-gray proximally.

Basic III plumage (3½ year, $N_{3.5} = 19$, $N_{4.5} = 3$).—Molt into Basic III plumage produced a notable change into near-definitive appearance. The head was white with distinct brown flecking on the forehead and crown. Fifteen birds had brown or gray flecking extending posteriorly behind the eye and darker flecking around the eye. The white nape feathers of these birds extended only partially down the neck. Three birds had faint gray flecking through the cheek without an eye stripe and one had a pure white head with faint gray flecking around the eye. Seventeen eagles had a predominantly yellow beak usually with a brown-black line extending forward from the nares and along the crest of the beak. One bird had a pure yellow beak and another retained beak coloration similar to a 2½-year-old eagle. The lower mandible was almost pure yellow. Most Basic III eagles had a yellow cere with some blackish-gray mottling dorsally (15 birds) but the cere was pure yellow in three birds, and one bird’s cere was yellow only at the nares. The iris was pale yellow.

The contour feathers generally were dark brown with buffy margins;

however, five eagles had slight white flecking on the belly and chest and two birds had slight white flecking on the mantle. Wing coverts were dark brown, but three eagles had slight white mottling on the proximal wing coverts. Some white flecking was evident on the wing linings in flight. The rectrices of all birds were mostly white, with brown flecking proximally and heavy brown mottling on the distal margins of the feathers.

Basic IV plumage (4½ year, $N_{4.5} = 17$, $N_{5.5} = 1$).—The only consistent field-identification characteristic distinguishing Basic III and IV plumages was the predominantly white rectrices of the Basic IV that lacked a terminal brown stripe. Four birds were in definitive plumage with white heads and tails. The remaining 13 birds had white heads with brown flecking around the eye and on the forehead next to the cere. One eagle had a heavily flecked eye stripe and, apart from the nearly white tail, would easily be confused with a 3½-year eagle. The beak and cere were yellow but usually had light brown at the base that extended forward as a faint line from the nares. The cere was usually all yellow. The iris was pale yellow. The body contour feathering and wing coverts were dark brown with the margins of the feathers tipped with buffy-brown.

Basic V plumage (5½ year, $N_{5.5} = 6$, $N_{6.5} = 1$).—All six birds were in definitive feathering and were indistinguishable from the four, 4½-year birds in definitive Basic IV plumage. The beak and cere were generally yellow, but two birds had slight brown mottling at the base of the beak or top of the cere. The head was white with faint gray flecking around the eyes. The iris was pale yellow. The body and wings were dark brown with scalloped buffy feather margins. Rectrices were white with occasional flecks of black or brown.

Older eagles ($N = 13$, 4 photographed in successive plumages).—Twelve birds were in definitive plumage; however, one eagle photographed at 7½ and 8½ years-of-age had extensive gray flecking around the eyes, auriculars, and forehead (see Frontispiece). In 1984, 6½-year eagle was photographed with similar markings, but had molted into a pure white head plumage when photographed in 1985 at 7½ years-of-age.

DISCUSSION

In all 24 instances when an individual eagle was photographed in two successive winters, the plumage conformed to the six plumages described. This supports the interpretation that changes in plumage and in color of the beak, cere, and iris are age-related and are not the result of random variation among subadults. In addition, 108 banded eagles were observed, but not photographed, during two to four successive winters at the feeding stations. The observed plumage and color changes of these also followed the sequence described. The key field identification criteria for each plumage are summarized in Table 1.

TABLE 1
A KEY TO FIELD IDENTIFICATION OF BALD EAGLE PLUMAGES.

1. Head and tail white or mottled white. Iris pale yellow. Beak and cere >70% yellow	4
1. Head brown or tan, beak and cere blackish-gray or <30% yellow. Iris brown or ochre	2
2. Beak and cere entirely blackish-gray, iris sepia, no inverted white triangle on mantle	Juvenal ½-year-old
2. Beak and cere blackish-gray mottled with buffy-yellow	3
3. Iris buffy-brown, buffy-yellow mottling restricted to nares and base of the beak near gape	Basic I 1½-year-old
3. Iris pale ochre (light cream), cere and beak mottled buffy-yellow throughout	Basic II 2½-year-old
4. Heavy brown mottling at distal margin of rectrices. Usually extensive gray or brown flecking in auriculars, forehead, and crown. Often white flecking on wing linings, belly, and chest	Basic III 3½-year-old
4. Tail white. Some birds with occasional brown flecks in tail or head	Basic IV or Definitive
(Basic IV: About 75% of birds retain some gray flecking around eye and on forehead next to cere. Remainder are definitive. Definitive: White head and tail, yellow beak and cere. Many birds retain brown flecks on rectrices and nape feathers.)	

Southern (1967) described seven plumages of Bald Eagles based on study skins of unknown age birds thought to represent six or seven age classes. Appropriate ages could be assigned to Southern's seven plumage categories by using Table 1.

Juvenal plumaged eagles (½ year old) closely resembled Southern's plumages A and B, although there is no evidence of a late-winter molt during the first winter as suggested by Southern. Basic I plumaged eagles matched Southern's B/C and C plumages. Basic II plumaged eagles corresponded with C/D and D plumages. Near-definitive plumage (Basic III plumage) was equivalent to Southern's E and possibly F classes. Basic IV plumaged eagles corresponded with much of Southern's description of plumage F, except for the presence of white on the mantle and up to 60% brown mottling on the tail. Some Basic III specimens examined by Southern were likely included with the Basic IV eagles in plumage F. Adult definitive plumage of Basic V was similar to Southern's plumage class G.

There has been considerable confusion in field studies attempting to assign Bald Eagles to age classes based on plumage characteristics. Juvenal, Basic I, and Basic II plumages have been particularly difficult to differentiate because of the similarity in body feathering, and, traditionally, they have been combined into one or two plumage classes (e.g., Sherrod

et al. 1976, Bortolotti and Honeyman 1983). The amount of buffy or white mottling on the belly and chest is variable among individuals, and the best field characters for aging young eagles seems to be in the head plumage, and the color of the beak, cere, and iris. Both the 1½- and 2½-year-old eagles have an "osprey-like" head although this characteristic is more distinct in 2½-year-old birds. The lighter cap and throat of 2½-year-old eagles combined with the light cream iris and extent of yellow in the cere and beak allows correct separation of these age groups. The distinct predefinitive plumage of 3½-year eagles allowed consistent classification of this age group.

Definitive plumage was observed in 4½- and 5½-year-old birds (Basic IV and V plumages), which would cause difficulty in correct classification of these age groups. In general, 4½-year-old eagles had more brown flecking around the eye and on the forehead and more brown in the cere and beak than 5½-year-old eagles; however, brown or gray flecking on the forehead or cheek was retained by some birds at least 8½ years-old or longer which created further difficulty in correctly aging older birds.

Attainment of definitive plumage is not synonymous with sexual maturity. A 3-year-old Bald Eagle nested successfully in predefinitive plumage in Tennessee (D. A. Hammer, pers. comm.). There is evidence, however, that some birds do not successfully raise young until 6 or 7 years old (Gerrard, unpubl. data).

There are few data available to compare geographic variability in the molt sequence of Bald Eagles. Other known-age eagles from Nova Scotia ($N = 11$), Prince Edward Island ($N = 4$), Ontario ($N = 2$), Saskatchewan ($N = 1$), Michigan ($N = 1$), and South Carolina ($N = 1$) were observed during this study and could be assigned to the appropriate plumage classes using the aforementioned criteria. Descriptions of marked known-age eagles observed in Saskatchewan (Gerrard et al. 1978, Bortolotti and Honeyman 1983) and Chesapeake Bay (Clark 1983) also followed a similar pattern of plumage replacement. Saskatchewan eagles showed a similar molt sequence to that observed in Maine. Clark's (1983:823) description of molt sequence was similar, but he referred to the "white belly" plumage being "completed the end of the first year of age," although it seems from his description of plumage that second-year was intended. Confusion in several accounts occurred by interchanging the terms "x year old" and "xth year." For example, an eagle in its first year has not had its "first birthday" and is still in juvenal plumage. Use of the molt terminology in Fig. 1 should prevent such errors.

Early descriptions of plumage changes in Bald Eagles were from observations of captive eagles. An eagle taken in Michigan (Wilson 1922) exhibited a molt sequence identical to that described in this paper. Near-

definitive appearance was acquired with the completion of molt into the Basic IV plumage at 4 years-old. Injury and nutritional deficiencies in captive birds are known to interrupt normal molt sequences (Payne in Palmer 1972). A captive Bald Eagle in Maine delayed pre-basic molt after a gunshot wound and remained a year behind the appearance of wild birds of the same age. Jollie (1947) noted the same tendency in a captive Golden Eagle and suggested that captive birds may take longer to attain definitive plumage than do wild birds.

Molt in northern Bald Eagles seems to be limited to about 6 months in the late spring, summer, and early fall, but it may be initiated earlier (November or December) in southern birds. There was no evidence of active molt or cast feathers in the winter at any of the feeding sites in Maine. It is likely that yearly body molt is not complete, in that some feathers are retained from one year to the next. Jollie (1947) documented that two molts were needed to renew the body plumage of a captive Golden Eagle. Retention of contour feathers would explain the white mottling in the belly, chest, and mantle in Basic III and IV plumages. Incomplete yearly molt of the nape feathers may explain the retention of brown or gray flecking in the otherwise white head of eagles in Basic IV and V plumages. Gray or brown flecking was observed in the nape feathers, rectrices, and tail coverts of most Bald Eagles in definitive plumage. The pattern of flecking may be consistent in consecutive molts in definitive plumage (Bortolotti and Honeyman 1983).

Primaries and secondaries also may be retained for 2 to 3 years. The closely related White-tailed Sea Eagle (*Haliaeetus albicilla*) loses 3 or 4 primaries and 6 or 7 secondaries during each annual molt (Forsman 1981). Some greater and lesser wing coverts are not molted yearly and are retained from one plumage to the next. For Bald Eagles, usually all 12 rectrices are molted randomly (Bortolotti and Honeyman 1983), although a few 4½- and 5½-year-old eagles photographed in Maine retained a mottled brown rectrix from the previous plumage. White-tailed Sea Eagles have a tendency for the innermost pair of rectrices to be shed first, followed by the outermost 2 pairs (Love 1983).

Because many of the better distinguishing characteristics for determining most age groups are in the beak, cere, and iris coloration, care should be taken in aging museum specimens. Fading and discoloration of the beak and cere and written descriptions of iris color may be misleading.

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COLOR PLATE

The Frontispiece has been made possible by an endowment established by George Miksch Sutton.