CRITERIA FOR DETERMINING AGE AND SEX OF NESTLING BALD EAGLES

By Gary R. Bortolotti

Accurate determination of age and sex is valuable for research on life histories of species. Sex identification criteria may be particularly important for studies of birds that are sexually dimorphic in size, because an undetected bias in sex ratio of a sample may in turn bias the results of investigations into growth (Ricklefs 1968), survivorship (Newton et al. 1983), foraging behavior (Andersson and Norberg 1981), and other aspects of a species' biology. There has also been increasing interest in management practices such as releasing young birds, especially raptors, to the wild, where a specific sex ratio of the birds is preferred. The Bald Eagle (*Haliaeetus leucocephalus*) is one such species for which many life history studies, and the aforementioned management programs, have been conducted. Although there are criteria for discriminating between the sexes of post-fledging Bald Eagles (Bortolotti 1984a), none has been published for nestlings, nor are there any age-predictive criteria for eaglets. This paper presents information on age and sex determination of nestling Northern Bald Eagles (*H. l. alascanus*), developed during a 3-year study of their growth.

METHODS

I monitored the development of 64 young Bald Eagles from 48 nests for the nestling periods of 1980-1982, at Besnard Lake, Saskatchewan (55°20'N, 106°00'W). The lake is situated in the boreal forest at the southern edge of the Precambrian Shield, and supports about 23 breeding pairs (Gerrard et al. 1983). Aspects of the biology of this population of eagles have been previously described (e.g., Whitfield et al. 1974, Gerrard et al. 1975, 1978, 1980).

By observing the behavior of incubating Bald Eagles from a distance, the time of hatching of the eggs can easily be predicted (Bortolotti et al. 1983). I climbed to nests when hatching appeared imminent, and thus observed eggs pipping or in the process of hatching for almost all of my study nests. For the first 2 weeks after hatching, I climbed to the nest and took only a few measurements (see below) on the nestlings to minimize disturbance to the birds. Subsequently, my assistant climbed to the nests and lowered the eaglets to the ground where I measured them. The birds were handled an average of once every 6.7 (usually every 5 to 8) days until they were about 60 days old (hatching = day 0) when I stopped because of increasing risk of nestlings prematurely leaving the nest. Eaglets older than about 60 days old frequently jump off the nest in response to a human climber. Twenty eaglets about 80 days old were captured on the ground by hand and measured just after they

had prematurely fledged (naturally and human-induced) and could not fly well. None of these birds was injured or unhealthy in any way. There was no indication that my visits had any deleterious effect on the nestlings or their parents (Bortolotti et al. 1983). Chicks that died naturally as a result of brood reduction before their sex could be determined were excluded from analyses. None of the surviving eaglets appeared unhealthy or grew aberrantly compared to the other eaglets in my sample.

I measured 11 mensural characters per eaglet, however, only 3 of them throughout the entire nestling period. The chord of the culmen from the distal edge of the cere to the tip (i.e., without cere) and the length of middle toe without claw were measured with dial calipers. I weighed chicks lighter than 1200 g with Pesola spring scales, and heavier chicks with a Chatillon dial scale with a hanging basket. I felt the crop of each chick to estimate what percentage of it contained food. Confirmation of my ability to estimate crop contents, and the approximation of the weight of the food in the crop, were possible because I conducted feeding experiments with eaglets throughout the nestling period. Actual body weight of eaglets was arrived at by subtracting the weight of the crop contents from the gross weight of the bird. The above variables were the only ones monitored during the first 2 weeks to minimize disturbance and because some characters could not be measured. As the nestlings grew older, the risk of disturbance to them and their parents decreased and more time could be spent at the nest. I then also measured the depth of the bill at the leading edge of the cere by holding dial calipers perpendicular to the long axis of the skull and flush to the underside of the gonys. Young eaglets have triangular-shaped bills and thus this character cannot easily be measured in the first 2 weeks of nestling life. Other variables measured with calipers were length of tarsometatarus, length of hallux claw, and mean width of tarsus (the average of 2 orthogonal measures of width at the narrowest part of the tarsus just above the phalanges). All measurements were taken each year except hallux claw which was measured in 1982 only. Culmen length, bill depth, and hallux claw are diagrammed in Bortolotti (1984a). Figure 1 illustrates my method of measuring the length of the foot pad. I stretched out the eaglet's middle front toe and hallux fully, pressed them flat against a metal ruler, and recorded the maximum expanse of foot flesh (not including talons) as sighted from directly above the ruler. I measured unflattened wing chord (chord of arc) with a metal ruler. For measurement of eighth primary length and tail length, I inserted a thin metal ruler between primaries 8 and 9, and between the central rectrices, respectively, up to the flesh. The feathers were held flat against the ruler for a straight length.

I took measurements, except those during the initial 2–3 weeks of nestling life, on eaglets lying flat on their backs. I measured consistently from the same side of the bird's body. All linear measurements are presented in mm, and weight is in g.

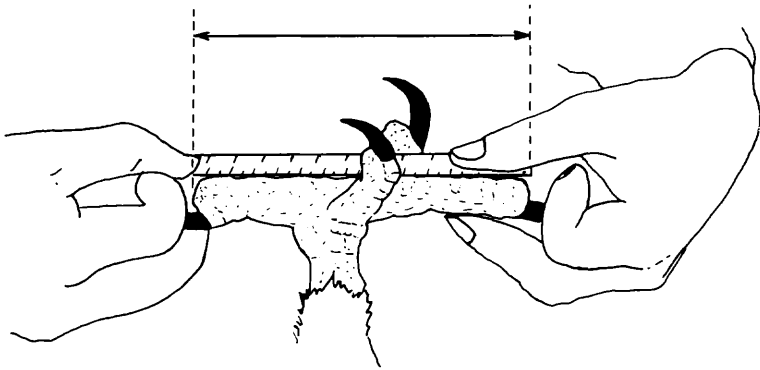When using morphometric data for predictive purposes, the variance

FIGURE 1. Measurement of a Bald Eagle's foot pad. The maximum expanse of the foot's flesh, as indicated by the dashed lines, is measured with the metal ruler held flat against the foot.

associated with the method of measurement should be assessed. The value of any variable as a criterion for the determination of age or sex depends not only on its predictive accuracy for a parametric population, but also on the precision and accuracy with which it can be measured on a sample. Therefore, I evaluated the relative repeatability of measurement of each character. I measured an eaglet 51 to 60 days old, released it from my grasp, put down the measuring device, recorded the number, and then repeated the process on the same bird for the same variable several times over. Different birds were used for different variables. I did not examine repeatability of measurements in younger birds because I wanted to minimize the length of time I spent at the nest and thus the disturbance to the breeding adults.

Analyses were performed on 2 different data sets. For data on growth of known-age birds, I randomly chose a subsample of birds so that the sexes, broods of different size, and birds of different positions in a brood (first vs. second hatched) would be represented by approximately equal numbers of measurements. This was done to eliminate any potential bias that differences in growth related to sex or brood composition might introduce. The subsample was used for all analyses of age variation, and some of sex differences. The total sample of birds (about 25% larger) included eaglets not observed hatching, but that could be reliably aged ±1 day by comparison to chicks of known age, and was used for some descriptions of sex differences. The statistical analyses for age estimation follow recommendations by Dapson (1980).

Two nestlings, whose growth I had been monitoring, died of natural causes (accidents in wind storms) at the ages of 36 and 48 days respectively. The sex of these birds was determined by histological examination of the gonads.

To see if the measurements I made on nestlings are comparable to

TABLE 1. Relative repeatability of measurements on nestlings, and degree of sexual dimorphism of nestlings 60 days old or more, and study skins, of Bald Eagles.

| Variable | Repeatability of measurement | | | | Degree of sexual dimorphism[a] | |
	x̄	n[b]	SD	CV[c]	Study skins[d]	Nestlings
Foot pad	132.1	23	0.42	0.31	—	10.7
Bill depth	30.73	18	0.259	0.843	10.9	10.9
Tarsus width—1	15.75	20	0.176	1.12	12.6[e]	13.8[e]
—2	17.21	20	0.370	2.15		
Mid-toe	68.05	19	0.658	0.97	—	9.3
Hallux claw	39.52	17	0.151	0.382	11.9	[f]
Culmen length	45.94	18	0.078	0.169	8.4	[f]
Tarsus length	76.8	17	1.41	1.83	—	3.6
Wing chord	380.9	22	0.83	0.22	6.8	[f]
Eighth primary	224.6	22	1.14	0.51	6.8	[f]
Tail	124.8	21	0.62	0.50	4.9	[f]

[a] Dimorphism index (Storer 1966).
[b] Number of repeated measures per nestling (51 to 60 days old).
[c] Coefficient of variation.
[d] Youngest plumage class (Bortolotti 1984a).
[e] Calculated from x̄ of 1 and 2.
[f] Growth not complete as nestlings.

eagles 1 year old and greater, hereafter referred to as "mature," I measured 5 wild Bald Eagles from Saskatechewan and 11 captive eagles obtained from across northern Canada. Three of these birds were males, and 4 were females, as determined by laparoscopy or necropsy. The sex of 1 male and 1 female was inferred from the fact that they were a breeding pair. I assigned a sex to the other birds by criteria presented in Bortolotti (1984a), resulting in a total of 5 males and 11 females.

RESULTS

The degree of confidence that any variable can be used for predictive purposes depends on the consistency of results of successive measurements. The relative repeatability, and hence reliability, of each variable is inversely related to the magnitude of its coefficient of variation (Table 1). My repeated measures were not truly independent of each other because they were done successively. However, the alternative method of taking measurements on different days, would have encountered the problem of growth. Although the measures of variance are dependent on the size of the nestlings, my experience leads me to believe that this relative repeatability was basically constant throughout the nestling period. The culmen, foot pad, and feather measurements appear to be the most repeatable (Table 1). Weight variability could not be meaningfully assessed because the measurement variance depended on the type of weighing device used, accuracy of estimating crop weight, and
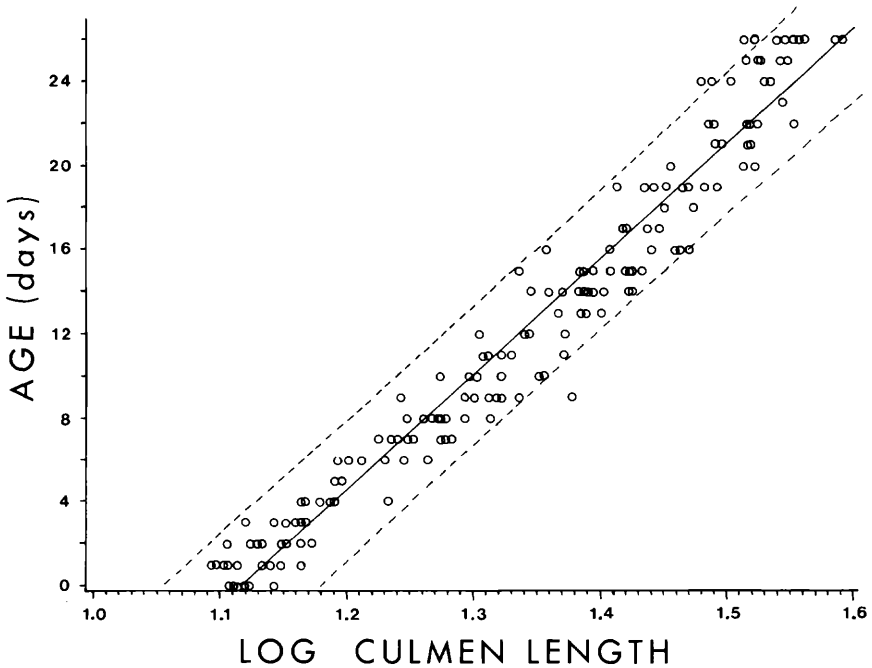
FIGURE 2.   Regression of age on log of culmen length for known-age Bald Eagle nestlings 0–26 days old (sexes combined). The 95% confidence limits about individual predictions are shown as dashed lines.

age and activity of the birds, all of which, however, seemed nearly insignificant sources of variation compared to the rapid growth and large daily fluctuations observed.

Variables used as criteria for discriminating between the sexes must not only be repeatable, but also highly dimorphic. Table 1 presents the degree of sexual dimorphism for each character calculated from data on nestlings, and, for comparison, study skins. The variables which are most suitable, i.e., repeatable and highly dimorphic, appear to be bill depth and foot pad. Mean tarsus width might have been a good discriminator of the sexes, but its usefulness as such is reduced by its high measurement variance. Weight is a highly dimorphic variable, but because it is so strongly influenced by the general condition of the bird, and any individual may show large daily fluctuations (Bortolotti unpubl.), it is of more limited value than other characters.

Age determination.—The subsample of data balanced for sex and brood composition (see Methods) consisted of 22 presumed males and 20 presumed females of known age from 24 nests (8 per year).

For the first few days after hatching the chicks can perhaps best be aged by appearance. On the day of hatching the area of the body where
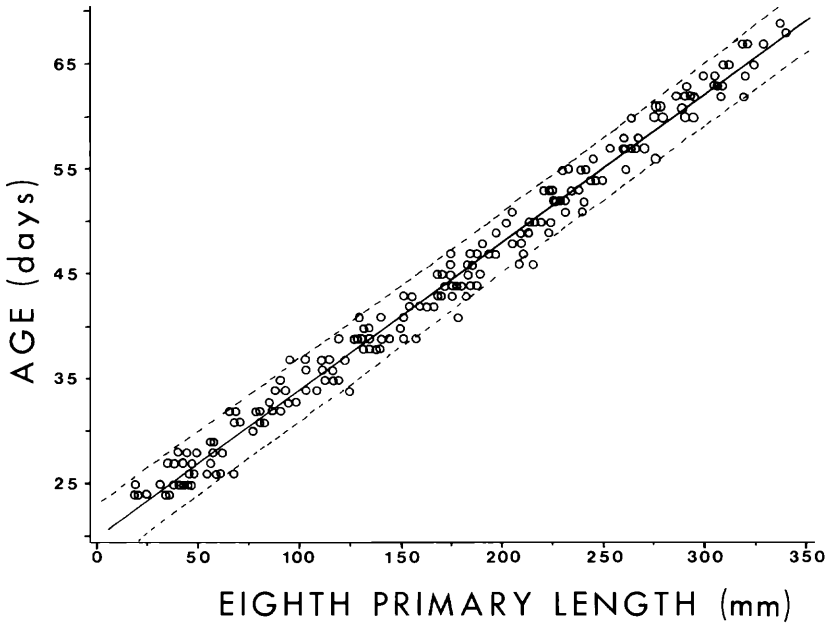
FIGURE 3. Regression of age on eighth primary length (mm) for known-age Bald Eagle nestlings 24–72 days old (sexes combined). The 95% confidence limits about individual predictions are shown as dashed lines. Some points represent more than one measurement.

the allantois is attached is swollen, circular shaped, and somewhat protruding. Remnants of the allantois can be seen on the chick for up to 3 days after hatching, but after day 0 it is desiccated and thread-like. On the day of hatching the chicks generally appear very weak and spend most of their time lying in the nest. The skin is initially loose, wrinkled, and a bright pink, but it fills out, is noticeably tighter, and fades to a soft pink on day 1. The legs too are very pink on day 0, but are a faded flesh color on day 1. Beginning as early as days 2 and 3, but usually on day 4 or 5, the skin (upon close inspection) on the ventral side is tinged with blue. In the next 4 or 5 days the skin over most of the body is blue-gray.

For the statistical analysis of age variation, I used several regression models, but only present results which yielded the highest predictive accuracy with the minimum of complexity. Because of the long nestling life of eagles (72 to 88 days long in Saskatchewan), I present a method for aging both young and old eaglets based on size. From 0 to 26 days old, nestlings are best aged by culmen length:

$$Age = -57.7 + (52.0 \times \log \text{culmen length})$$

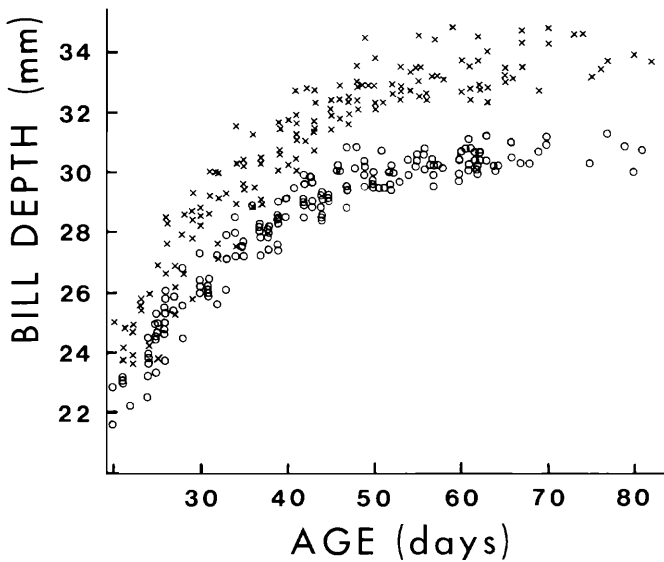$(r^2 = .953, \text{SE of estimate} = 1.239, n = 156)$ Fig. 2. Sexual dimorphism

FIGURE 4. Growth of bill depth (mm) for 33 presumed male (○) and 31 presumed female (×) nestling Bald Eagles.

in culmen length only appears toward the end of this period, so the sexes were alike in size and thus were combined in the analysis. Log transformation of culmen length improved linearity and the data became homoscedastic. Confidence limits about individual predictions (which are biconcave about the line, see Dapson 1980) are approximately ±3.0–3.1 days wide.

For older nestlings, feather lengths proved to be good predictors of age. The remiges and rectrices emerged around days 20 and 25 respectively, however, they are initially difficult to measure because they are surrounded by a thick layer of down. From the time I started measuring them shortly after their emergence until the nestlings were 72 days old, eighth primary and tail growth were highly linear. After 72 days the growth rates decreased. Although it would appear from Table 1 that tail would be a preferred measurement, the confidence limits for the regression line predicting age were not as narrow as those using eighth primary. This may be in part because tail feathers, but not primaries, were subject to noticeable wear by the nest material. For males and females combined (i.e., to be used when the investigator does not know the sex of the birds), the linear regression equation to age nestlings 24 to 72 days old is:

$$\text{Age} = 19.9 + (.14 \times \text{eighth primary length})$$

($r^2 = .985$, SE of estimate = .236, n = 199) Fig. 3. Males are best aged by:
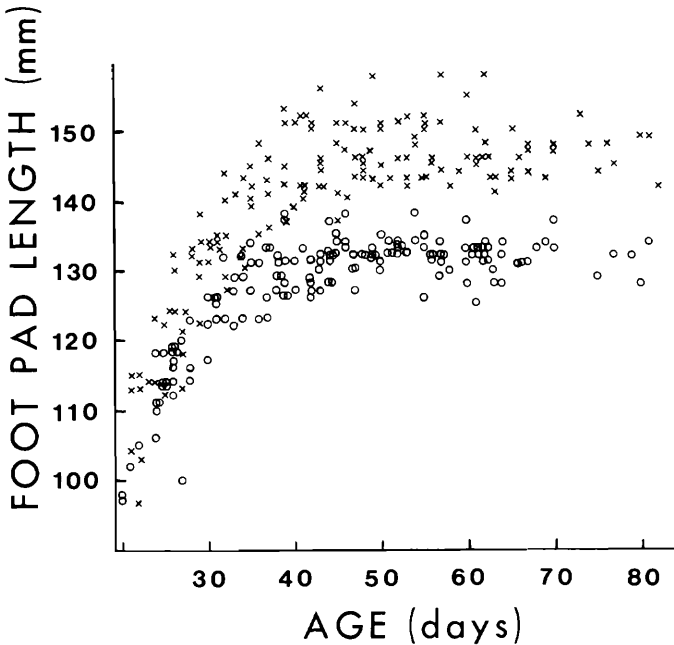
FIGURE 5. Growth of foot pad (mm) for 33 presumed male (O) and 31 presumed female (×) nestling Bald Eagles.

$$\text{Age} = 19.2 + (.14 \times \text{eighth primary length})$$

($r^2 = .988$, SE of estimate $= .305$, n $= 102$). Females are best aged by:

$$\text{Age} = 20.6 + (.14 \times \text{eighth primary length})$$

($r^2 = .987$, SE of estimate $= .319$, n $= 97$). The confidence limits about individual predictions were approximately $\pm 2.8–2.9$ days for all 3 equations.

Sex determination.—For a comparison of the size difference between the presumed sexes, I present data on 64 eaglets, of which 51 were measured 8 to 12 times over the nestling period. The other 13 birds were handled fewer than 3 times. The eaglets came from a total of 48 nesting attempts approximately evenly distributed over the 3 years. A total of 495 measurements was taken per variable monitored from day 0, and somewhat fewer data points for those variables where measurement began later in the season.

As only 2 nestlings were of known sex, sex classification was based on the fact that for culmen length, bill depth, foot pad, and weight, the distribution of birds was very strongly bimodal with a large area where no overlap occurred. Only a nominal overlap occurred for mean tarsus width and mid-toe. The characters which best separated the presumed

TABLE 2.　Increase in bill depth with age for presumed male and female nestling Bald Eagles.

Age interval	Sex	n[a]	Mean bill depth (mm)	95% confidence limits of the x̄	2 SD range
15–19	M	11	20.4	19.5–21.3	17.7–23.0
	F	6	20.6	18.7–22.4	17.8–24.1
20–24	M	6	22.9	21.8–24.0	20.7–25.0
	F	11	24.6	24.1–25.1	23.0–26.2
25–29	M	16	25.0	24.5–25.5	23.2–26.8
	F	13	27.0	26.1–27.9	24.0–30.0
30–34	M	11	26.8	26.2–27.4	25.0–28.6
	F	11	28.9	28.2–29.6	26.8–31.0
35–39	M	14	27.9	27.6–28.2	26.9–28.9
	F	13	30.3	29.8–30.8	28.6–32.0
40–44	M	14	29.0	28.7–29.3	28.1–29.9
	F	11	31.4	30.7–32.1	29.4–34.3
45–49	M	9	29.6	29.1–30.1	28.3–30.9
	F	14	32.3	32.0–32.6	31.3–33.3
50–54	M	12	29.8	29.6–30.0	29.2–30.4
	F	11	32.8	32.4–33.2	31.7–33.9
55–59	M	8	30.1	29.9–30.3	29.5–30.7
	F	8	33.3	32.8–33.8	32.1–34.5
60–82	M	19	30.4	30.2–30.6	29.5–31.3
	F	18	33.4	33.0–33.8	31.9–34.9

[a] n is the number of measurements.

sexes and were very repeatable, were bill depth and foot pad. The development of eaglets (total sample) for these 2 variables is illustrated in Figs. 4 and 5 respectively. Because I measured each chick every 6–7 days, sample sizes per any day of age were small. Therefore, to obtain quantitative criteria to identify the sexes using bill depth and foot pad throughout the period of growth, I grouped the birds into 5-day intervals (Tables 2 and 3). Only the subsample of data was used. Presumed sexes became distinguishable at the age of 20–24 days for bill depth, and 25–29 days for foot pad (also compare presumed sexes in Figs. 4 and 5). The sexes were clearly separated at about 40–45 days old when growth was almost complete.

Since the growth data were repeated measurements of the same individuals, it was obvious that a leveling off to an "ultimate" (mature) size had occurred for some variables (but see later discussion regarding bill depth). I estimated the ultimate size for those variables where the last few successive measurements of the bird (usually over 2–3 weeks) were the same or within measurement error. The only variables for which growth appeared to be complete were foot pad, mid-toe, mean tarsus width, and tarsus length. Estimates of the ultimate size for these variables are compared to measurements made on mature live birds and

TABLE 3. Increase in the length of foot pad with age for presumed male and female nestling Bald Eagles.

Age interval	Sex	n[a]	Mean foot pad length (mm)	95% confidence limits of the x̄	2 SD range
15–19	M	10	87.8	83.2–92.4	74.6–101.0
	F	5	88.6	80.8–96.4	75.1–102.1
20–24	M	5	109.2	102.1–116.3	96.9–121.5
	F	8	110.0	103.2–116.8	93.4–126.6
25–29	M	16	114.8	112.3–117.3	105.5–124.1
	F	13	125.1	120.3–129.9	109.0–141.1
30–34	M	11	126.2	123.8–128.5	119.1–133.3
	F	11	134.5	131.1–137.9	124.4–144.6
35–39	M	14	129.3	127.3–131.3	122.2–136.4
	F	13	142.7	139.4–146.0	131.5–153.9
40–44	M	14	130.3	128.6–132.0	124.4–136.2
	F	11	146.4	142.8–150.0	135.7–157.1
45–49	M	9	132.4	131.1–133.7	128.9–135.9
	F	14	146.5	143.3–149.7	135.3–157.7
50–82	M	39	131.8	130.9–132.7	127.0–136.6
	F	37	147.1	145.6–148.5	138.4–155.8

[a] n is the number of measurements.

study skins in Table 4. Also in Table 4 are data for bill depth at the size it appeared to have leveled off at, although this must not have been its ultimate mature size (compare data to live mature birds and skins). The growth of bill depth was extremely slow during the last half of the nestling period (see Fig. 4, and compare age groups 55–59 days to 60–82 days in Table 2). It was so slight that often the difference in size (if any) between bill depth of a bird measured at 60 days old and then subsequently at 80 days old could not be accounted for as anything but measurement variance. Fig. 6 shows the distribution of all nestlings for their ultimate size of foot pad and maximum size of bill depths. I believe the 2 very distinct groups represent the sexes.

The asymptotic size of culmen length and of weight, as estimated by fitting individual Gompertz growth curves (Ricklefs 1967) to the data for each chick, are included in Table 4 as a further comparison of size of chicks to birds of the other categories. Hallux claw for the live mature birds is included for comparison in Table 4 because this variable has been shown to be important in determining the sex of eagles (Bortolotti 1984a).

DISCUSSION

Although criteria for discriminating between the sexes have only recently been published (Bortolotti 1984a), data presented here suggest that Bald Eagles are highly sexually dimorphic. Latitudinal variation in

TABLE 4.   Size of Bald Eagle nestlings 60 days old or more, live mature eagles, and study skins of eagles.

Variable	Sex	n	Nestlings x̄ ± SE (range)	n	Live mature eagles x̄ ± SE (range)	n	Study skins[a] x̄ ± SE (range)
Foot pad	M	33	132.3 ± 0.45 (126–138)	3	130.0 (128–134)		—
	F	31	147.3 ± 0.68 (142–158)	8	143.8 ± 0.77 (142–148)		—
Mid-toe	M	33	64.6 ± 0.35 (60–68)	3	63.3 (62–72)		—
	F	31	70.9 ± 0.42 (66–75)	10	70.4 ± 0.72 (67–73)		—
Tarsus length	M	33	71.4 ± 0.45 (66–76)	2	66.5 (66–67)		—
	F	31	74.0 ± 0.61 (65–80)	9	71.2 ± 1.57 (67–81)		—
Tarsus width	M	33	14.37 ± 0.352 (13.4–15.7)	5	14.43 ± 0.308 (13.8–15.5)	77	14.41 ± 0.103 (12.8–16.4)
	F	31	16.50 ± 0.422 (15.6–17.8)	9	16.52 ± 0.251 (15.5–17.9)	57	16.35 ± 0.136 (14.1–20.3)
Bill depth[b]	M	33	30.42 ± 0.084 (29.5–31.3)	5	31.74 ± 0.458 (30.4–33.2)	63	32.24 ± 0.136 (29.6–34.6)
	F	31	33.63 ± 0.137 (32.5–35.4)	11	34.53 ± 0.048 (34.0–35.6)	45	35.97 ± 0.266 (32.6–41.2)
Culmen length[b]	M	26	49.14 ± 0.258[c] (45.5–51.0)	4	49.58 ± 0.473 (48.3–50.5)	76	50.81 ± 0.236 (41.7–54.3)
	F	20	54.42 ± 0.246[c] (52.0–56.5)	11	54.75 ± 0.572 (52.4–58.0)	55	55.27 ± 0.333 (50.4–60.6)
Weight[b]	M	26	4066 ± 35.08[c] (3575–4500)		—	18	4014[d] (3524–4568)
	F	21	5172 ± 46.54[c] (4800–5600)		—	18	5089[d] (4359–5756)
Hallux claw	M		—	4	39.21 ± 0.548 (38.2–40.9)	77	39.65 ± 0.198 (32.7–43.0)
	F		—	9	43.73 ± 0.546 (42.0–46.7)	55	44.66 ± 0.254 (41.2–48.9)

[a] Mean of all plumage classes of skins (Bortolotti 1984a).
[b] Growth not complete at this age or at time of fledging.
[c] Asymptotic size as estimated from Gompertz growth curves.
[d] Data from Imler and Kalmbach (1955), no measure of variance given.

size (Brown and Amadon 1968) combined with long distance movements (Broley 1947, Postupalsky 1976, Gerrard et al. 1978) and the age-dependent feather lengths of this species (Bortolotti 1984a), have likely contributed to confusion over the distinction between males and females
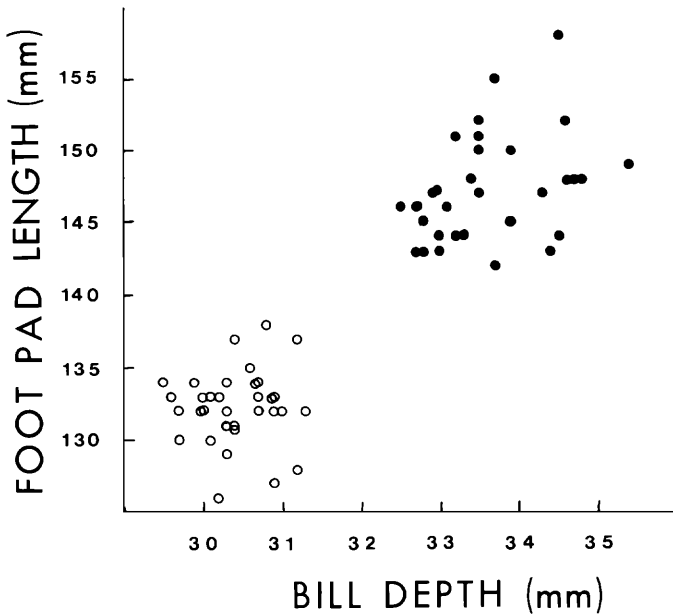
FIGURE 6. Size of nestling Bald Eagles (60 days old or more) for bill depth (mm) and
    length of foot pad (mm). Presumed males are open circles, and presumed females are
    closed circles.

on the basis of size. Given the strongly bimodal distributions in devel-
opment (Figs. 4 and 5) and in ultimate size (Fig. 6), and the agreement
of size measures made on skins, live mature birds (Table 4), and the 2
necropsied nestlings, I believe that the sex identification criteria pre-
sented here are valid and accurate despite the paucity of birds of known
sex.

    The mean size values (Table 4) and the dimorphism indices (Table
1) are similar for nestlings and study skins. Since the sample of skins
covered the complete geographic range of *H. l. alascanus*, the infor-
mation in this paper regarding sex, and likely also age, is likely applicable
to all Northern Bald Eagles. This claim is also supported by the fact
that the asymptotic weights of juvenile Saskatchewan eagles are virtually
the same as weights of immature eagles collected in Alaska by Imler
and Kalmbach (1955) (Table 4). There is, however, a greater degree of
overlap in size for measurements of males and females made on skins
than those for nestlings. The distributions of the sexes of study skins
were nonoverlapping only when considered multivariately (Bortolotti
1984a). This difference in degree of overlap may be the result of the
geographic origins of the birds of the samples, small sample size of
eaglets, or perhaps problems associated with the measurement of study

skins. Such factors may not greatly alter mean values, but can increase the probability of having outliers, and thus broaden the range of values.

Although nestlings near the time of fledging were similar in size to live mature birds, they appeared to be somewhat larger for foot pad. This may be an artifact of the method of measurement. The toes of nestlings were relatively easily spread apart for measurements; those of mature birds were very powerful, and usually clenched tight when the bird was handled, making it difficult for me to extend the toes fully. Although foot pad can be used to sex mature eagles, since actual size may be underestimated if the toes cannot be properly straightened, alternative criteria (Bortolotti 1984a) may be preferable.

The slow growth of bill depth continues after the time of fledging, but when ultimate size is reached is not known. Although I found no indication of growth of bill depth from my examination of study skins of birds of different ages (Bortolotti 1984a), small sample size, geographic variation, and my method of age (plumage) classification, could have obscured evidence of small annual increments. Coulson et al. (1981) found the bill depth of Herring Gulls (*Larus argentatus*) to grow for at least the first 9 years of life. In a comparison of chicks to museum specimens, Coulter (1978) concluded that the bills of Western Gulls (*L. occidentalis*) did not attain full size until the birds were in adult plumage at 3 years old. Similarly, Bortolotti (1984b) found the culmen lengths of immature Golden Eagles (*Aquila chrysaetos*) to be smaller than those of adults. Therefore, although bill depth is useful for identifying the sex of nestlings and birds greater than 1 year old (Bortolotti 1984a), it should perhaps not be used for birds in the all-brown juvenal plumage. Likewise, the hallux claw criterion of Bortolotti (1984a) should be used with caution on juveniles because the claw is not fully grown at fledging.

Since sex identification can be most reliably made when the growth of foot pad and bill depth are nearly complete at about 40 to 45 days of age, banding or other activities requiring eaglets of known sex are best undertaken at this time.

SUMMARY

I monitored the development of 33 presumed male and 31 presumed female nestling Saskatchewan Bald Eagles between 1980 and 1982. I measured up to 11 variables on the chicks every 6–7 days until they were about 60 days old. Twenty of these birds were also measured shortly after they had fledged. Using known-age birds, a formula was derived to age nestlings 0–26 days old to an accuracy of ±3 days using the chord of their culmen. From 24–72 days old the growth of the eighth primary feather was highly linear and was used to predict the age of nestlings to ±3 days. Strongly bimodal distributions of all size variables suggested a strong sexual dimorphism. The sexes could best be discriminated by depth of bill and length of foot pad. Sexual dimorphism in size was distinct at about 20–24 days old for bill depth, and 25–29 days old for foot pad. These 2 variables leveled off in size at about 40–45 days old.

Only foot pad, length of middle toe, and length and width of tarsus appeared to reach mature size while the birds were still nestlings.

LITERATURE CITED

ANDERSSON, M., AND R. A. NORBERG. 1981. Evolution of reversed sexual size dimorphism and role partitioning among predatory birds, with a size scaling of flight performance. Biol. J. Linn. Soc. 15:105–130.
BORTOLOTTI, G. R. 1984a. Sexual size dimorphism and age-related size variation in Bald Eagles. J. Wildl. Manage. 48:72–81.
———. 1984b. Age and sex size variation in Golden Eagles. J. Field Ornithol. 55:54–66.
———, J. M. GERRARD, P. N. GERRARD, AND D. W. A. WHITFIELD. 1983. Minimizing investigator-induced disturbance to nesting Bald Eagles. Proc. Bald Eagle Days, 1983, Winnipeg, Manitoba.
BROLEY, C. L. 1947. Migration and nesting of Florida Bald Eagles. Wilson Bull. 59:1–20.
BROWN, L. H., AND D. AMADON. 1968. Eagles, hawks and falcons of the world. Country Life Books, Feltham, Middlesex, U.K.
COULSON, J. C., N. DUNCAN, C. S. THOMAS, AND P. MONAGHAN. 1981. An age-related difference in the bill depth of Herring Gulls, *Larus argentatus.* Ibis 123:499–502.
COULTER, M. 1978. Growth in the Western Gull, *Larus occidentalis:* a summary of results. Colonial Waterbirds 3:84–91.
DAPSON, R. W. 1980. Guidelines for statistical usage in age-estimation technics. J. Wildl. Manage. 44:541–548.
GERRARD, J. M., P. N. GERRARD, G. R. BORTOLOTTI, AND D. W. A. WHITFIELD. 1983. A 14-year study of Bald Eagle reproduction on Besnard Lake, Saskatchewan. Pp. 47–57, *in* Biology and management of Bald Eagles and Ospreys, D. M. Bird, chief ed., Harpell Press, Ste. Anne de Bellevue, Quebec.
———, P. GERRARD, W. J. MAHER, AND D. W. A. WHITFIELD. 1975. Factors influencing nest site selection of Bald Eagles in northern Saskatchewan and Manitoba. Blue Jay 33:169–176.

——, ——, AND D. W. A. WHITFIELD. 1980. Behavior in a non-breeding Bald Eagle. Can. Field-Nat. 94:391–397.

——, D. W. A. WHITFIELD, P. GERRARD, P. N. GERRARD, AND W. J. MAHER. 1978. Migratory movements and plumage of subadult Saskatchewan Bald Eagles. Can. Field-Nat. 92:375–382.

IMLER, R. H., AND E. R. KALMBACH. 1955. The Bald Eagle and its economic status. U.S.D.I. Fish and Wildlife Service, Circ. 30.

NEWTON, I., M. MARQUISS, AND P. ROTHERY. 1983. Age structure and survivial in a Sparrowhawk population. J. Anim. Ecol. 52:591–602.

POSTUPALSKY, S. 1976. Banded northern Bald Eagles in Florida and other southern states. Auk 93:835–836.

RICKLEFS, R. E. 1967. A graphical method of fitting equations to growth curves. Ecology 48:978–983.

——. 1968. Patterns of growth in birds. Ibis 110:419–451.

STORER, R. W. 1966. Sexual dimorphism and food habits in three North American accipiters. Auk 83:423–436.

WHITFIELD, D. W. A., J. M. GERRARD, W. J. MAHER, AND D. W. DAVIS. 1974. Bald Eagle nesting habitat, density, and reproduction in central Saskatchewan and Manitoba. Can. Field-Nat. 88:399–407.

Department of Zoology, University of Toronto, Toronto, Ontario M5S 1A1, Canada. Received 10 Aug. 1983; accepted 1 May 1984.