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AGE DETERMINATION OF AMERICAN KESTRELS: A REVISED KEY

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Abstract.—Several plumage characteristics may be used to determine age in American Kestrels (*Falco sparverius*). In males, juvenal body plumage is recognizably different from the definitive first basic plumage. In females juvenal plumage strongly resembles the definitive first basic plumage. Kestrels do not have an alternate plumage. The first prebasic molt is incomplete; juvenal remiges and rectrices are retained until the second prebasic molt. Flight feather characteristics, including presence of molt, retention of one or more pairs of secondaries, presence and pattern of fault bars, degree of feather wear, and (in females) the width of the black subterminal band on rectrices, provide evidence of age throughout the year. I present a revised key for age and sex determination of American Kestrels.

CLAVE REVISADA PARA DETERMINAR LA EDAD EN *FALCO SPARVERIUS*

Resumen.—Varias características del plumaje del falconcito (*Falco sparverius*) pueden ser utilizadas para determinar su edad. En los machos, el plumaje juvenil se puede diferenciar claramente del primer plumaje básico. Sin embargo, en las hembras los dos tipos de plumaje previamente mencionados se parecen. Los falconcitos no muestran plumaje alterno. La primera muda pre-básica es incompleta, ya que el juvenil mantiene los remeras y las rectrices hasta la segunda muda. Las características de las plumas de vuelo, (incluyendo indicios de muda), la retención de uno o más pares de secundarias, presencia o irregularidades en el patrón de barras, el grado de desgaste de las plumas y el ancho de la banda negra subterminal en las rectrices (en el caso de las hembras) proveen de información para determinar la edad de estas aves. En este trabajo se revisa la clave para determinar la edad y el sexo de los falconcitos.

Male and female American Kestrels (*Falco sparverius*) are easily discernable in all plumages. The wings of males are primarily blue-gray whereas those of females are reddish-brown, and females have numerous black bars across all rectrices whereas male rectrices (excluding the outermost pair) usually have only a single, relatively wide black band, which is in a subterminal position. Male and female body plumages also are distinctive (Bent 1938). Determination of age, however, is considerably more difficult. As explained below, the currently available key to kestrel age and sex (U.S. Fish and Wildlife Service 1980) warrants revision because its use leads to incorrect age determinations in some instances and in others fails to identify the most specific age category possible.

The purpose of this paper is (1) to review plumage characteristics which previously have been suggested to be useful in determining age in kestrels, and to identify those characteristics that are reliable indicators of age, (2) describe two additional plumage characteristics (retained secondaries and rectrix wear) which provide information on age, and (3)

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present a revised key to age and sex determination which corrects errors in the current key and incorporates additional aging criteria.

SEQUENCE OF MOLTS AND PLUMAGES

American Kestrels begin to acquire juvenal plumage as nestlings; this molt is completed soon after fledging. The first prebasic molt, which occurs in the late summer or early fall of the hatching year, is incomplete; juvenal body plumage is entirely or partially replaced, but juvenal remiges and rectrices are retained (Bent 1938, Parkes 1955). Subsequently, kestrels undergo one complete molt per cycle, the annual prebasic molt, which occurs during or shortly after the breeding season (Balgooyen 1976, Willoughby and Cade 1964). Kestrels do not have an alternate plumage. Although successive basic plumages may differ within an individual, patterns of change are inconsistent among individuals (see Parkes 1955). Therefore, the first basic plumage may be regarded as definitive.

BODY PLUMAGE CHARACTERISTICS

Most male kestrels have a distinct rufous crown patch surrounded by gray. However, of 15 male specimens collected after completion of the first prebasic molt (The Ohio State University Zoology Museum), 21% exhibited either diffuse rufous feathering on the crown, forming no distinct patch, or no rufous crown feathers at all. One such specimen had dark gray shaft streaks on an otherwise light blue-gray crown.

The juvenal body plumage of male kestrels differs from that of older males in several respects. First, although some males in basic plumage may exhibit shaft streaks on the head, such streaking tends to be restricted to the forehead, not extending into the rufous crown patch, if one is present. In contrast, males in juvenal plumage tend to have prominent streaking across the crown (K. C. Parkes, pers. comm.). However, because there is much individual variation in this characteristic, the pattern of crown streaking should not be used as the sole criterion to identify juvenal body plumage in males (W. S. Clark, pers. comm.).

Two other characteristics more readily distinguish the juvenal and basic body plumages of males. The upper breast in juvenal males is streaked heavily while males in basic plumage have immaculate to lightly spotted upper breasts, and the black barring of the back is more extensive in juvenals, covering the anterior third of the scapular-interscapular region (Parkes 1955).

The juvenal body plumage usually is lost during the first prebasic molt, which may begin as early as August (two captive birds in Oregon; Roest 1957) or extend into November (five wild birds in Florida; pers. obs.), but generally occurs in September and October (Bent 1938; K. C. Parkes, pers. comm.). However, some males retain a few to nearly all of the distinctive juvenal body feathers. Therefore, males carrying a mixture of juvenal and basic body plumage may be recognized well into the second calendar year. I captured and examined sixteen males that were less than one year old (determined by fault bar characteristics; see below) in Florida

and Ohio during winter, 1983–1987. Of these, four carried one or more distinctive juvenal body feathers.

Female American Kestrels in juvenal plumage strongly resemble those in basic plumage. The rufous crown patch tends to be indistinct and invaded by dark shaft streaks in juvenals; however, some older birds have similar crown patch characteristics (Parkes 1955). Retention of juvenal body feathers in females, if it occurs, could be detected if faded juvenal feathers contrast with fresh basic feathers. Even so, unless other information on age is available, evidence of an interrupted first prebasic molt would be indistinguishable from that of any subsequent interrupted prebasic molt. Body plumage in females apparently does not provide reliable criteria for age determination.

FLIGHT FEATHER CHARACTERISTICS

Although the juvenal body plumage is relatively short-lived in most male kestrels, age-specific characteristics of remiges and rectrices, when present, provide information useful for age determination of both sexes throughout the year. In the following discussion of flight feather characteristics, the term "adult" refers to a kestrel that has completed a second or subsequent prebasic molt (i.e., no longer carries juvenal remiges or rectrices).

Evidence of molt.—Replacement of remiges and rectrices occurs annually during the second and subsequent prebasic molts. The timing of these molts are related to reproductive events. Females typically begin molting during incubation, whereas the molt in males is delayed until later in the breeding cycle (Willoughby 1966, Balgooyen 1976). Thus, molting may begin as early as April in the southern United States or as late as June in Canada (Bent 1938), and may not be completed until the autumn migration, September through November (Smallwood 1988). Because flight feathers are not replaced during the first prebasic molt, the presence of a gradual flight feather molt in progress, characterized by the sequential replacement of bilateral pairs of remiges and rectrices (*vis-a-vis* replacement of one or a group of feathers accidentally lost), is diagnostic of a kestrel in its second or subsequent calendar year.

One or more flight feathers, usually the outer pair or pairs of secondaries, occasionally are retained through the adult prebasic molt (W. S. Clark, pers. comm.). The presence of retained flight feathers indicates that the second or subsequent prebasic molt already has occurred and therefore reliably identifies an adult. Eighteen kestrels known to be adults by criteria other than retained secondaries (fault bars or feather wear; see below) were captured as they arrived on the wintering grounds in southcentral Florida in 1985; more females (6 of 12) than males (0 of 6) possessed retained secondaries (Smallwood 1988). Interrupted flight feather molt associated with early fall migration may be one strategy by which females improve their ability to acquire preferred winter territories (Smallwood 1988).

Rectrix coloration.—The black subterminal band on the rectrices of

adult females is substantially wider than the more basal black bands. However, the subterminal bands for females carrying juvenal rectrices range from as narrow as the more basal bands (occasionally even narrower than the basal bands; pers. obs.) to as wide as adult subterminal bands. A narrow subterminal band therefore identifies juvenal rectrices. Because the outermost pair of rectrices is dissimilar in pattern to the other rectrices, and the central pair shows little or no variation between age classes, the central and outermost pairs of rectrices should be disregarded when making the above determination (U.S. Fish and Wildlife Service 1980).

In order to examine the relationship between kestrel age and width of the subterminal band, I captured 72 female kestrels of known age in Florida and Ohio during winter, 1984–1987. Age was determined by criteria other than subterminal band width (fault bar patterns and feather wear; see below). I examined the second through fifth pairs of rectrices and visually estimated in increments of 0.25 the width of the subterminal band relative to the immediately basal black band (i.e., assigned each tail to the relative subterminal band width categories of 1.00, 1.25, etc.). Bands on a typical rectrix were not of uniform width. Therefore, I based the above assignments on the portion of the band crossing the approximate midpoint of each web, ignoring wider or narrower portions near the rachis or feather margins. The median width of the subterminal band for 44 adults was 2.25 times that of the adjacent black band. The minimum subterminal band width, 1.75 times that of the adjacent band, was found on 12.5% of the adults examined. For 28 females known to carry juvenal rectrices, the median width of the subterminal band was 1.25 times that of the adjacent black band. The width of the subterminal band exceeded 1.75 times that of the adjacent band in 10.7% of juvenals. The distribution of adult and juvenal subterminal band widths is shown in Figure 1.

In males, the tips of the juvenal rectrices often are pinkish or rufous, while those of adults tend to be white or gray (Bent 1938, Parkes 1955). I observed rectrix coloration for 43 male kestrels of known age (determined by fault bar characteristics; see below) captured in Ohio and Florida, 1981–1987. Although the association between terminal band color and age was significant ($\chi^2 = 11.01$, df = 1, $P < 0.001$), 15.4% of the adults had rusty to yellowish tips and 35.3% of the juvenals had white tips. Thus, the variability in terminal band coloration precludes the use of this characteristic as a criterion for aging male kestrels.

Fault bar patterns.—Fault bars are imperfections, most evident on rectrices and remiges, that result from improper feather formation during a molt. These developmental abnormalities usually are attributable to energetic or nutritional stress, or to mechanical injury to the growing feather (Riddle 1908; but see Murphy and King 1984, 1987). A fault bar is a narrow region, roughly perpendicular to the rachis, in which the barbules are reduced in size or are lacking altogether. Fault bars may resemble post-developmental damage, particularly that caused by lice, but may be distinguished by slight to gross deformation of the rachis and usually by a reduction of pigmentation (pers. obs.). In addition, fault bars occur on

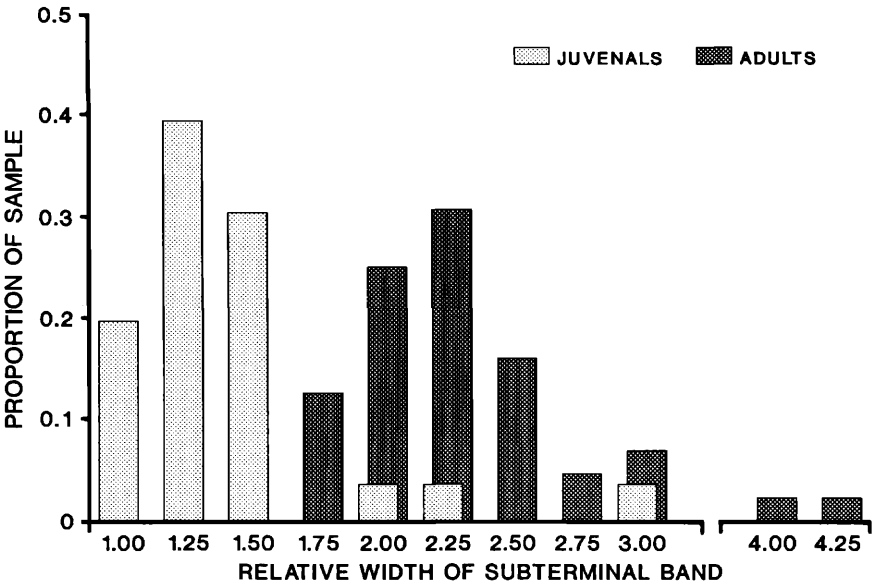

FIGURE 1. Width of the black subterminal band on the second through fifth pairs of rectrices from adult and juvenal (first-winter) female American Kestrels. Width of subterminal band is relative to the width of the immediately basal black band. Adult subterminal bands were significantly wider than those of juvenals (two-tailed Wilcoxon rank sum test, $n = 72$, $Z = 6.29$, $P = 0.0001$).

bilateral pairs of retrices or remiges (see below). Of 110 kestrels I banded in southcentral Florida in January and February, 1984, 53% bore recognizable fault bars.

Because a fault bar forms within a follicle during feather development, the spatial pattern of fault bars in the tail or wings is indicative of the pattern of feather acquisition during the previous molt (Hamerstrom 1967). This pattern, if present, is therefore a reliable indication of age. Fault bars extending regularly across all rectrices (i.e., fault bars located approximately the same distance from the distal end of each feather) form simultaneously during the postnatal molt and may be used to identify juvenal tail feathers. Fault bars also may be apparent on primaries and secondaries as well (Fig. 2a), but they tend to be most pronounced on rectrices (Hamerstrom 1967, pers. obs.). Multiple episodes of fault bar formation during the postnatal molt may occur (Fig. 2b).

Sequential replacement of flight feathers occurs during the second and subsequent prebasic molts. Corresponding feathers of the right and left sides generally fall out together or within three days of each other (Willoughby 1966) and from one to a few bilateral pairs of remiges or rectrices develop at any one time in the follicles of the alar and caudal tracts. Fault bars that form during the adult prebasic molt therefore occur on only one

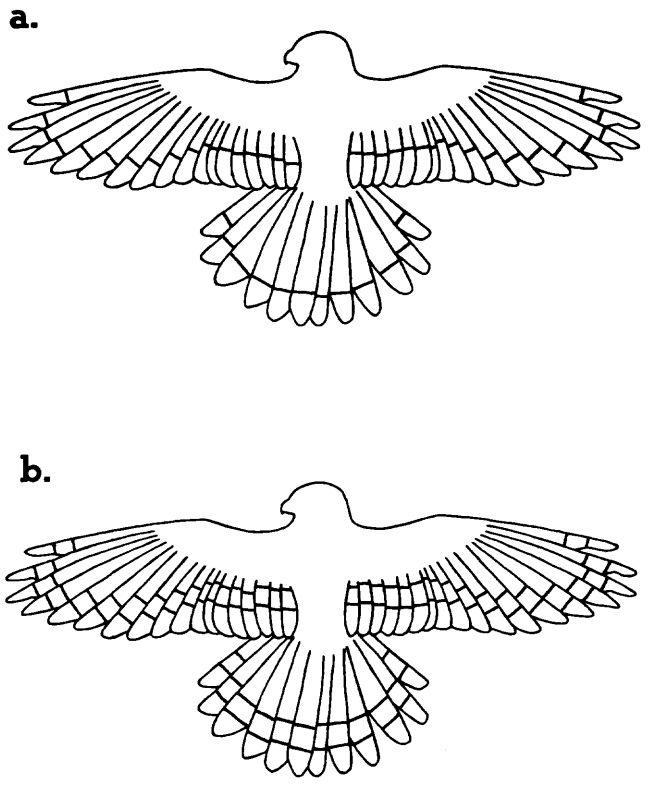

FIGURE 2. Typical fault bar patterns on American Kestrel flight feathers resulting from a) one episode of fault bar formation or b) two episodes of fault bar formation during the postnatal molt.

or a few pairs of flight feathers (Fig. 3a). Multiple episodes of fault bar formation during the adult prebasic molt may affect several to most pairs of rectrices and remiges. Fault bars thus formed are staggered (i.e., occupy a different position for each pair of rectrices or remiges, indicative of the sequence of pair replacement), but are still bilaterally symmetrical (Fig. 3b).

Flight feather wear.—The amount of feather wear, especially on the rectrices, provides additional information in regard to age determination. The presence of fresh, unworn flight feathers from September to as late as December is evidence of the relatively recent complete prebasic molt of some adults (Parkes 1955; Roest 1957, pers. obs.). Strongly worn feathers during this period, however, are not diagnostic of juvenals because the complete prebasic molt in some adults occur as early as the postnatal molt in young (Willoughby and Cade 1964). In the case of early adult prebasic molts, adult and juvenal males may be distinguished during

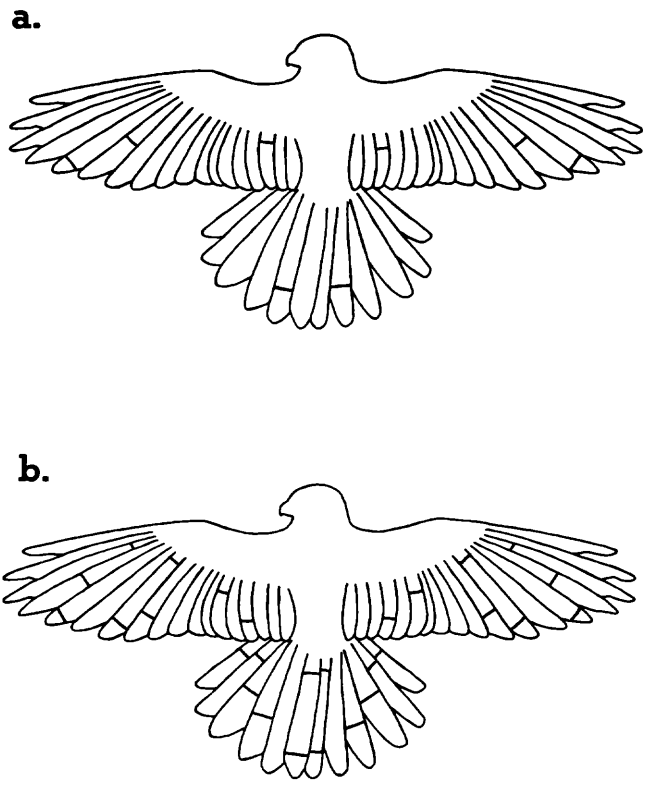

FIGURE 3. Typical fault bar patterns on American Kestrel flight feathers resulting from a) one episode of fault bar formation or b) multiple episodes of fault bar formation during a second or subsequent prebasic molt.

summer by their distinctive body plumages. The juvenal and basic plumages of females are similar. Therefore, juvenal females are difficult to distinguish from early-molting adult females during summer, when both carry unworn flight feathers, unless other evidence of age is available. Age determination by feather wear should not be attempted until known-age fall and winter specimens have been examined.

EVALUATION OF CURRENT AGE AND SEX KEY

The banding manual key to kestrel age and sex (U.S. Fish and Wildlife Service 1980) incorporates many of the plumage characteristics discussed above, but its simplified organization leads to imprecise age determination in several instances. First, a single couplet (2A/2B) combines body plumage and fault bar characteristics in males. In recently fledged males, the body plumage usually is lost within a few months, but fault bar characteristics persist for at least a year. Most HY males from the first prebasic

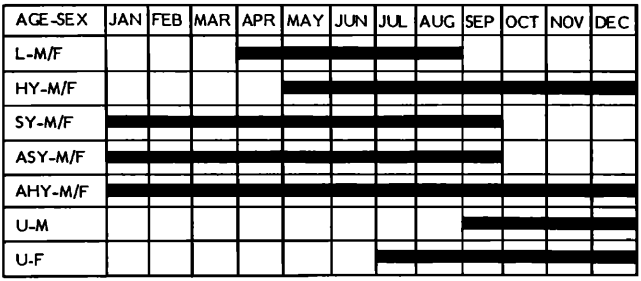

FIGURE 4. American Kestrel age and sex classes distinguished by the revised key (see text).

molt through December and SY males from January until the second prebasic molt carry the definitive body plumage but, contrary to line 2B, if fault bars are present they extend regularly across the remiges and rectrices. Second, although the presence of irregularly spaced fault bars in females, indicative of a previous second or subsequent prebasic molt, appears in line 3B, that information is not utilized in the following couplet. Third, couplet 4A/4B does not recognize that unknown-age females may be observed in July and August, particularly in the southern United States. At that time of year, the juvenals that have wide subterminal tail bands strongly resemble the adults that have already completed early prebasic molts.

In addition to problems resulting from a simplified organization, the key erroneously indicates that a female with a subterminal band less than twice the width of the other black bands necessarily carries juvenal rectrices (line 3A). Of the adult females examined (above), 12.5% had subterminal bands slightly less than twice the width of the basal black bands. A relative width less than 1.75 is a more conservative criterion for identifying juvenal rectrices.

Another shortcoming of the key is the failure to recognize ASY birds during the beginning of the year, even though AHY birds are recognized in December. Any characteristic that may be used to identify an AHY bird in December, and that does not change during the winter (unlike feather wear or skull pneumatization, for example) logically may be used to identify an ASY bird beginning in January. The spatial pattern of fault bars in kestrel flight feathers is clearly such a characteristic. From January until the next prebasic molt, bilaterally symmetrical fault bars on only a few pairs of remiges or rectrices are diagnostic of ASY kestrels because such fault bars would have been acquired during the previous year's second or subsequent prebasic molt.

A revised key for age and sex determination is presented below. This key will yield the sex and age determinations by month as indicated in Figure 4.

A REVISED KEY TO AGE AND SEX IN AMERICAN KESTRELS

1A. Wings blue ..... Male (see 2)
1B. Wings reddish-brown ..... Female (see 3)
2A. Breast heavily streaked; entire back up to the nape barred with black (some males retain a few to many of these juvenal body feathers through the first prebasic molt) ..... HY/SY
2B. Breast clear or with some black spots and usually with a pinkish-cinnamon wash; upper one-third to one-half of back not barred ..... (see 4)
3A. Black subterminal band on second through fifth pairs of rectrices less than 1.75 times as wide as the next dark tail band on those feathers ..... HY/SY
3B. Black subterminal band on second through fifth pairs of rectrices at least 1.75 times as wide as the next dark tail band on those feathers ..... (see 4)
4A. Flight feather molt evident ..... (see 5)
4B. Flight feather molt absent ..... (see 7)
5A. Fault bars absent, or character difficult to determine ..... AHY
5B. Fault bars present on at least some pairs of flight feathers ..... (see 6)
6A. Fault bars extending regularly across all rectrices and/or remiges ..... SY
6B. Bilaterally symmetrical fault bars present on only some pairs of rectrices and/or remiges ..... ASY
7A. One or more worn retained flight feathers (usually pairs of secondaries) present, contrasting with newer flight feathers ..... AHY/ASY
7B. No retained flight feathers evident ..... (see 8)
8A. Fault bars present on at least some pairs of flight feathers ..... (see 9)
8B. Fault bars absent, or character difficult to determine ..... (see 10)
9A. Fault bars extending regularly across all rectrices and/or remiges ..... HY/SY
9B. Bilaterally symmetrical fault bars present on only some pairs of rectrices and/or remiges ..... ASY
10A. Males ..... (see 11)
10B. Females ..... (see 12)
11A. January through August ..... AHY
11B. September through December ..... (see 13)
12A. January through June ..... AHY
12B. July through August ..... U
12C. September through December ..... (see 13)
13A. Flight feathers (especially rectrices) unworn, recently molted ..... AHY
13B. Flight feathers worn, not recently molted, or character difficult to determine ... U

(*Note:* Obvious signs of immaturity, including acquisition of juvenal remiges and rectrices during the postnatal molt and persistent natal down, have been excluded. Plumage characteristics refer to the old or worn feathers if molt is occurring. *Caution:* Familiarity with feather wear and distinguishing fault bars from post-developmental feather damage, such as that caused by lice, may require some expertise. Inexperienced banders should choose "character difficult to determine" in couplets 5, 8, and 13).

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