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BREEDING CHRONOLOGY, MOLT, AND MEASUREMENTS OF ACCIPITER HAWKS IN NORTHEASTERN OREGON

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Nesting Northern Goshawks (*Accipiter gentilis*), Cooper's Hawks (*A. cooperii*), and Sharp-shinned Hawks (*A. striatus*) were studied in the Blue and Wallowa mountains of Oregon from 1974 to 1979. Other reports on accipiters from this study evaluated pesticide residues (Henny 1977), nest site characteristics (Moore and Henny 1983), and breeding age of Cooper's Hawks in relation to productivity and nest-site characteristics (Moore and Henny 1984).

We describe in this paper the approximate date clutches were completed for each species and age class. Molt and feather growth overlap extensively with breeding, and we discuss this phenomenon relative to breeding stage. We also provide measurements and weights of breeding birds. Reynolds and Wight (1978) presented data on initiation of incubation for accipiters in Oregon, but published data on other parameters during the nesting season were not available. Newton and Marquiss (1982) provide the only detailed molt study for accipiters with their investigation of the European Sparrowhawk (*A. nisus*). Accipiter weights and measurements during migration in Wisconsin (Mueller et al. 1976, 1979, 1981) provide comparative data.

STUDY AREA AND METHODS

The study was done within and around Wallowa-Whitman National Forest between 45° and 46° north latitude at 500–1600 m elevation in the Blue Mountains province of Oregon. Franklin and Dyrness (1973) and Hall (1973) describe the physiognomy of this province and climatic conditions of the various forest types.

An egg was collected for pesticide analysis from each nest with 2 or more eggs. To estimate when clutches were completed, we used embryonic development of the sample egg, and criteria such as hatching dates and size of young; dates could not be estimated for all nests. Following Reynolds and Wight (1978), we assumed the incubation period for all 3 accipiters was 31 days; the nestling period for Northern Goshawks was 37 days, Cooper's Hawks 30 days, and Sharp-shinned Hawks 24 days.

In most European Sparrowhawks, replacement of the primary feathers in each wing spanned the whole molt period (Newton and Marquiss 1982); therefore, we used primary feather replacement to indicate molt progress as a whole. Each primary was scored, according to its growth, as follows: old feather—0; feather missing to ¼ grown—1; feather between ¼ and ½—2; feather between ½ and ¾—3; feather ¾ to full grown (not hard penned)—4; feather full grown and hard penned—5. As there are 10 primaries per wing, a fully-molted bird scores 100. Molt of the 12 rectrices was also recorded. Primaries were numbered from the innermost outwards (P1–P10) and rectrices from the central pair outwards (R1–R6). Body molt was not recorded in detail. Molt and feather growth on the 2 wings were usually synchronous. To examine the degree of correspondence between wings and right and left rectrices, birds were placed in 1 of 3 categories: (1) synchronous molt and feather growth; (2) equivalent feathers in molt, but 1 or more feathers at a different growth stage (=different score) to their opposite counterparts; (3) 1 or more non-equivalent feathers in molt, and at the same or different growth stage (same procedure used by Newton and Marquiss 1982).

Standard measurements (Baldwin et al. 1931) and weight as well as footpad length were recorded. The footpad was measured with dividers in a straight line from tip of the middle toe pad to tip of the hind toe pad, with both middle toe and hallux fully extended. The birds were measured by 3 individuals who worked together and routinely double-checked each other's measurements. A *t*-test was used to compare weights and measurements between locations and time periods. Age was estimated by plumage, see Mueller et al. (1976, 1979, 1981). We used terminology of Palmer (1972), but lumped birds during the nesting season (excluding birds produced that nesting season) into only 2 age or plumage classes: (1) *Juveniles* (in second calendar year of life) which were beginning to molt and grow Basic Plumage, and (2) birds in *Basic Plumage* which generally included an entire new feathering, although we believe some Northern Goshawks and Cooper's Hawks could have been further split into a Basic 1 (in third calendar year of life) because they retained a few juvenal feathers due to an incomplete molt. However, to simplify our presentation, the 2 age classes were called juveniles and adults.

THE NESTING SEASON

Northern Goshawk.—The larger Northern Goshawk was the first accipiter to nest in our area. Clutches were completed between 12 April and 6 May with a mean date of 24 April (Fig. 1). Excluded from the mean were a renest after the original nest was blown out by a windstorm on 24 April (the second clutch was completed in another nest on 15 May) and a completed nest without eggs located on 12 May 1977. The latter juvenile female nest contained 1 abandoned dirty egg on 6 June. The average clutch completion date (excluding juveniles and renests)

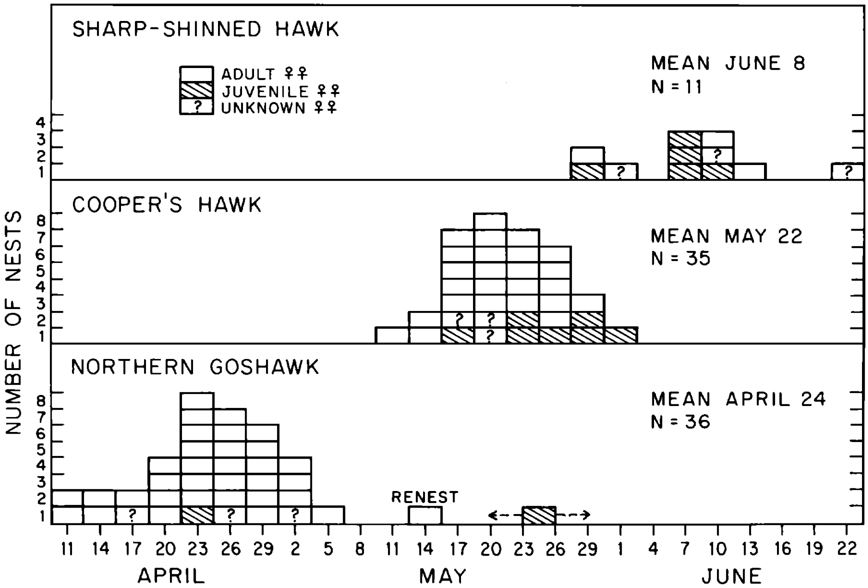

FIGURE 1. Date clutch was completed for accipiters nesting in northeastern Oregon, 1975–79.

showed some variation from year to year. The earliest season was 1978 (17 April, n = 7), followed by 1979 (23 April, n = 3), 1975 (25 April, n = 2), 1977 (26 April, n = 12), and 1976 (28 April, n = 11). In southeastern Oregon for comparison, Reynolds and Wight (1978) recorded the earliest incubation beginning about 10 April, and the latest 2 June with a mean of 6 May (n = 29). We assume their dates for incubation are within a day or two of clutch completion dates. Their study area elevation (1430 to 2130 m) was much higher than ours, which may account for the later nesting season (average 12 days later).

Two female Northern Goshawks in juvenal plumage nested during this study, including the late nest mentioned above which failed. The other juvenile female laid a 3-egg clutch and fledged 2 young (1 egg was collected).

Cooper's Hawks.—The intermediate-sized Cooper's Hawks completed their clutches nearly 1 month after Northern Goshawks (mean date 22 May) with a range of 12 to 31 May (Fig. 1). Timing of Cooper's Hawk nesting was similar to the 19 May mean (n = 8 nests) for southeastern Oregon (Reynolds and Wight 1978). In contrast to Northern Goshawks, female Cooper's Hawks in juvenal plumage accounted for 22% (8 of 37) of nesting birds we were able to age (Moore and Henny 1984). In general, juvenile females completed clutches about 5 days later than adult females (mean 26 May vs. 21 May). With the exception of the Northern Goshawk renesting attempt and lone egg laid by a juvenile

Northern Goshawk, dates for clutch completion showed no overlap between the species.

Sharp-shinned Hawk.—The smallest of the accipiters, the Sharp-shinned Hawk, was last to nest, with clutch completion ranging from 30 May to 21 June (Fig. 1). Limited data showed no obvious differences in timing of the nesting season for adult- and juvenal-plumaged females; 6 of 10 (60%) known-age nesting females were juveniles.

General.—Newton (1979:96) generalized that ". . . the larger species tend to lay before the smaller, which helps them to complete their long breeding cycles before food becomes scarce again." This pattern was graphically shown for the 3 accipiters in several North American locations by Snyder and Wiley (1976), Hennessy (1978), Reynolds and Wight (1978), and again in this study.

Female Northern Goshawks nesting in juvenal plumage were rare during our study (2 of 46 females aged at the nest or 4.3%). Reynolds and Wight (1978) observed 70 Northern Goshawk females nesting in Oregon; all were in adult plumage. McGowan (1973, 1975) reported 4 of 11 Northern Goshawk females nesting in Alaska in 1971 were juveniles. Production of young that year was considered excellent by McGowan. Only 2 attempts failed and they were both juveniles. In 1972 (a year with lower production), all 16 nesting females were in adult plumage, while in 1973 (similar to 1972), all 12 nesting females were again in adult plumage. Based on McGowan's data, juvenile females appear to nest only when nesting success is good. One juvenile nesting attempt during our study was extremely late. Huhtala and Sulkava (1981) reported egg laying in Finland by juvenile Goshawks 10–30 days later than others in the same spring.

Our percentage of juvenal-plumaged female Cooper's Hawks in the breeding population was much higher than the previously reported 6% (2 of 34) by Reynolds and Wight (1978) and 6% (2 of 36) by Meng (1951), but similar to the 20% (3 of 15) reported by Hennessy (1978). The delay in egg-laying by juvenile female Cooper's Hawks was similar to reports from New York (Meng 1951).

Little is known about juvenal-plumaged female Sharp-shinned Hawks' nesting, although Meng (1951) reported one from New York nested later than those in adult plumage.

MOLT

General pattern of molt.—Each species replaced its primaries in order from the innermost (P1) outwards to P10 which is in agreement with other reports for accipiters (e.g., Mueller et al. 1981, Newton and Marquiss 1982). Although the complete molt cycle was not documented in this study, typically (as with the European Sparrowhawk) when 1 feather was partly grown, the next was shed. After molt started, the number of primaries on 1 wing missing or growing ranged from 0 to 3 for each species. In general, the number of feathers being molted at one time increased in each species as molt progressed to outer primaries.

Rectrix molt sequence varied (Fig. 2). The central rectrix (R1) was most often the first to be shed for all species. Birds captured early in molt were used to evaluate rectrix replacement patterns. Northern Goshawks replaced R1 first 8 times and R2 first 3 times. Cooper's Hawks were similar with R1 replaced first 28 times, R2 first 2 times, and R3 first 1 time. Four Sharp-shinned Hawks all replaced R1 first. Molt sequence was further evaluated by grouping birds into categories based on total rectrices molted and replaced at time of capture. R3, R4, and sometimes R6 seem to molt after R1 and R2 (Note: when R2 was molted early it may have been retained an extra year). The most common rectrix molt sequence for each species appeared to be 1, 3, 4, 6, 5, 2, but with considerable variation. A portion of the asymmetrical patterns observed may result from feathers knocked out and replaced prior to normal molt.

Molt symmetry between sides was greatest in primaries and least in the tail (Table 1). This agreed with findings of Newton and Marquiss (1982) for the European Sparrowhawk and with what they imagined to be the importance of these feather groups in flight, with the closest match in the most crucial group (primaries). Asymmetry in primary molt was merely the result of a feather on one side being shed a few days ahead of its opposite number, and maintaining its lead thereafter. The degree (%) of asymmetry for European Sparrowhawks (Newton and Marquiss 1982) was based on combined data from all stages of molt, whereas our data represented mostly the first half of the molt (Table 1). Therefore, the two studies are comparable in general terms only.

Occasionally some North American accipiters fail to complete rectrix molt. For example, an adult male Cooper's Hawk, captured on 19 May 1977, had not started molt. Color and wear led us to conclude that R2 and R5 on each side were retained an extra year. R2 and R5 seem to be among the last feathers molted and therefore, were logical candidates for retention if the molt was not completed. An adult male Cooper's Hawk captured 30 May 1977 had not started its molt, but appeared to retain R5 on the left side for an extra year; a male captured 24 January 1981 had not replaced R2 on either side. An adult male Northern Goshawk captured on 28 July 1977 (had not begun tail molt) also appeared to retain R2 and R5 on the left and R2 on the right for an extra year. Other examples exist with individual or combinations of rectrices retained. Incomplete rectrix molt was most common with the Northern Goshawk.

Arrested molt.—Some individuals of all species caught between 18 June (Northern Goshawk) and 3 August (Sharp-shinned Hawk) had stopped molting temporarily. Their primaries and rectrices consisted entirely of full-grown feathers, some new and others old. Many adult male Northern Goshawks temporarily stopped molting after replacing their second primary. When the male molt was arrested, it tended to occur slightly earlier in the season than with the female (Table 2); perhaps because he is the primary provider of food for the female and young early in

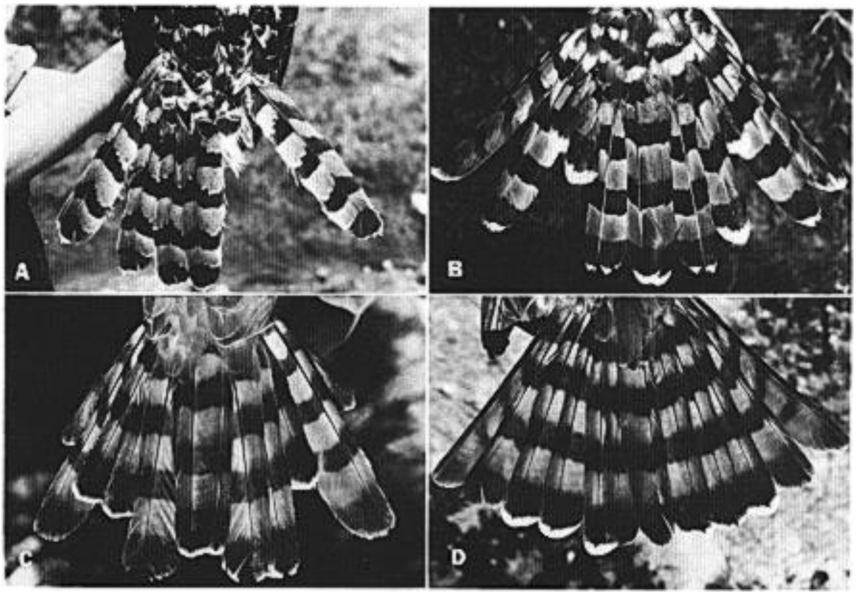

FIGURE 2. Photographs of accipiter rectrices. A. Juvenile female Northern Goshawk (3 June 1978) with feather damage. B. Juvenile female Cooper's Hawk (29 July 1977) with R1 and R6 replaced and R3 and R4 being replaced on each side. C. Adult female Sharp-shinned Hawk (22 July 1977) replacing R1, R3, R4, and R6 (on left) and R1, R4, and R6 (on right). D. Adult male Sharp-shinned Hawk (3 Aug. 1977) which replaced R2, R3, and R4 (on each side). Note the white tips on the new rectrices.

the nesting cycle (Snyder and Wiley 1976). Arrested molt in females occurred about the time they started helping feed their young. We believe the period when individuals stopped molting coincided with their peak energy demands. Walsberg (1983a:191) summarized molt energetics, ". . . for unknown reasons feather replacement requires a substantial increase in energy expenditure in some species in captivity. The increase is large enough to significantly affect the energy relationship of free-living birds . . . ." Walsberg (1983b:147) further noted that molt often accompanies marked reductions in activity (e.g., incubating females) that largely could compensate for energetic costs of feather production. Then, a resumption or increase in activity (e.g., female starting to feed young or young getting larger and requiring more male feeding flights) seems to trigger an arrest of the accipiter molt. Other evidence of arrested molt in wild breeding female Goshawks during the late fledgling stage is available from molt dates (see Table 3 in Ellenberg and Dietrich 1981). An arrested molt also occurs in the European Sparrowhawk (Newton and Marquiss 1982).

Males initiated their molt later in the season than females—perhaps because molting also decreased hunting abilities or efficiency. Therefore, with males beginning their molt later than females and arresting

TABLE 1. Degree of correspondence between molt in two wings and two halves of the tail (excludes hawks that have not begun molt).

	Primaries				Rectrices			
	Northern Goshawk	Cooper's Hawk	Sharp-shinned Hawk	European Sparrow-hawk[a]	Northern Goshawk	Cooper's Hawk	Sharp-shinned Hawk	European Sparrow-hawk[a]
Numbers of hawks checked	62	62	20	535	37	46	18	241
% With equivalent feathers molted and at same growth stages	74	76	85	88	30	52	33	55
% With equivalent feathers molted but at different growth stages	13	18	10	11	8	17	22	29
% With non-equivalent feathers molted or growing	13[b]	6[b]	5[b]	1	62	30	44	16

[a] From Newton and Marquiss (1982).
[b] Always a single feather was missing or in very early growth on one side, but not yet dropped on the other side.

TABLE 2. Proportions of birds with arrested molt in different periods.

	16–31 May		1–15 June		16–30 June		1–15 July		16–31 July		1–15 August	
	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
Northern Goshawk[a]												
Total birds with molt started	3		1	1	12	27	4	10	2			
No. (%) with arrested molt	0		0	0	6 (50)	11 (41)	0	4 (40)	0			
Cooper's Hawk[b]												
Total birds with molt started		1	4		2	1	6	9	11	18	2	3
No. (%) with arrested molt		0	0		0	0	2 (33)	0	0	2 (11)	0	0
Sharp-shinned Hawk												
Total birds with molt started							2	1	1	9	3	4
No. (%) with arrested molt							0	0	0	1 (11)	0	1 (25)

[a] Juveniles excluded because not observed nesting or rarely nested.
[b] Juvenile males excluded because not observed nesting.

their molt earlier, the last primary molted before the arrest was P2 for males and ranged from P3 to P6 for females.

Timing of Northern Goshawk molt.—Although the mean date for clutch completion was 24 April (Fig. 1), breeding birds were not trapped until 2 months later when young attained bandable size (Fig. 3). The primary molt scores at this time for adult females in 1976, 1977, 1978, and 1979 showed minimal annual variation and ranged from (mean ± SD (n)) 38.1 ± 6.4 (9) in 1978 to 45.4 ± 7.9 (11) in 1977.

Adult females with dates of clutch completion known were trapped 53–78 days later. The earliest 15 (captured 53–61 days later) included 6 with arrested molts and a primary molt score of 41.3 ± 6.3, while the last 15 (captured 62–78 days later) also included 6 with arrested molts and a primary molt score of 44.2 ± 7.4. During the 8.9-day interval between the two groups, average molt scores increased 2.9 points, an increase of 0.33 points per day. We could not estimate when primary molting began; however, Ellenberg and Dietrich (1981) reported female Goshawks in West Germany regularly molted the first 3 primaries within 8 to 10 days after egg laying. Stauber (1962) reported similar findings in North America. The primary molt of males was slow (i.e., arrested) until July (Fig. 3).

The molt of the rectrices by males and females was more variable than the molt of primaries (Fig. 4). In fact, molt scores for adult females in 1976, 1977, 1978, and 1979 ranged from 5.0 ± 4.9 (11) in 1977 to 28.2 ± 20.3 (9) in 1978; considerable variability also occurred within years.

Timing of Cooper's Hawk molt.—The mean date for clutch completion was 22 May (Fig. 1); an adult female on 31 May 1976 had dropped P1, P2, and P3 on each wing with replacement just beginning (molt score of 6). A nest was not located, but the presence of a brood patch suggested she was laying or incubating. No other adult females were captured until about mid-July when the primary molt was about 50% completed (Fig. 3). As with Northern Goshawks, primary molt of female Cooper's Hawks was ahead of males'.

Fifteen adult female Cooper's Hawks with known dates of clutch completion were captured 50–70 days later. The earliest 7 (captured 50–55 days) included none with arrested molts and they had a mean primary molt score of 48.1 ± 2.6, while the last 8 (captured 56–70 days) included one with arrested molt and they had a mean molt score of 56.0 ± 5.5. Average molt scores increased 7.9 points during the interval, an increase of 0.91 points per day.

Four nesting juvenile females exhibited the following molt scores in relation to days after clutch completion: day 39 (48), day 45 (52), day 61 (58), and day 66 (67)—within the range of older nesting females or perhaps slightly ahead (Fig. 3). Juvenile males were not observed nesting and rarely have been reported nesting in other studies (Rosenfield and Wilde 1982). Non-nesting juvenile males began primary molt before older males and had higher molt scores by late July (Fig. 3).

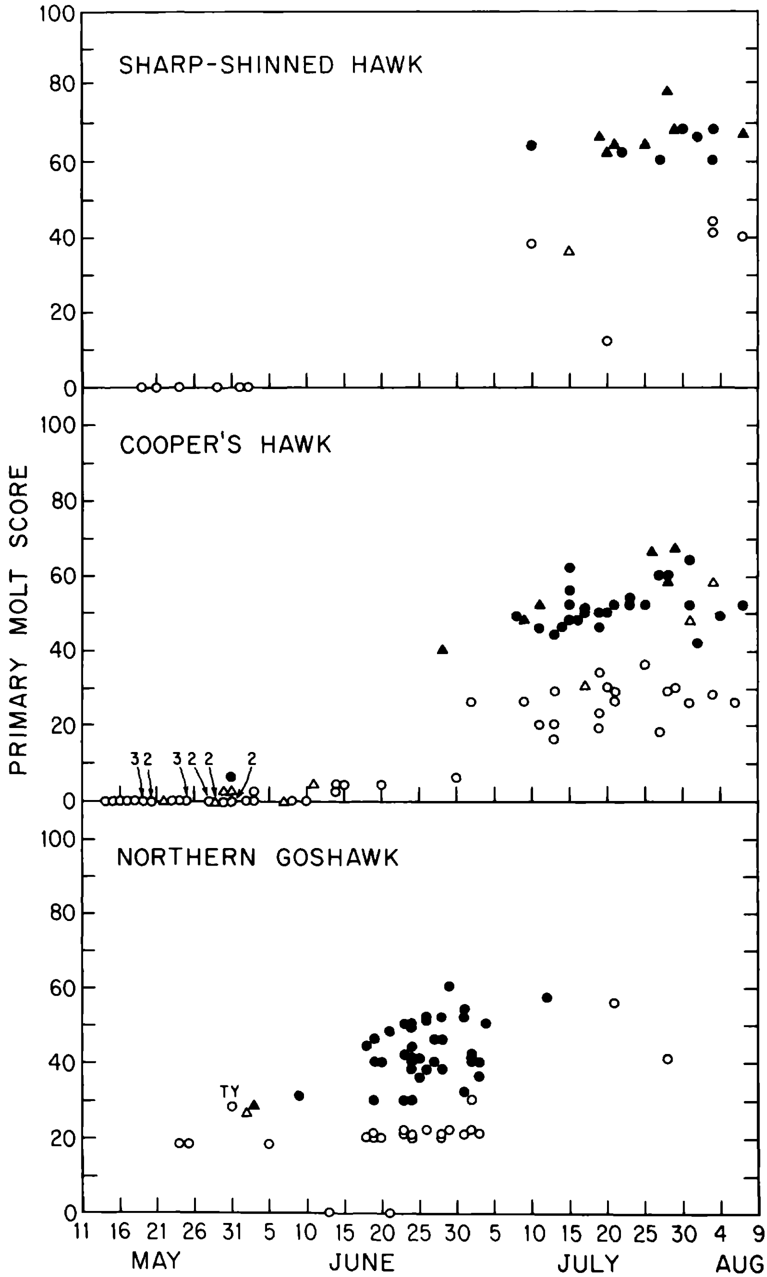

FIGURE 3. Primary molt scores for accipiters in relationship to date, 1975–79. A bird with all new primaries scores 100. Males (open), females (closed), juveniles (triangles), adults (circles), and third year (TY).

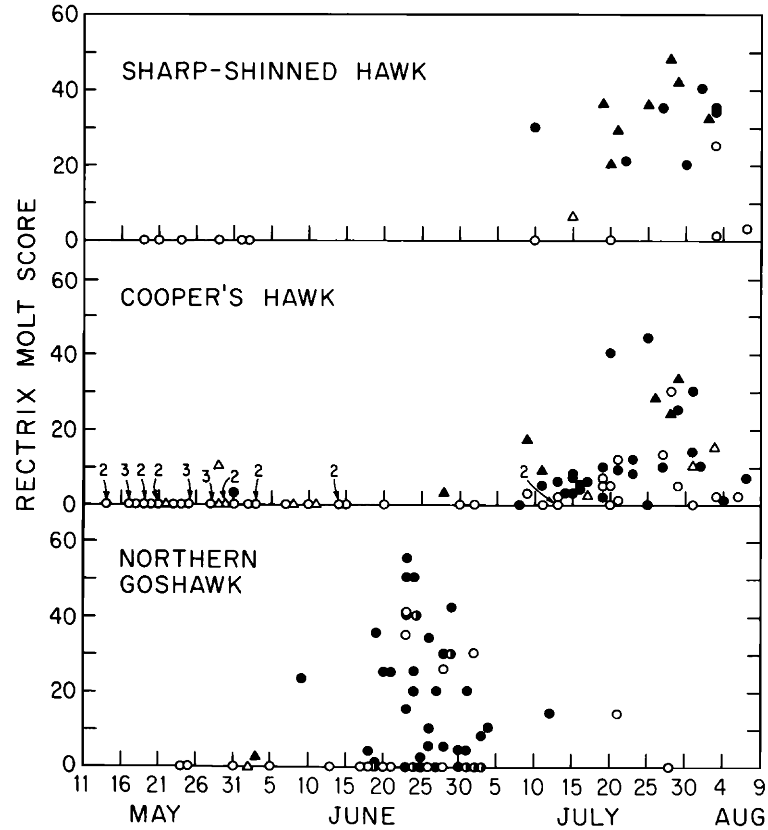

FIGURE 4. Rectrix molt scores for accipiters in relationship to date, 1975–79. A bird with all new rectrices scores 60. Males (open), females (closed), juveniles (triangles), adults (circles). For Northern Goshawks, a half closed circle indicates a male and female with the same score on that date.

With the exception of a juvenile male captured on 29 May that had R4 broken and R2 and R3 replaced with new hard-penned basic plumage (probable replacement of knocked out rectrices) on the left side (Fig. 4), molt of rectrices by male Cooper's Hawks did not begin until early July. As with primary molt, nesting females in juvenal plumage were molting rectrices on a schedule similar to, or perhaps slightly ahead of, the older birds.

Timing of Sharp-shinned Hawk molt.—Adult males captured in late May or early June were not molting primaries (Fig. 3), but by mid-July it was obvious that molt in the female was ahead of the male. Juvenile molt scores were similar to adults'.

No adult males captured in May, June, or July were molting rectrices, but 3 captured in August had started. Females captured from 10 July until 3 August were all molting.

General.—Newton and Marquiss (1982) calculated female European Sparrowhawk molt at 0.42 points per day (actually 0.84 using our terminology for both wings combined), but indicated rates were much greater near the start and end of molt than around the middle, when many individuals stopped molting (arrested) for a time. Our Northern Goshawk and Cooper's Hawk molt rates were estimated for the middle of the molt cycle. The 0.91 points per day for female Cooper's Hawks was similar to the smaller European Sparrowhawk. However, the larger Northern Goshawk was much slower (0.33) which probably reflects the increased incidence of arrested molt.

MEASUREMENTS AND WEIGHTS

Mueller et al. (1981) concluded that Cooper's Hawks have shorter wings and tails in spring than autumn because of feather wear over winter. This generality is probably true for all 3 accipiters. P6 or P7 (usually the longest) has the greatest influence on wing chord length and was seldom replaced at the time of measurement during this study; therefore, feather wear may cause our wing chord measurements to be slightly less than in autumn. Study skin shrinkage (Fjeldsa 1980, Henny and Clark 1982) confounds a direct comparison of live bird measurements with museum specimens so none was made.

Northern Goshawk.—The wing chords (mm) of adult males ($P > 0.05$) and adult females ($P > 0.05$) were shorter (possibly due to feather wear mentioned above), but not significantly different from adult fall migrants (Adult II's when using the terminology of Mueller et al. 1976) in Wisconsin (321.1 vs. 323 and 350.3 vs. 353). Likewise, wing chords of adult males ($P > 0.50$) and adult females ($P > 0.10$) were not significantly different from those from interior Alaska (McGowan 1975) (321.1 vs. 322 and 350.3 vs. 347). However, rectrices (mm) of Oregon adult males ($P < 0.01$) which included more old worn feathers, and Oregon adult females ($P < 0.05$) which included more new feathers, were significantly shorter than those from Wisconsin (224.2 vs. 230 and 262.4 vs. 266).

Northern Goshawks in Wisconsin and Goshawks in Sweden tended to gain weight as fall progressed (Mueller et al. 1976, Marcstrom and Kenward 1981); therefore, weights were not directly comparable between Oregon nesting season birds and Wisconsin fall migrants. The average hatching date for Northern Goshawk eggs in Oregon was about 24 May. Adult male and female Northern Goshawks trapped in Oregon during the following month weighed slightly less than those trapped later (Table 3), but differences were not significant ($P > 0.50$). Even though the Oregon and Wisconsin weight comparison was confounded, we documented the differences. Mean Oregon summer weights of adult males ($P < 0.001$) and adult females ($P < 0.001$) were lower by 19.8% and 15.6% than fall weights from Wisconsin (741.7 g vs. 925 g and 972.8 g vs. 1152 g). Two juvenile Northern Goshawks with nesting status unknown weighed less than the average for older birds (2 June male 690 g and 3 June female 955 g).

Cooper's Hawk.—Wing chords of adult males ($P < 0.001$) and adult females ($P < 0.001$) from Oregon were significantly shorter than spring Cooper's hawks from Wisconsin (223.5 mm vs. 236 mm and 253.7 mm vs. 266 mm) (Table 3). Rectrices of adult males ($P < 0.001$) and adult females ($P < 0.001$) from Oregon were also shorter than spring birds from Wisconsin (178.7 mm vs. 188 mm and 206.6 mm vs. 212 mm). Most females and some males from Oregon had replaced central rectrices.

Oregon summer weights (mid-May to early August) may not be comparable to spring weights (mid-March to mid-May) from Wisconsin (Mueller et al. 1981), but adult males ($P < 0.001$) and adult females from Oregon ($P < 0.001$) weighed 19.4% and 14.5% less than those from Wisconsin (279.7 g vs. 347 g and 472.6 g vs. 553 g). Although statistical tests were not conducted, Oregon weights were also 19.9% and 10.7%, respectively, below fall weights from Wisconsin. Nine juvenile males weighed 276.0 ± 26.5 g (early period 263.9 ± 10.9 g, late period 318.5 ± 19.1 g). The non-breeding young males weighed less than older birds early in the season, but outweighed them later. Five juvenile females (4 known to nest) weighed 485.6 ± 29.3 g during the late period which was slightly higher than the 474.1 ± 42.6 g for older females at the same time.

Sharp-shinned Hawk.—Our limited data (26 birds) preclude any statistical analyses (Table 3). Summer wing chord measurements from Oregon (males 172.0 mm, females 199.7 mm) were very similar to spring or fall values from Wisconsin (Mueller et al. 1979) (males 170 mm and 171 mm and females 202 mm and 203 mm). Rectrices of ten adult males from Oregon averaged 131.4 mm while 7 adult females (all had replaced the central rectrices) averaged 161.6 mm. Spring migrant adult males from Wisconsin averaged 2 mm shorter than fall migrants (130 mm vs. 132 mm), while adult females were identical for fall and spring (156 mm).

Eleven adult males from Oregon (95.9 g) weighed slightly less than fall migrants (103 g) and spring migrants (99 g) in Wisconsin. Seven adult females from Oregon (178.4 g) weighed nearly the same as adult female fall migrants (174 g) and spring migrants (183 g) in Wisconsin. Weights of 2 juvenile males from Oregon (one known to nest) were similar to weights of 11 adults from Oregon (95.7 ± 9.4 g vs. 95.9 ± 3.7 g). Five juvenile females (all known to nest and captured during late time period) weighed 189.2 ± 9.8 g which compared favorably with 183.7 ± 24.3 g for 6 adult females during the same period.

SUMMARY

Most Northern Goshawks completed laying eggs in April, while most Cooper's Hawks completed their clutches in May with essentially no overlap. The Sharp-shinned Hawks laid in late May and June. Juvenile females represented 4% of the Northern Goshawk breeding population;

TABLE 3. Measurements (mm) and weights (g) ($\bar{x} \pm SD$, n [range]) of adult Northern Goshawks, Cooper's Hawks, and Sharp-shinned Hawks from northeastern Oregon during the nesting season.

	Northern Goshawk		Cooper's Hawk		Sharp-shinned Hawk	
Category	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
Bill without cere	21.2 ± 0.55 16 (20.2–21.9)	24.1 ± 0.94 26 (22.2–25.5)	15.0 ± 0.66 31 (13.5–16.3)	18.2 ± 0.79 18 (17.1–20.5)	9.8 ± 0.45 9 (9.2–10.4)	12.1 ± 0.57 6 (11.3–12.8)
Footpad	82.3 ± 2.09 23 (77.9–86.6)	90.7 ± 2.26 37 (86.9–97.3)	66.0 ± 2.21 42 (61.0–70.2)	76.8 ± 2.24 23 (74.1–83.0)	50.2 ± 1.41 11 (48.2–52.3)	59.1 ± 1.81 7 (56.7–62.0)
Tail length	224.2 ± 5.34 21 (212–232)	262.4 ± 7.57 37 (249–280)	178.7 ± 4.30 37 (171–189)	206.6 ± 7.18 23 (190–216)	131.4 ± 2.55 10 (127–136)	161.6 ± 8.89 7 (150–176)
Wing chord	321.1 ± 7.41 22 (307–336)	350.3 ± 7.85 36 (340–370)	223.5 ± 4.90 41 (214–233)	253.7 ± 6.70 24 (237–265)	172.0 ± 3.26 11 (167–177)	199.7 ± 9.70 7 (184–210)
Weight						
Early[a]	738.2 ± 44.5 12 (655–800)	962.4 ± 66.3 9 (885–1077)	277.3 ± 14.9 31 (235–300)	459.5 ± 29.0 2 (439–480)	96.5 ± 3.3 6 (93–100)	147 1 (147)
Late[b]	747.0 ± 56.9 8 (685–838)	976.0 ± 62.8 29 (860–1085)	284.1 ± 24.4 17 (245–338)	474.1 ± 42.6 18 (395–542)	95.2 ± 4.4 5 (90–101)	183.7 ± 24.3 6 (152–225)
Combined	741.7 ± 48.6 20 (655–838)	972.8 ± 63.0 38 (860–1085)	279.7 ± 18.8 48 (235–338)	472.6 ± 41.1 20 (395–542)	95.9 ± 3.7 11 (90–101)	178.4 ± 26.2 7 (147–225)

[a] For Northern Goshawk (24 May–23 June), for Cooper's Hawk (14 May–14 June), and for Sharp-shinned Hawk (19 May–2 June).
[b] For Northern Goshawk (24 June–23 July), for Cooper's Hawk (28 June–6 August), and for Sharp-shinned Hawk (10 July–3 August).

22% of the Cooper's Hawk breeding population (highest reported for the species); and 60% of the Sharp-shinned Hawk breeding population. Northern Goshawks and Cooper's Hawks in juvenal plumage generally nested later in the season, but not Sharp-shinned Hawks.

Females of each species began molting first. Primaries were molted from the innermost outward in all species, but rectrix molt sequence was variable. Usually R1 was molted first. Primary molt of the two wings was usually synchronous; however, the rectrix molt was not as orderly. Arrested molt was observed in some individuals of all species; it probably has an energy-saving function.

Wing chords of adult Northern Goshawks from Oregon were not different from Wisconsin fall migrants or birds from Alaska; however, rectrices were significantly shorter in Oregon than in Wisconsin. Cooper's Hawks nesting in Oregon were much smaller than those trapped in Wisconsin. Wing chords and rectrices were significantly shorter for both sexes, and, although weights were not directly comparable, Oregon Cooper's Hawks also weighed much less. The limited number of Sharp-shinned Hawks measured precluded statistical analyses.

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