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MIGRATION AND MORTALITY OF ALBERTA FERRUGINOUS HAWKS[1]

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Abstract. Since 1967, 2,444 Ferruginous Hawks (*Buteo regalis*) have been banded in southeastern Alberta and 80 recoveries are examined. The majority of Alberta Ferruginous Hawks winter in Texas. Upon departing from their grassland breeding range in September or October, they exhibit a strong tendency to remain in habitat broadly categorized as grassland. As a result, the hawks mix little with the westerly populations frequenting desert shrub habitat. While in Texas, Ferruginous Hawks are common near black-tailed prairie dog (*Cynomys ludovicianus*) colonies regardless of the land use in the surrounding area. Survivorship schedules based on band returns suggest that 66% of the hawks die during their first year.

Key words: *Ferruginous Hawk; gene flow; migration; survivorship; grassland; winter ecology.*

INTRODUCTION

Animals may move for many reasons including finding food, finding mates, avoiding predators and because of aggressive interactions. Most animals disperse at least a short distance from their natal to breeding site. Some also exhibit long distance migrations (see Swingland and Greenwood 1983 for a review). Migration represents a long distance movement followed by a return. The ultimate cause of migration is an avoidance of temporarily adverse ecological conditions, but proximate factors (e.g., food supply, weather) may trigger the onset and small-scale direction of movement. Migratory movements of most bird populations are highly consistent, suggesting a genetic basis to this behavior. Migratory restlessness has been shown to have a genetic basis (Berthold and Querner 1981), and since migratory restlessness is positively correlated with distance migrated, the latter is assumed to be heritable also.

In this paper we describe the migratory habit of the Ferruginous Hawk (*Buteo regalis*) banded in Alberta. This population inhabits the most northern portion of this species' range consisting of sparsely treed grassland east of the Rocky Mountains and south of parkland habitat. The hawks rely largely on ground squirrels for prey and depart from their breeding range in Alberta at a time when the Richardson's ground squirrel (*Spermophilus richardsonii*) are entering estivation/hibernation (Schmutz et al. 1979).

Although the migratory behavior of Ferruginous Hawks has not been proven heritable, we assume that such heritability exists and therefore that migration behavior can be influenced by natural selection. In this analysis we suggest a pattern of migration which we think is exhibited by Alberta Ferruginous Hawks in general. Since we base this analysis on reports of hawks which were either dead, sick or injured, we assume that this subset of individuals behaved in a way similar to those not reported.

METHODS

From 1967 to 1980, 1,915 Ferruginous Hawks were banded under a permit held by R.W.F. and from 1983 to 1985, 529 were banded under a permit held by J.K.S. The bands were applied when the nestlings were more than half grown. Most banding was done on a 3,000 km^2 area southeast of Hanna, Alberta but some hawks were banded throughout southeastern Alberta. Two of 74 hawks recovered were banded in southwestern Saskatchewan. Once a report of a banded hawk was received, a questionnaire was sent to the finder requesting additional information on precise location, habitat and condition of the hawk when found (freshly killed, partly decayed, fully decayed).

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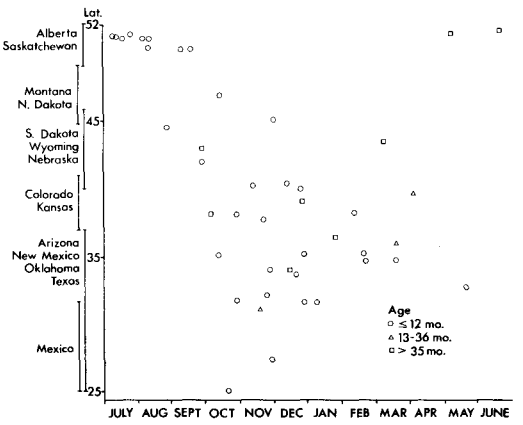

FIGURE 1. Latitude and time of year of recoveries of Ferruginous Hawks. Dates for hawks reported as freshly killed were used directly. From 5 to 45 days depending on location and time of year were subtracted from the finding date of eight hawks reported as partly decayed.

To study their distribution on the winter range, J.K.S. counted Ferruginous Hawks and other raptors seen on a road transect in southwestern New Mexico and northern Texas. The route was from El Paso to Seminole, north around Amarillo and back to El Paso via Clovis and Roswell, New Mexico. This count took place from 3 to 7 November 1985. Hawk location, activity, habitat type, and land use were recorded. To minimize a potential bias in visibility imposed by differences in vegetation or terrain, the search was concentrated within 200 m of the road. A total of 246 raptors were recorded on 1,392 km travelled.

RESULTS AND DISCUSSION

In some raptor populations, adults remain in their breeding area year-round and these may be joined by others from other areas (Mebs 1964). Some Ferruginous Hawks are present all year in the southern part of their breeding range (Olendorff 1973, Smith and Murphy 1978) but whether these were migrants or summer residents was unknown.

TIMING OF MIGRATION

In Alberta, apparently all individuals departed from their northern part of the breeding range by late October. Young which were marked in Utah, departed independently of nest mates and their parents (Woffinden and Murphy 1983).

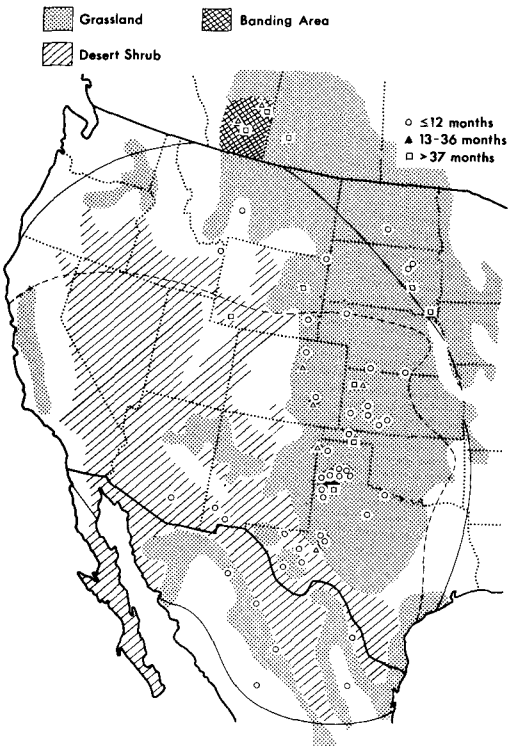

FIGURE 2. Location of recovered Ferruginous Hawks is shown in relation to banding area and wintering range of this species. The solid line outlines the entire wintering range of this species based on 1,532 sightings of Ferruginous Hawks during 37,172 hr of observation on Audubon Christmas Bird Counts from 1980 to 1983. The broken line denotes the "concentrated" winter range and includes counts where more than one hawk was seen per 100 km travelled. In Mexico, Ferruginous Hawks were seen on few counts totalling only 112 hr of observation and hence a concentrated range is not shown. The entire range shown there represents sightings and recoveries combined.

Young also appear to migrate on their own in Alberta. After fledging, during the second half of July and all of August 1985, 10 adults and 20 young were recorded on a study area south and east of Hanna, Alberta, whereas only four adults and no young were seen in September and October. One breeding pair was observed on what was presumed to be their previously used nest tree on 16 October 1985. One young of this pair was found partly decayed in Texas on 22 October 1985. The locations of recoveries reported as freshly killed or partly decayed also suggest that most young Ferruginous Hawks leave Alberta in August (Fig. 1). Later, during November through February only one (5%) of 19 individuals was

found north of Colorado and Kansas. Few were reported in March through June but the three adults, 36 months old or older, were found distinctly further north than four younger individuals. This small sample suggests that subadults do not return to their natal area or they spend less time there than adults. Age at first breeding is three years in this species based on a sample of seven known-age adults livetrapped at nests.

MIGRATION ROUTES

Of 74 Ferruginous Hawks reported dead, 13 died during the first four months of life within 150 km of their banding location. The remaining 61 locations are shown in Figure 2. The results indicate that the migration route and winter distribution of Alberta Ferruginous Hawks are distinctly nonrandom in comparison to the total population. While Ferruginous Hawks can be found wintering anywhere in the western U.S., Alberta hawks occupied only the midwestern states and most wintered in Texas. On Audubon Christmas Bird Counts (American Birds 1980 to 1983), Ferruginous Hawks were more abundant south of about 43°N latitude. The pattern was corroborated by a preponderance of Alberta hawks recovered south of Wyoming and South Dakota during November through February. Thus, while those from Alberta segregate themselves from the remainder of the wintering population further west, their distribution north and south more closely reflects that of the population as a whole. The preponderance of Alberta hawks in the midwestern states in winter does not merely reflect east-west differences in abundance. Ferruginous Hawks were common in California but no individuals banded during this study were found there (Table 1). Only six Ferruginous Hawks were reported from northern Mexico. Our data may underestimate the importance of this region as a wintering area because reporting rates may differ.

Prior to this study, Ferruginous Hawks were banded in Alberta by Salt (1939). Despite a 30 year lag between studies and a change in breeding distribution in the interim (Schmutz 1984), there was no difference between the two studies in the distribution of recoveries. The average longitude of 15 of Salt's (1939) U.S. recoveries was 104°W and of 48 in this study 103°W. Other raptors have shifted their wintering locations during less than 30 years' time (Newton 1979) suggesting that no natural selection was operating on Alberta hawks to cause a change in the areas used.

TABLE 1. Number of Ferruginous Hawks recorded on Audubon Christmas Bird Counts (American Birds) in 1980 to 1983. Only states with counts of one or more Ferruginous Hawks during at least 100 hr of observation over four years are included. The number of Ferruginous Hawks recovered are also given.

State or country	Hawks/ 100 hr	Total time (hr)	Recoveries
Kansas	15.0	568	3
Nebraska	7.5	227	6
Colorado	6.5	2,943	4
Wyoming	5.6	108	3
New Mexico	5.4	1,821	1
Mexico	5.4	112	5
Oklahoma	5.1	901	2
Nevada	4.9	143	
Texas	4.9	5,624	15
Arizona	4.7	4,220	1
Utah	4.2	708	
Washington	3.7	164	
South Dakota	3.2	407	4
California	2.9	18,530	
Oregon	2.0	298	
Montana	1.8	164	2
Missouri	1.4	144	

To further compare the east-west distribution of recoveries of Ferruginous Hawks banded in North Dakota (Gilmer et al. 1985) with those of this study we considered all recoveries south of Wyoming (41°N latitude). Of 22 recoveries of North Dakota hawks, 11 (50%) were west of a line extending the eastern boundary of the Texas Panhandle (100°W longitude). Of 42 hawks originating from Alberta, 38 (91%) were recovered west of 100°W longitude ($\chi^2 = 13.18$, $P < 0.001$). Therefore, North Dakota hawks were more widely scattered east and west than Alberta hawks and the latter overlap in significant numbers only with the western segment of the North Dakota population. Alberta hawks, which have a more northerly origin, do not "leap-frog" on migration over those from North Dakota as is the case in some other raptors (Newton 1979). There was no significant difference in degrees latitude between the southernmost ⅓ of the Alberta ($n = 23$) and the North Dakota populations ($n = 13$; Mann-Whitney U = 163, $P = 0.428$).

Despite an east-west difference in winter distribution between Alberta and North Dakota hawks, both populations preferentially occupied habitat broadly categorized as grassland (Hammond Inc. 1982). Actually, 83% of 135 Ferru-

TABLE 2. Counts of Ferruginous Hawks on road transects according to habitat and land use in western Texas and southeastern New Mexico. The total distance travelled was 1,392 km between 3 and 7 November 1985. Counts of Red-tailed Hawks are shown for comparison. Percentages are in parentheses.

	Shrubland	Grassland	Cultivation and grassland	Cultivation (>90%)		Prairie dog town	Total
				Dryland	Irrigation		
Ferruginous Hawks	3 (4)	2 (3)	9 (13)	11 (15)	24 (33)	23 (32)	72
Hawks/100 km	0.68	2.60	5.17	4.64	5.49	79.30	5.17
Red-tailed Hawks	17 (29)	9 (15)	2 (3)	13 (22)	16 (27)	2 (3)	59
Hawks/100 km	3.88	11.67	1.15	5.49	3.66	6.90	4.24

ginous Hawks banded within grassland habitat (Fig. 2) in Colorado (Harmata 1981), North Dakota (Gilmer et al. 1985), and Alberta (Salt 1939, this study) were recovered again in grassland. This habitat clearly has been altered by agricultural practices but the results suggest that this land is still important to the hawks either because of resources provided, because of traditional migration routes or both. Alberta hawks appear to be concentrated east of the Rocky Mountains along the western portion of grassland in the southern U.S. (Fig. 2). It appears that the hawks do not migrate in a straight line to western Texas but rather veer easterly along the mountain range and then south. Only three (13%) of 24 recoveries north of New Mexico and Oklahoma were on the west side of a line directly connecting the center of the banding area with western Texas (Binomial Test $P < 0.001$). If the route taken had been direct, 50% of the recoveries should have been on either side. It is probable therefore, that appropriate habitat serves as a guide to the migrating hawks in addition to a general southward direction that may be under genetic influence. This may also explain why Alberta Ferruginous Hawks were concentrated along the western edge of the belt of grassland habitat.

Ferruginous Hawks banded in the desert shrub habitat of the western U.S. move southward also and appear to frequent desert habitats in winter (Thurow et al. 1980, Perkins and Lindsey 1983, Woffinden and Murphy 1983). It is conceivable that the populations which occupy the different habitats are subtly different ecologically and may represent different "ecotypes." We compared the percentage of prey items used during the nesting period in an effort to approximate the degree of difference in the use of food by Ferruginous Hawks in desert versus grassland habitat. In grassland habitat sciurid and geomyid rodents comprised on average 77% of prey, lagomorph prey comprised 8% (Olendorff 1973, Lokemoen and Duebbert 1976, Schmutz et al. 1980, Gilmer and Stewart 1983). In desert shrub habitat the converse was true, lagomorphs comprised 50% and sciurids only 7% of prey (Smith and Murphy 1978). It is probable that the most effective hunting tactics are different for lagomorph versus rodent prey and that hawks of the subpopulations differ in hunting behavior and morphology. Local adaptations that may exist, may be preserved by reduced gene flow which is evident between subpopulations.

HAWK DISTRIBUTION IN TEXAS

The hawks were more widely scattered during winter than their natal nests were in Alberta. The nests of 16 (84%) of 19 individuals that died during November to February, were located in an area of about 840 km^2. On their wintering grounds, 84% of these same hawks were found over an area 440 times larger.

Ferruginous Hawks show a strong preference for grassland habitat during the nesting period (Schmutz 1984) and hence it is not surprising that this preference is also evident outside the nesting period. In many parts of their range, a well documented decline in population size has been attributed to a loss of nesting habitat owing to cultivation of grassland (Olendorff 1973, Howard and Wolfe 1976, Gilmer and Stewart 1983, Houston and Bechard 1984). However, during November 1985, Ferruginous Hawks were abundant in intensively cultivated and irrigated areas in Texas (Table 2). In view of their preference for grassland during the nesting period, the high number of Ferruginous Hawks found in intensively cultivated areas was surprising.

The hawks were least common in shrubland, moderately common in grassland, and most common in cultivated areas. The regularity with which Ferruginous Hawks were found near

black-tailed prairie dog (*Cynomys ludovicianus*) colonies (K. Seyffert, pers. comm.; Table 2) suggests that this rodent represents an important prey species during winter. The distribution of black-tailed prairie dogs (Bart and Grossenheider 1964) corresponds well with the distribution of grassland habitat (Fig. 2) in the midwestern U.S. Prairie dog colonies were always found in patches of grassland in Texas. Ferruginous Hawks frequented these colonies regardless of the surrounding land use. The Red-tailed Hawk (*B. jamaicensis*) was also present in all categories of habitat and land use but was relatively uncommon at prairie dog colonies and most common in grassland (Table 2).

The type of land use alone was a poor predictor for the presence of Ferruginous Hawks. The hiatus between two clusters of recoveries, one in northern Texas and one in western Texas (Fig. 2), appears to reflect an actual gap in distribution. No Ferruginous Hawks were seen there on a 185 km portion of the route west and north of Seminole whereas 72 (6.37/100 km) were seen in the Lubbock-Amarillo area. The latter area corresponds with a cluster of recoveries in northern Texas (Fig. 2). The reasons for Ferruginous Hawks having been infrequent in or absent from the Seminole area are not obvious. The intensity of cultivation and the type of land use in these areas were similar. Perhaps subtle differences in land use or other ecological factors caused differences in prey density.

MORTALITY

Of 1,915 Ferruginous Hawks banded between 1967 and 1980, 71 (3.7%) have been recovered. The remaining nine recovered were color banded in 1984 or 1985. Of the 71 reports of banded hawks received, 43 respondents addressed the known or probable cause of death. The cause was not known for 27 (63%) individuals but shooting was suspected in eight. Of the remaining 16 hawks, eight (18%) were struck by a vehicle, five (11%) were found injured or sick, one (2%) was killed by an unidentified raptor, one (2%) struck a power line and one (2%) was electrocuted.

The majority of first year deaths occurred during the first few months of independence. Of 31 yearlings, 81% had died prior to January whereas only 46% of hawks older than one year died during this same period ($\chi^2 = 4.93$, $P = 0.027$). This suggests that migration and the establishment of a winter home range is more detrimental to the hawks' survival than food shortages which may be expected to be most severe in late winter and spring. The survivorship schedule is presented in Table 3. The data suggest that 66% of the young died during their first year of life. The oldest individual in this study was in its 14th year of life. Some individuals lived to at least their 15th and 20th year in earlier studies (see Houston 1984). Data based on recoveries must be treated with caution in estimating survivorship since it is probable that reporting rates differ for hawks of different ages (Lakhani and Newton 1983, Anderson et al. 1985). Young hawks may die of different causes and more often in places frequented by people, introducing a bias into the data. To overcome this shortcoming a study is presently underway to estimate survival directly using color bands readable at a distance.

TABLE 3. Survival schedule of Ferruginous Hawks.[1] Since some recently banded hawks have yet to be reported only individuals banded from 1967 to 1980 are used here.[2]

Age interval (years)	Number alive at beginning of interval	Fraction surviving	Number dying	Fraction dying
0–1	71	1.00	47	0.66
2	24	0.34	6	0.09
3	18	0.25	2	0.03
4	16	0.22	5	0.07
5	11	0.16	3	0.04
6	8	0.11	2	0.03
7	6	0.08	1	0.01
8	5	0.07	3	0.04
9	2	0.03	1	0.01
10	1	0.01	0	0.00
11	1	0.01	0	0.00
12	1	0.01	0	0.00
13	1	0.01	0	0.00
14	1	0.01	1	0.01

[1] This survival schedule represents the actual mortality profile including natural and man-related causes of mortality.
[2] An additional six recoveries were received while this manuscript was in press and these are included in the mortality section only.

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