ENVIRONMENTAL INFLUENCE ON THE INCIDENCE OF FLIGHT IN THE ROUGH-LEGGED HAWK

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LARGE numbers of the Rough-legged Hawk (*Buteo lagopus*) winter in the agricultural areas of the northern one-third of Illinois. In the course of my investigation of the winter habits and behavior of this species in DeKalb County, Illinois, during the winters of 1964–65 and 1965–66, it became apparent that there were pronounced day-to-day differences in the relative numbers of Rough-legged Hawks flying and standing. It appeared that these differences might be related to fluctuations in local weather conditions. Therefore, I attempted to learn more about the activity patterns of the hawks in relation to major environmental variables.

Rough-legged Hawks hunt for food either by soaring and hovering or by watching for prey from a perch. Although I have no direct evidence, it may be that more prey animals are captured per unit time by flying birds as compared to perching hawks. Thus, the presence or absence of favorable conditions for flight may be a determining factor in the relative number of Rough-legs flying in search of food at any one time.

The study was conducted in a 43.1 square mile area located near the center of DeKalb County; the major part of this area is in Afton Township. The terrain varies from flat to gently rolling; no large areas of timber are present and more than 80 per cent of the land is in crops. Lone trees, small groups of trees, and other suitable perching sites are scattered throughout the study area.

METHODS

I recorded hawk flight activity while censusing birds in the study area and conducting general observations. Periodically during the two winters, car censuses were made along a 50-mile survey route. For each Rough-legged Hawk observed, I recorded the date and time of observation and whether the bird was flying or standing when first encountered. Daily weather readings were obtained from the U. S. Weather Bureau, DeKalb Station (Earth Science Department, Northern Illinois University) located approximately 3.5 miles to the north of my study area. Readings of all variables used in this study were taken three times a day (0730, 1200, and 1545 hours) at the station, and times of maximum and minimum daily temperatures were recorded. With this information it was possible

to interpolate and determine the weather conditions prevailing in the general area at the time of each observation.

During the course of the study I recorded observations of 534 Rough-legged Hawks, 140 in the 1964–65 winter period and 394 in 1965–66. My 1964–65 observations were made between 14 November and 28 March, while my 1965–66 records were obtained from 24 October to 15 March. Each record does not necessarily represent a different individual; however, I did not knowingly record the activity of the same bird twice in a single day.

I think that the relative number of birds flying served as a good index of activity for the Rough-legged Hawk population in the study area, and this is what I will refer to when speaking of activity. Since I considered the activity to be what the hawk was doing when I first encountered it, it was rarely difficult to place the bird in one category or the other (i.e., standing or flying).

After observations were completed, I compiled data for the environmental variables and subjected them to the standard chi-square test for randomness. I based my conclusions on statistical significance at the 95 per cent probability level, but the chi-square values obtained and the degrees of freedom are given so that the reader may draw his own inferences. The environmental factors analyzed are wind velocity, cloudiness, changes in barometric pressure, relative humidity, temperature, and time of day.

RESULTS

Exactly one-third (178 of 534) of the birds recorded were flying when first sighted. J. J. Craighead and F. C. Craighead, Jr. (*Hawks, owls and wildlife*, Harrisburg, Stackpole Co., 1956; see p. 48), reported that 65 per cent of 128 Rough-legged Hawks observed on car censuses in Michigan during the winter of 1941–42 were flying, as were 3 of 6 Rough-legs they observed in 1947–48. The difference between their results and my own may be the result of different techniques rather than because of an actual difference in the frequency of flying birds.

Wind velocity.—At the weather station wind velocities were measured on the Beaufort scale, velocities being estimated from characteristic movements of tree limbs and branches. I divided the wind velocities into intervals of five miles per hour (Figure 1). However, since only four observations were made with winds 25 to 29 mph, these data were combined with those in the 20- to 24-mph interval for statistical analysis.

The null hypothesis that no difference in Rough-leg activity occurred during times of various wind velocities was rejected, since a chi-square value of 37.15 was obtained, and the probability of having a chi-square

	Wind Velocity in Miles Per Hour					
	0-4	5-9	10-14	15-19	20-29	Total
Standing	70	167	102	13	4	356
Flying	26	65	55	11	21	178
Total	96	232	157	24	25	534
Per Cent Flying	27.1	28.0	35.0	45.8	84.0	

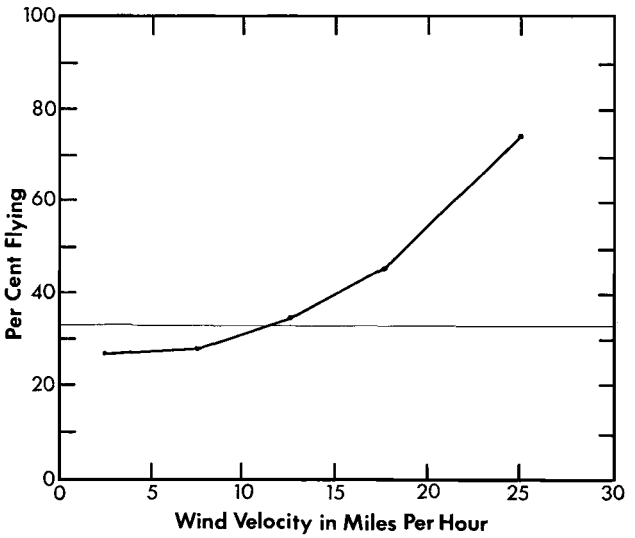

Figure 1. The percentage and number of birds flying under various wind conditions. The horizontal line at 33.3 per cent represents the theoretical distribution expected from a random sample if the variables, wind velocity and percentage of flying birds, were independent.

value larger than 14.86 from a random sample with four degrees of freedom is 0.005. With increasing wind velocity there was an increase in hawk activity (Figure 1).

It would appear to be of advantage to a Rough-leg to fly when wind velocities are higher, since less energy need then be expended to keep aloft when soaring and, especially, while hovering. On several occasions when strong winds were blowing, I observed Rough-legs "hovering" over a given spot for several minutes with barely a flap of their wings.

Cloudiness.—At the DeKalb weather station the percentage of cloud cover was noted to the nearest 10 per cent and recorded in one of three categories: clear (0 to 30 per cent), partly cloudy (40 to 70 per cent), and cloudy (80 to 100 per cent). I rejected the null hypothesis that

	Cloud Cover in Per Cent 0-30	40-70	80-100	Total
Standing	101	45	210	356
Flying	71	25	82	178
Total	172	70	292	534
Per Cent Flying	41.2	35.7	28.0	

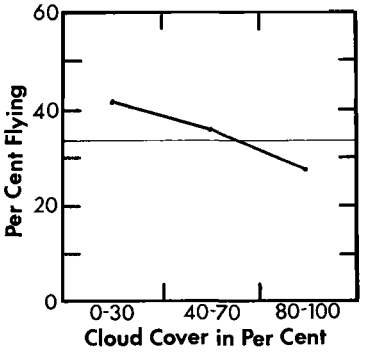

Figure 2. The number and percentage of Rough-legged Hawks flying under different conditions of cloud cover. The horizontal line at 33.3 per cent represents the theoretical distribution expected from a random sample with independent variables.

there was no difference in Rough-legged Hawk activity under different cloud conditions. With increasing cloudiness there was a decrease in activity (Figure 2). A chi-square of 8.71 was computed for the sample, and the probability of obtaining a value larger than 7.38 by chance alone with two degrees of freedom is 0.025. It should be emphasized that overcast skies were usually associated with lower wind velocities and higher relative humidity.

Changes in barometric pressure.—The characteristic trend in air pressure was recorded at the weather station as rising, steady, or falling. A significant relationship existed between the activity of Rough-legged Hawks and changes in air pressure. More birds were flying when air pressure readings were rising and fewer when the air pressure was falling (Figure 3). A chi-square value of 11.48 was obtained, and the probability of having such a value larger than 10.60 from a random sample with two degrees of freedom is 0.005.

Although falling barometric pressure generally indicates the approach of a low pressure center, atmospheric pressure at a given locality varies continually (G. E. Taylor, *Elementary meteorology*, Englewood Cliffs,

	Barometric Pressure			
	Rising	Steady	Falling	Total
Standing	41	97	218	356
Flying	39	51	88	178
Total	80	148	306	534
Per Cent Flying	48.8	34.5	28.8	

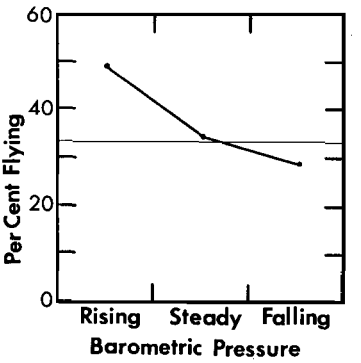

Figure 3. The number and percentage of Rough-legged Hawks flying with different trends in barometric pressure. The horizontal line at 33.3 per cent represents the theoretical distribution expected from a random sample with independent variables.

Prentice-Hall Inc., 1954; p. 111). This day-to-day variation is made up of some rather regular oscillations superimposed on irregular components caused by the passage of storms and is primarily caused by the alternate heating and cooling of the earth's atmosphere. The principal reason why a significantly higher percentage of birds was flying with rising air pressure is not entirely clear, but rising air pressure is generally associated with fair weather, and this may account for the increased activity. Apparently during the times when I took my sample, the increased turbulence usually associated with low pressure areas (the approach of which would be indicated by falling barometric pressure) did not generally manifest itself in higher wind velocities. This appears to be true because a higher percentage of Rough-legs was flying with higher winds and with rising rather than falling barometric pressure.

Relative humidity.—I grouped the readings of the relative humidity, from 40 to 100 per cent, into intervals of 10 per cent, the last interval being 90 to 100. I rejected the hypothesis that there was no difference in Rough-legged Hawk activity under different conditions of relative

	Relative Humidity in Per Cent						
	40-49	50-59	60-69	70-79	80-89	90-100	Total
Standing	2	33	39	64	150	68	356
Flying	16	20	38	23	52	29	178
Total	18	53	77	87	202	97	534
Per Cent Flying	88.8	37.7	49.3	26.4	25.7	29.8	

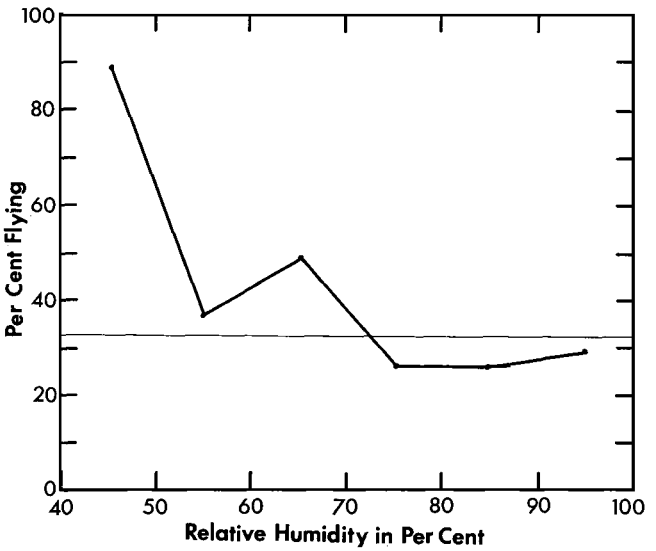

Figure 4. The number and percentage of Rough-legged Hawks flying under different conditions of relative humidity. The horizontal line at 33.3 per cent represents the theoretical distribution expected from a random sample with independent variables.

humidity (Figure 4). I computed a chi-square of 41.88, and the probability of obtaining a value of more than 16.75 from a random sample with five degrees of freedom is 0.005. A higher percentage of birds took flight with lower relative humidities. Relative humidities of 40 to 49 per cent were associated with warmer days occurring early in the study period and many of the birds recorded on these dates may represent migrating birds. Certainly lower relative humidities would be associated with windy, clear, and warm days, and such periods appear to be near the optimum for activity of Rough-legs.

Temperature.—I divided the temperature range, of −10° to 69°F, into 10-degree intervals. Since the number of observations at tempera-

	Temperature in Degrees Fahrenheit						
	−10-9	10-19	20-29	30-39	40-49	50-69	Total
Standing	15	62	53	148	63	15	356
Flying	3	37	40	57	19	22	178
Total	18	99	93	205	82	37	534
Per Cent Flying	16.7	37.4	43.1	27.9	23.2	59.5	

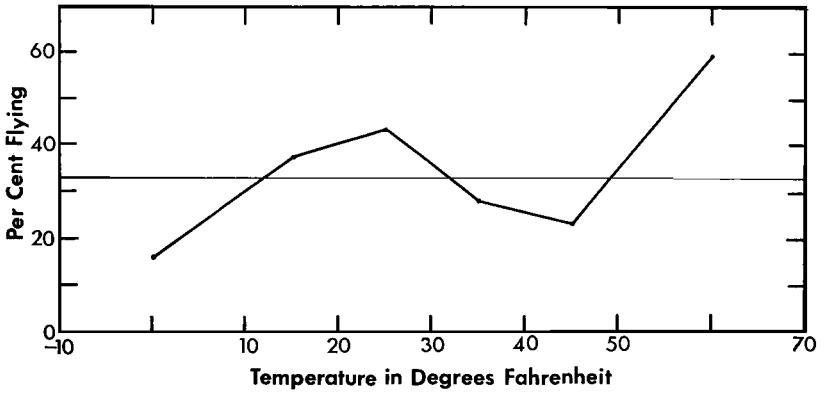

Figure 5. The number and percentage of Rough-legged Hawks flying under different temperature conditions. The horizontal line at 33.3 per cent represents the theoretical distribution expected from a random sample with independent variables.

tures on each end of the range was small, I had to combine intervals at each extreme to allow for statistical analysis (Figure 5). I rejected the hypothesis that there was no significant difference in hawk activity at different temperatures. A chi-square value of 24.93 was computed for the sample and the probability of obtaining a value larger than 16.75 with five degrees of freedom is 0.005.

Although samples were small at both temperature extremes, it appears that during extremely low temperatures the birds are somewhat less active and under conditions of higher temperature they are significantly more active. The basically bimodal condition indicated in Figure 5 may have resulted from the occurrence of different types of air masses passing through the study area. The increase in activity depicted near 25° F corresponds roughly to the temperatures associated with the polar continental air masses, and the other peak in activity may be associated with characteristic temperatures and winds of dry Superior continental air masses.

Time.—I divided the period between 0800 and 1800 hours into five

two-hour intervals. The null hypothesis that there was no significant difference in hawk activity at different times during the day was accepted (Figure 6). I obtained a chi-square value of 5.70, and this was significantly less than the 95 per cent value of 9.49 with four degrees of freedom. There was no pronounced change in activity indicated for the time periods tested.

I noted that Rough-legs left communal roosting sites from approximately 0630 to 0700 hours (depending in part on the time of year) and dispersed into the surrounding area. Unfortunately I do not have quantitative data for the time period before 0800 hours, but my general observations indicate no substantial difference in activity from other times of the day. Depending on the time of year, Rough-legs returned to night roosts from 1700 to 1800 hours.

DISCUSSION

While there may be some cyclic variation in the relative number of birds flying at different times of the day, my data indicated that local weather conditions had a more pronounced effect on the activity of Rough-legged Hawks during the winter months. Craighead and Craighead (*op. cit.*, p. 50) noted that flight activity of the several hawk species they studied decreased markedly during "bad weather." This is, in part, essentially what I have quantified for the Rough-legged Hawk. Low wind velocity, overcast skies, falling barometric pressure, high relative humidity, and low temperatures (conditions under which relatively few Rough-legs were flying) often combine to produce what is considered bad weather.

The probability of demonstrating the reaction of Rough-legged Hawks to changes in weather was increased by the fact that this study was attempted during the winter season when food getting was presumably the principal factor affecting their behavior. The flight activity associated with courtship, nest building, and care of young did not enter in as an additional variable. The level terrain and the lack of large groves of trees allowed me to observe essentially all the Rough-legs in a given area. Thus, even when a relatively large number of birds was on the ground at a given time, it is unlikely that I missed seeing a significant number of hawks. I think that the elimination of the above-mentioned variables was important in obtaining samples that accurately represented the activity of the population for a particular time or under specific conditions.

It would be desirable to obtain additional data so that sample sizes would be large enough to allow for multidimensional analysis. This would enable me to make a more precise determination of the relative

	Time					
	800-959	1000-1159	1200-1359	1400-1559	1600-1759	Total
Standing	23	33	70	145	85	356
Flying	9	19	30	88	32	178
Total	32	52	100	233	117	534
Per Cent Flying	28.1	36.5	30.0	37.8	27.4	

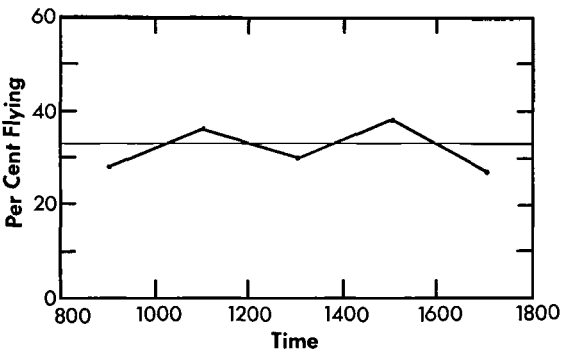

Figure 6. The number and percentage of Rough-legged Hawks flying at different times of day. The horizontal line at 33.3 per cent represents the theoretical distribution expected from a random sample with independent variables.

importance of the several variables as well as to analyze the interrelations of the variables in a better way.

The fact that activity was correlated with several variables (wind velocity, cloud cover, etc.) in my study indicates that the birds are reacting, as one would anticipate, to the end product of several interrelated and interacting variables, including those tested, and perhaps several others. Since this is the case, one would obtain only a very incomplete picture of the factors governing winter activity in this species if but one variable were studied in the field or under controlled laboratory conditions. Of all the variables studied, wind velocity had the most marked effect on the Rough-legs. However, other factors certainly play an important role and a knowledge of the composite effect, as well as the effect of each variable, is vital to an understanding of winter activity patterns of the Rough-legged Hawk.

ACKNOWLEDGMENTS

This research was supported by the Frank M. Chapman Memorial Fund, American Museum of Natural History, and the Museum provided a spotting scope for use during the study. I thank William E. Southern, James F. Lahey, Richard F. Johnston,

and Marion A. Jenkinson for critically reading the manuscript and making helpful suggestions. My wife, Mary Sue Schnell, assisted in many ways throughout the study, and R. Steven Gourley and John L. Weeks gave assistance in the field.

SUMMARY

Changes in the relative numbers of wintering Rough-legged Hawks flying and standing were analyzed in relation to several environmental variables. One-third of all the birds recorded (178 of 534) were flying when first seen. The data indicate that local weather conditions are important in determining Rough-legged Hawk activity in winter.

Optimum conditions for flight occurred with high wind velocity, clear skies, rising air pressure, low relative humidity, and high temperature. There was no statistically significant difference in hawk activity at different times of day. The fact that activity was correlated with several variables indicates that the Rough-legs react to the end product of numerous interrelated and interacting variables, including those tested.

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