ILLUMINATION AND WOOD DUCK ROOSTING FLIGHTS[1]

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ROOSTING flight habits of Wood Ducks (*Aix sponsa*) were studied during August–November 1959–63. The objective was to describe the influence of seasonal advance on light and time associated with Wood Duck roosting flights and to determine the roles of light and time on roosting flight characteristics.

Phillips (1926) observed daily movements of a flock of 20 Wood Ducks and recorded less than 15 minutes variation in time of termination of evening flight activity. Martin (1957) reported that at two Indiana roosts morning departures usually began about one-half hour before sunrise with a mass departure usually about 20 minutes before sunrise. Evening flights began before sunset, with most birds arriving 15 to 30 minutes after sunset. However, on a rainy evening the bulk came 15 minutes earlier. Stewart (1957) measured light during five roosting flight periods in Ohio and concluded that there was little or no relationship between time of flight and light intensity. However, morning departures were usually in larger flocks, and illumination was less than at time of evening flights. Martin and Haugen (1960) described seasonal changes in times of flights at a roost at Muskrat Lake, Louisa County, Iowa, from August to October 1958. For each 10-day period that passed, Wood Ducks left the roost an average of 4 minutes earlier with respect to sunrise, and evening flights arrived an average of 7 minutes later with respect to sunset. Hester and Quay (1961) reported observations of 40 evening flights at three roosts in North Carolina during 1953, 1954, and 1960. As the season advanced from mid-October to early January, flights began 1.9 minutes later with respect to sunset for each 10 days elapsed. Times of peak and end of evening flights likewise decreased in relation to sunset. Hein (1961) observed Wood Duck roosting flights on 24 mornings and 16 evenings during August–October 1959–60 at a roost in Allamakee County, Iowa. Flight periods occurred in increased darkness and duration of flight periods grew shorter as fall advanced.

For the present study, observations were made during 294 morning or evening roosting flight periods at 30 Wood Duck roosts. These roosts were distributed between 41°0′ and 43°15′ north latitude and between 90°0′ and 94°45′ west longitude; most were in the Mississippi River bottoms of northeastern Iowa. During August–November, Wood Ducks gathered each evening

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TABLE 1

LINEAR REGRESSION EQUATIONS FOR SEASONAL CHANGES IN TIMES OF WOOD DUCK ROOSTING FLIGHTS DURING MID-AUGUST TO NOVEMBER, 1959–63

Event	Regression equation[a] $Y = \bar{y} + b(X - \bar{x})$	Degrees of freedom	t-value[b]
Morning flight			
Start	$Y = -28 - 0.050(X - 267)$	93	-1.50
Peak[c]			
End	$Y = -8 - 0.363(X - 267)$	93	-7.40*
Duration	$Y = 20 - 0.312(X - 267)$	93	-6.78*
Evening flight			
Start	$Y = -4 + 0.467(X - 270)$	191	10.61*
Peak	$Y = 16 + 0.201(X - 270)$	191	6.48*
End	$Y = 28 + 0.095(X - 270)$	191	3.45*
Duration	$Y = 32 - 0.361(X - 270)$	191	9.63*

[a] Regression equation is interpreted as follows:
Y = number of minutes from sunrise or sunset at which the event occurs for a given value of X.
$\bar{y}$ = mean number of minutes from sunrise or sunset at which the event occurred for the sample.
b = sample regression coefficient; i.e., average change in minutes per day for time of the event.
X = day of the year numbered from 1 January.
$\bar{x}$ = mean day of the year for the sample.
[b] t-value tests the null hypothesis that the regression coefficient is zero; asterisk indicates rejection of the hypothesis at 0.05 significance level.
[c] Common regression equation for all years cannot be calculated for peak of morning flight because analysis of covariance showed differences among regression coefficients for different years at 0.01 significance level.

at the same traditional sites to spend the night on the water amidst emergent vegetation. In September, peak premigration numbers at all roosts checked averaged between 370 and 600 Wood Ducks per roost in different years. The highest count at a roost was 5,400. Detailed descriptions of these roosts and roosting populations were given by Hein (1965).

METHODS

An observation point was usually selected near the center of a roost. Often it was possible to wade right in among roosting birds in the predawn darkness. Being close enough to hear ducks leave the water was helpful in spotting birds in poor light. At evening, presence of a motionless observer was unnoticed or ignored by Wood Ducks. A low place from which birds could be seen against a sky background was selected.

Evening observations began one hour before sunset and continued until the last birds arrived about 40 minutes after sunset. Observation periods for morning roosting flights began 45 minutes before sunrise, earlier than first Wood Duck departures from the roost, and continued until the roost was deserted or until 30 minutes after sunrise.

Only flights totaling 40 or more Wood Ducks in five or more flocks were

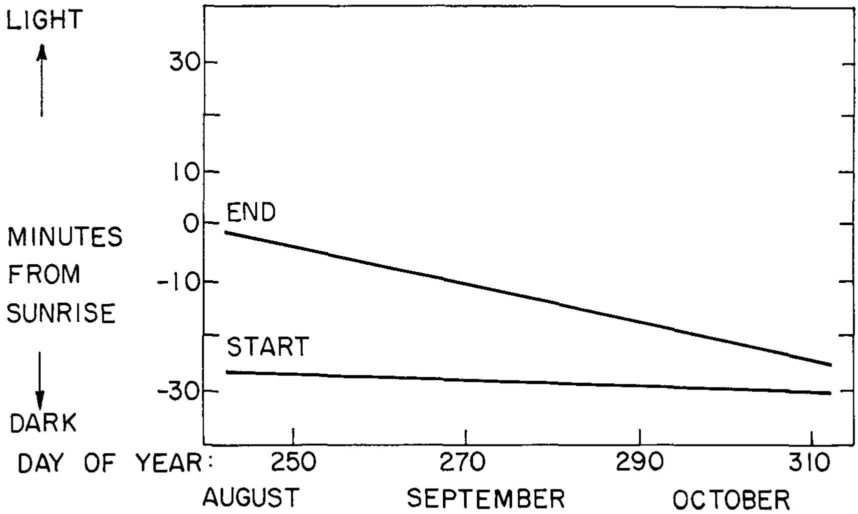

FIG. 1. Seasonal changes in time of morning roosting flights of Wood Ducks in relation to sunrise (regression equations are given in Table 1).

included in the analysis used to describe roosting flights. Numbers of birds were recorded by one-minute intervals. Times of start, peak, and end of flights were recorded as minutes from sunrise or sunset. The peak of flight was taken as the time when 50 per cent of all Wood Ducks in the roost had been counted.

The illumination associated with roosting flights was measured with a General Electric PR-2 light meter pointed at the sky directly overhead. A dynacell booster allowed readings as low as one-fourth footcandle of incident light. Readings were made throughout the observation period and were later transformed to logarithms to base 2 for linear regression analysis. Illumination was not measured in 1961.

To describe the relationships between times of flights and advance of the season, linear equations were computed to express the regression on date, of times of start, peak, end, and duration of morning and evening flights each fall. Thus, there were eight equations for each fall, making a total of 40 linear regression equations for the 5-year study. For the set of five equations describing each event in five autumns, analysis of covariance was used to test for differences among regression coefficients and among means in different years. Then, where the covariance analysis permitted, common linear regression equations were computed to describe seasonal changes in times of Wood Duck roosting flights in all years.

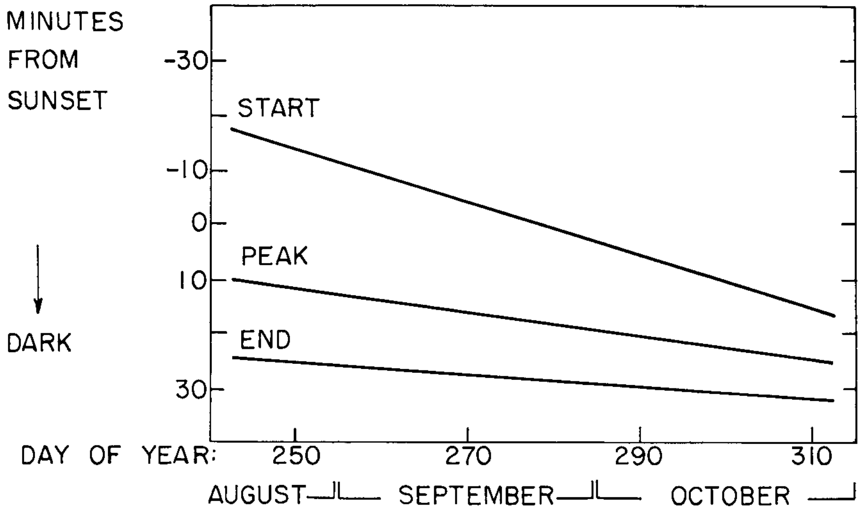

FIG. 2. Seasonal changes in time of evening roosting flights of Wood Ducks in relation to sunset (regression equations are given in Table 1).

Light relationships were analyzed by the same general procedure. For each year, equations were computed for the regression on date of light measured at start, peak, and end of morning and evening flights. For each event, analysis of covariance was used to test for differences among regression coefficients and among means in different years. Common linear regression equations were then computed to express seasonal changes in illumination associated with Wood Duck roosting flights in all years.

RESULTS

Analysis of covariance indicated that seasonal changes in times of flights were similar in all five fall seasons. Only for the time of peak morning flight were regression coefficients in separate years different at the 0.01 significance level. Start of morning flight and end of evening flight showed the least tendency to change as the season progressed, while end of morning flight and duration of evening flight changed most markedly (Table 1).

In mid-August, Wood Ducks began leaving the roost about 25 minutes before sunrise, and all had departed before sunrise. For each 10 days that passed, the last birds left the roost 3.6 minutes earlier with respect to sunrise. Thus, by early November, duration of morning flight averaged less than 5 minutes, and often the departure was in one or two waves about 30 minutes before sunrise (Fig. 1).

TABLE 2

LINEAR REGRESSION EQUATIONS FOR SEASONAL CHANGES IN ILLUMINATION ASSOCIATED WITH WOOD DUCK ROOSTING FLIGHTS DURING FALL, 1959–63

Event	Regression equation[a] $Y = \bar{y} + b(X - \bar{x})$	Degrees of freedom	t-value[b]
Morning flight			
Start	$Y = -0.75 - 0.036(X - 268)$	85	10.44*
Peak	$Y = 0.45 - 0.060(X - 268)$	85	10.07*
End[c]			
Evening flight			
Start	$Y = 4.45 - 0.074(X - 270)$	146	14.19*
Peak	$Y = 1.39 - 0.067(X - 270)$	146	11.21*
End	$Y = -0.54 - 0.046(X - 270)$	146	12.63*

[a] Regression equation is interpreted as follows:
Y = illumination at which the event occurs for a given value of X.
$\bar{y}$ = mean illumination at which the event occurred for the sample.
b = sample regression coefficient; i.e., average change in illumination per day.
X = day of the year numbered from 1 January.
$\bar{x}$ = mean day of the year for the sample.
All illumination values are given as logarithms to the base 2 of footcandles of incident light.

[b] t-value tests the null hypothesis that the regression coefficient is zero; asterisk indicates rejection of the hypothesis at 0.05 significance level.

[c] Common regression equation for all years cannot be calculated for end of morning flight because analysis of covariance showed differences among regression coefficients for different years at 0.01 significance level.

Mean duration of evening flights decreased from about 45 minutes in mid-August to about 8 minutes in early November (Fig. 2). During each 10 days that elapsed, mean time in relation to sunset decreased 4.7 minutes for start, 2.0 minutes for peak, and 1.0 minutes for end of evening roosting flight.

Analysis of covariance permitted computation of common linear regression equations to describe seasonal changes in illumination measured at start, peak, and end of evening flights and at start and peak of morning flights (Table 2). In mid-August, morning flights began when illumination reached 1 footcandle; by November, birds departed with less than one-fourth footcandle of light (Fig. 3). Light concomitant with peak of morning flights decreased similarly as fall advanced. Evening flights likewise occurred with less light as the days passed. In mid-August, flocks arrived at the roost while illumination ranged from about 70 down to about 2 footcandles. Late-October flights arrived with light values between 4 and one-fourth footcandles (Fig. 4).

Certain changes in flight times accompanied poor visibility conditions. These changes tended to adjust flights toward times when illumination was similar to that prevailing for roosting flights on clear days. Thus, on dark, foggy days the morning departure from the roost was delayed, and time of first arrival of evening flights was advanced. Therefore, flights on mornings with poor visibility were compressed in time by a delay of the beginning of

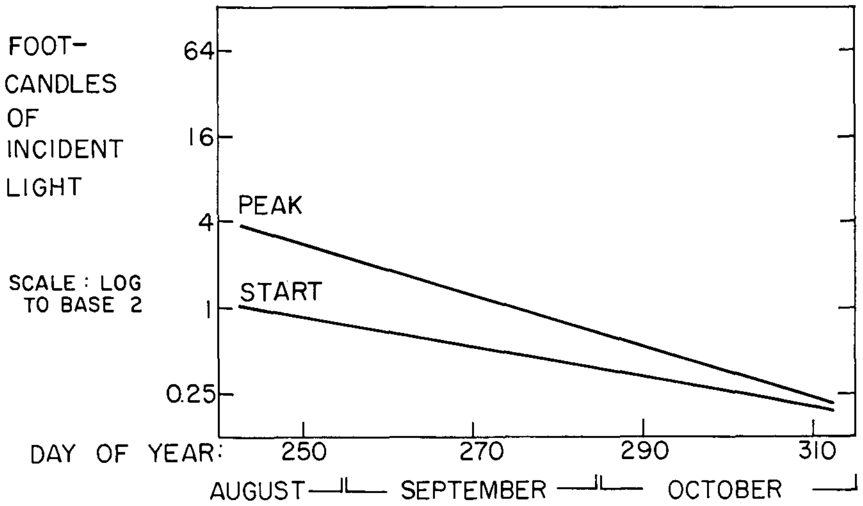

FIG. 3. Seasonal changes of illumination associated with morning roosting flights of Wood Ducks (regression equations are given in Table 2).

the flight. On the other hand, evening flights were prolonged on dark, hazy days, because the start of evening flights tended to be much earlier while the peak and end were only a little earlier on days of poor visibility. This adherence of roosting flights to predictable illumination levels was quite apparent on stormy days. However, exact effects of weather in modifying times of flights could not be stated more explicitly, because "stormy weather" could not be satisfactorily quantified.

DISCUSSION

Wood Duck roosting flights were controlled primarily by light. An illumination threshold near one-half footcandle triggered the morning flights. The stimulus to leave the roost was most likely metabolic, probably hunger since morning flights went directly to feeding areas. Hochbaum (1955) stated that daily feeding flights of waterfowl were governed by metabolic and solar cues. The stimulus to return at evening was probably social. Allee (1958) regarded roosting as a positive social appetite that grew stronger with the approach of darkness. Here the trigger governing response to the stimulus was decreasing illumination with the threshold some value below 200 footcandles.

Seasonal changes in times of flights did not compensate for shorter daylight feeding hours or for greater energy demands as has been postulated for some other birds (Lundin, 1962; Seibert, 1951). Rather, such changes are considered to be responses to changing intensity of the stimuli at a particular

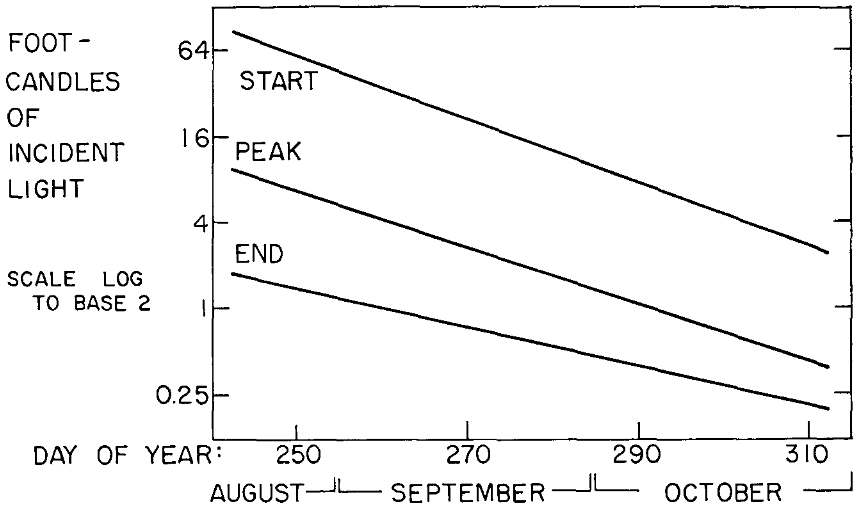

FIG. 4. Seasonal changes of illumination associated with evening roosting flights of Wood Duck (regression equations are given in Table 2).

sun time. That is, as the sun rose later with respect to clock time, the hunger stimulus built up over a longer time and, therefore, became more intense at a given sun time. Thus, the threshold of illumination required to initiate flight became gradually lower as fall advanced. Likewise, evening flights occurred later with respect to sunset because the stimulus to recongregate had less time to build up to an intensity necessary for action after morning dispersal from the roost. Thus, evening flights were triggered by gradually lower light values as the days shortened.

SUMMARY

Roosting flights of Wood Ducks were described as functions of time for convenience. However, they were responses to endogenous stimuli, and they occurred within limits of illumination which changed in a predictable manner as the season advanced.

LITERATURE CITED

ALLEE, W. C.
1958 The social life of animals. Revised ed. Beacon Press, Boston.

HEIN, D.
1961 Wood Duck roosting flights at Paint Creek, Iowa. *Proc. Iowa Acad. Sci.*, 68:264–270.
1965 Wood Duck roosting flight phenomena. (Ph.D. Thesis, Iowa State Univ., Ames.)

HESTER, F. E., AND T. L. QUAY
1961 A three-year study of the fall migration and roosting flight habits of the Wood Duck in east-central North Carolina. *Proc. SE Assoc. Game and Fish Commissioners*, 15:55–60.

HOCHBAUM, H. A.
1955 Travels and traditions of waterfowl. The Univ. of Minnesota Press, Minneapolis.

LUNDIN, A.
1962 Observationer rorande overvitring och overnattning hos kajan (*Corvus monedula*). *Var Fagelvarld*, 21:81–95.

MARTIN, D. N.
1957 Wood Duck autumn flight activity in relation to sunrise and sunset (mimeo.). Indiana Dept. Conservation, Indianapolis.

MARTIN, E. M., AND A. O. HAUGEN
1960 Seasonal changes in Wood Duck roosting flight habits. *Wilson Bull.*, 72: 238–243.

PHILLIPS, J. C.
1926 A natural history of the ducks. Vol. IV. Houghton, New York.

SEIBERT, H. C.
1951 Light intensity and the roosting flight of herons in New Jersey. *Auk*, 68:63–74.

STEWART, P. A.
1957 The Wood Duck, *Aix sponsa* (Linnaeus), and its management. (Ph.D. Thesis, Ohio State Univ., Columbus.)

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