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The influence of environmental conditions on the breeding behavior of the bald eagle (Haliaeetus leucocephalus) in Virginia

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THE INFLUENCE OF ENVIRONMENTAL CONDITIONS

ON THE BREEDING BEHAVIOR OF THE BALD EAGLE

(Haliaeetus leucocephalus)

IN VIRGINIA

A Thesis

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In Partial Fulfillment

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Master of Arts

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by

David O. Wallin

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APPROVAL SHEET

This thesis is submitted in partial fulfillment of
the requirements of the degree of

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ABSTRACT

Three bald eagle (<u>Haliaeetus leucocephalus</u>) nest sites in tidewater Virginia were observed for 365 hours to determine the effect of variations in environmental conditions on breeding behavior. Other studies have demonstrated that weather conditions can affect the foraging behavior of ospreys (<u>Pandion haliaetus</u>), some terns (<u>Sterna</u> sp.) and bald eagles. However, weather does not appear to significantly influence the ability of ospreys and some terns to provide prey for their young. The results of this investigation indicate that the ability of bald eagles to provide for their young does appear to be influenced to a certain degree by weather conditions.

There was no significant difference in the percentage of time spent perched near one nest by the adult male (mean=25.29%) and female (mean=36.63%). The percentage of time the adults perched near this nest was inversely related to the absolute day of the year. Sixty out of sixty one of the identifiable prey items brought to all nest sites by the adults were fish. Each adult at one nest site spent approximately 1/4 of the daylight hours foraging and each adult delivered prey at similar rates. The length of time between the departure of an adult from this nest site and its' return with a fish was similar for each adult (mean time=81 minutes). The duration of successful hunting flights by the adults at this nest was inversely correlated with wind speed variability and minimum wind speed and positively correlated with maximum wind speed. These relationships accounted for 60.2% of the variation in the duration of successful hunting flights. The time between successive prey deliveries by adults at all nest sites was similarly correlated with wind speed variability, minimum wind speed and maximum wind speed and also positively correlated with the distance from the nest site to open water. These relationships accounted for 69.8% of the variability in the time between deliveries. The rate at which adults delivered prey to each nest site (mean=0.24 del/h) was positively correlated with the number of young in the nest, mean wind speed and a dummy variable indicating the 05:30-09:00 time period. The rate of prey delivery was also inversely correlated with the absolute day of year. These relationships accounted for 21.7% of the variation in the rate of prey delivery. A dummy variable indicating whether or not prey was delivered during each observation period was also positively correlated with the number of young in the nest and mean sunniness. This relationship accounted for 11.3% of the variation in the dummy variable.

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INTRODUCTION

Since World War II, the Chesapeake Bay bald eagle (Haliaeetus leucocephalus) population, and many other bald eagle populations throughout North America, have experienced significant declines (Abbott 1957, 1959, 1962, 1963a, 1963b, 1964, 1967a, 1967b, 1968, 1969a, 1969b, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977a, 1977b, 1978, Broley 1958, Howell 1968, Sprunt 1969, Sprunt et al. 1973). Similar declines have also been observed in both European and North American populations of the peregrine falcon (Falco peregrinus) (Ratcliff 1963, 1967, Moore and Walker 1964, Hickey 1969) and the osprey (Pandion haliaetus) (Moore and Walker 1964, Hickey 1969, Ogden 1977). On both continents, the initiation of population declines in these three species and many others are closely correlated with the widespread introduction of DDT and other chlorinated hydrocarbon insecticides (Hickey and Anderson 1968). In declining raptor populations, reduced reproductive success has been associated with egg shell thinning (Hickey and Anderson 1968) and high levels of chlorinated hydrocarbons in inviable eggs (Wiemeyer et al. 1972). Additional studies with a variety of avian species have demonstrated a relationship between dietary intake of chlorinated hydrocarbons and the inhibition of calcium metabolism or mobilization (Cooke 1973). This inhibition results in eggshell thinning and reduced reproductive success (Bitman et al. 1969, Heath et al. 1969,

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Porter and Wiemeyer 1969, Blus 1972, Cecile et al. 1972, Cecile
et al. 1973). Kepone, another chlorinated hydrocarbon
insecticide, was discharged into the James River, near Hopewell,
Virginia, in substantial quantities from 1967 to 1975 (Bell et al.
1978). Laboratory studies with japanese quail (Coturnix coturnix
japonica) have also demonstrated a relationship between dietary
intake of this compound and eggshell thinning, reduced
reproductive success, neurological dissorders and even death
(Eroshenko and Place 1977). Kepone has been found in bald eagle
and osprey eggs and tissue samples collected throughout the
Chesapeake Bay region (Stafford et al. 1978).

Although environmental contaminants continue to cause
reproductive problems in the Chesapeake Bay bald eagle population,
recent studies indicate that the major pesticide-induced declines
may have stabilized somewhat (Byrd 1977, Clark and Lincer 1977,
Byrd 1978, Ditrich and Clark 1978, Byrd 1979, Pramstaller and
Clark 1979, Byrd 1980, Pramstaller and Clark 1980). In 1976, only
40 percent of the active nests successfully reared young at an
average rate of 0.54 young per active nest (Abbott 1976). Since
1976, an average of 52 percent of the known active sites have
successfully reared young to banding age (4-8 weeks) at an average
rate of 0.76 young per active nest (Pramstaller and Clark 1980).
Although inconsistencies in methods and definitions often
invalidate strict comparisons of productivity data from different

studies (Postupalsky 1973, Sherrod et al. 1976), these values at least approach those values which Sprunt et al. (1973) suggest are neccessary for the maintenance of a stable population.

As bald eagle populations recover from the declines of the pesticide era, pressures resulting from the continued expansion of human populations may become the major factor determining their status. The blatant destruction of favorable bald eagle habitat as a result of industrial, residential and recreational development can have an obvious impact on bald eagle populations. However, the ultimate effect of more subtle pressures associated with an increasing human presence may result in the abandonment by bald eagles of more extensive areas of apparently "ideal" habitat. It appears that human activity near nest sites, particularly during the early stages of the nesting cycle, may contribute to a decrease in reproductive success (Mathisen 1968, Grier 1969, Whitfield et al. 1974, Wiemeyer 1981). In some areas it appears that shoreline nest sites are being abandoned in favor of sites farther from the water, perhaps in response to increased human presence along waterfronts (Whitfield et al. 1974, Jaffee 1980). The impact of this relocation on reproductive success has not been thoroughly examined. Human activity has also been shown to disrupt normal foraging activities (Stalmaster and Newman 1978, N. Jaffee pers. comm.).

As human populations continue to expand, it seems likely that

increased human activity, particularly the development of shorelines for housing and recreation, could result in further declines in bald eagle populations. Efforts to reduce the impact of this expansion on bald eagle populations must be based on a complete understanding of all factors which may impinge on the biology of the species. Surprisingly, although the effects of environmental contaminants on bald eagle populations have been studied intensively in recent years, many fundamental aspects of the species' biology remain poorly understood. Among these, the relationship between environmental conditions and the foraging behavior of bald eagles has not been thoroughly examined.

Considerable attention has recently been given to the constraints imposed upon avian predators by the physical environment. Weather conditions have been shown to affect the foraging behavior of many piscivorous birds, including the osprey (Stinson 1978, Grubb 1977, Ueoka and Koplin 1973) certain terns, Sterna sp. (Dunn 1973) and the bald eagle (Jaffee 1980). Ospreys and most terns feed almost exclusively on live fish (Bent 1921, 1937, Brown and Amadon 1968). They generally search for prey from the wing and capture prey by plunge dives into the water (Dunn 1973, Grubb 1977). In contrast, bald eagles are more generalized in their diet, for in addition to fish, their primary prey during the breeding season, they also feed on a variety of birds, mammals, reptiles and amphibians (Herrick 1933, Murie 1940, Wright

1953, Imler and Kalmbach 1955, Retfalvi 1965, Harper 1973, Hehnke 1973, Ofelt 1975, Kussman 1976, Sherrod et al. 1976, McEwan 1977), and they will often consume dead or moribund prey when these are available (Herrick 1933, Bent 1937, Wright 1953, Imler and Kalmbach 1955, Broley 1958, Southern 1963, Hensel and Troyer 1964, Grewe 1966, Edwards 1969, Hehnke 1973, Servheen 1975, Kussman 1976, Sherrod et al. 1976). Bald eagles capture fish by thrusting the legs and talons into the water to seize prey as the eagle flies low over the water (Jaffee 1980). This technique would appear to be ideally suited to the capture of floating dead fish and moribund fish which might be floundering on the surface, but it may limit bald eagles to the capture of fish which are at or very near the water surface. In contrast, the plunge dives of ospreys and terns may enable them to capture fish which are perhaps a meter or more below the surface.

The rate of prey captures by ospreys is reduced when water surface conditions are rough, a condition which is related to high wind speeds, and when the sun is occluded (Grubb 1977). Surprisingly, additional studies have indicated that in spite of these environmentally imposed fluctuations in capture rates, the rate of prey delivery to the nest by adult ospreys is not significantly affected by variations in environmental conditions (Stinson 1978). The rate of prey captures by Sandwich terns (S. sandvicensis) and common terns (S. hirundo) increases with

increasing wind speed and when sea surface conditions are moderate (Dunn 1973). As with ospreys, environmental conditions have only a negligible effect on the growth rates of these tern chicks (Dunn 1975). The frequency of fishing attempts by bald eagles is reduced at high wind speeds, when the sun is occluded and when water surface conditions are rough (Jaffee 1980). Little is known regarding how these and other conditions may affect the ability of adult bald eagles to provide for their young.

The objectives of this investigation were: (1) to examine the influence of weather conditions which have been shown to influence the foraging behavior of bald eagles and other piscivorous birds on the rate at which adult bald eagles deliver prey to their young; (2) to examine the influence of a variety of environmental conditions on additional aspects of adult behavior which may affect the likelihood of successfully rearing young; and (3) to collect general data regarding the breeding biology of the species in the Virginia portion of the Chesapeake Bay region.

METHODS AND MATERIALS

During 1979 and 1980, three Virginia bald eagle nests were observed. Nest KG-79-02 (subsequently referred to as nest KG), located in King George county, was observed for 139 hours between 31 May and 10 July 1979. Nest WE-79-01 (subsequently referred to as nest WE), located in Westmoreland county, was observed for 126 hours between 27 April and 23 June 1980. Nest MI-80-01 (subsequently referred to as nest MI), located in Middlesex county, was observed for 99 hours between 19 June and 4 July 1980. Each of these nest sites is described in Appendix I.

Nests WE and MI were observed, using a 30X telescope, from blinds mounted on 10 meter steel towers and located 200 meters and 70 meters, respectively, from the nest. Nest WE was located at the edge of a steep, wooded ravine. By positioning the observation blind across the ravine from the nest, the activities of the adults could usually be observed whenever they were within approximately 300 to 400 meters of the nest. In contrast, local topography and vegetation at nests KG and MI limited the field of view to the nest tree itself and therefore limited the types of data which could be collected at these nests. At nest KG, a blind was set up under dense vegetation on the ground, 150 meters from the nest. This nest could not be observed directly, but was observed indirectly using a closed circuit television system. At nests WE and MI, closed circuit television systems supplemented

direct observation. At nests KG and MI, video cameras (Panasonic model WV220P, 110 v.a.c. and JVC model G71US, 12 v.d.c., respectively) in weatherproof housings were installed in large loblolly pines (Pinus taeda) approximately 25 meters from the nest tree. At nest WE, a video camera (Sony model AVC3400, 12 v.d.c.), in a weatherproof housing, was installed in the nest tree, 3 meters above the nest. Power and video cables extended from the camera housings to the observation blinds which housed a television monitor (Sony model 110, 12 v.d.c.) and a video recorder (Sony model AV3600, 110 v.a.c.). Twelve volt automotive batteries were used directly, or in conjunction with a 12 v.d.c. to 110 v.a.c. inverter (Terado model 50-191-3), to supply power to the equipment.

In order to minimize the chances of nest abandonment as a result of disturbance caused by the camera installation procedure, television equipment was not set up at the sites until the young had reached an age of five to six weeks. Adult bald eagles appear to be less sensitive to disturbance during the nestling stage than during incubation (Wiemeyer 1981). At five to six weeks of age, the eaglet's improved thermoregulatory abilities (Wiemeyer 1981), combined with warmer temperatures at this time of year (late May to early June), reduce the possibility of chilling during the camera installation process. Both observation towers were assembled at night in order to minimize disturbance. The tower at

nest MI was assembled a few days after camera installation, but the tower at nest WE was assembled, and preliminary observations begun, when the young were approximately two weeks of age. By positioning blinds to take advantage of surrounding vegetation and by using burlap screens, it was possible to enter and exit all blinds without the eagles being aware of my presence.

Weather variables examined in previous studies (Dunn 1973, 1975, Grubb 1977, Stinson 1978, Jaffee 1980) were also examined in this study. Weather conditions were recorded every 15 minutes. Sunniness was recorded as 100 percent if shadows had been present continuously during the preceeding 15 minute period, as 50 percent if shadows were present for a portion of the preceeding period and as 0 percent if no shadows were present. The percent cloud cover was estimated and the presence or absence of precipitation during the preceeding 15 minutes was recorded. Wind speed (m/s) was visually estimated by observing the disturbance caused by the wind in nearby trees and comparing it with guidelines in table 12-1 in Donn (1972). Temperature and relative humidity were measured with a Bendix motorized psychrometer.

The hatching dates of the young could only be determined approximately, on the basis of a limited number of aerial surveys. The earliest and latest approximate hatching dates among the three nest sites differed by only seven days. Since the age difference among the young was so slight and since the accuracy of the

hatching dates is uncertain, the absolute day of the year (Jan. 1=1, Feb. 1=32, etc.) was used as an index of the age of the young for all regressions.

All analysis of variance and stepwise multivariate regressions were calculated using appropriate programs in the Statistical Analysis System (Helwig and Council 1979). Bartlett's test for homogeneity of variances and a Kruskal-Wallis test for the equality of means when variances were unequal, were calculated using appropriate programs in the Statistical Package for the Social Sciences (Nie et al. 1975).

Multivariate regressions were performed using the following dependent variables: (1) the rate of prey delivery (deliveries per hour) during each observation period (05:30-09:00, 09:00-13:00, 13:00-17:00, 17:00-20:30) or fraction thereof; (2) a dummy variable for the event of prey delivery during each observation period or fraction thereof (the dummy variable has a value of 1 if one or more prey items were delivered during the observation period and a value of 0 if no prey were delivered; see Draper and Smith 1967, pp. 134-142, for discussion of the use of dummy variables); the percent time spent perched near nest WE by (3) the male, (4) the female and (5) one or both adults during each observation period or fraction thereof. A stepwise regression procedure was used to obtain the best regression using the following independent variables: (a) absolute day of the

year, (b) dummy variables indicating the observation period (A dummy variable is included for each of the four observation periods. For observations made during the 05:30-09:00 period, for example, the dummy variable indicating the 05:30-09:00 period is assigned a value of one and the dummy variables for the other three periods are each assigned a value of zero.), (c) maximum and (d) minimum wind speeds observed during each observation period or fraction thereof, (e) mean wind speed, (f) average difference between the maximum and minimum wind speeds observed each hour, (g) modal wind speed, (h) mean temperature, (i) mean percent relative humidity, (j) mean percent cloud cover, (k) mean sunniness, (l) percentage of 15 minute periods which were 100 percent sunny, (m) percentage of 15 minute periods which were 0 percent sunny and (n) the percentage of 15 minute periods during which precipitation was recorded. Two additional independent variables, (o) the number of young present in the nest and (p) the distance, in meters, from the nest to the nearest open water, were included in the regressions for dependent variables (1) and (2) only. Data from each observation period included in these analyses are based on a minimum of 90 minutes of observation.

Multivariate regressions were also performed using the following dependent variables: (6) elapsed time, in minutes, between successive food deliveries; (7) duration, in minutes, of a successful hunting flight by either adult at nest WE (the time

taken by an adult to fly from the vicinity of the nest site and return with a prey item). Since the limited field of view at nests KG and MI prevented observation of the adults unless they were perched in the nest tree, the duration of successful hunting flights at these nests could not be recorded. A stepwise regression procedure was used to obtain the best regression using the following independent variables: absolute day of year, maximum and minimum wind speeds observed since the previous food delivery or during the adult's absence, mean wind speed, average difference between the maximum and minimum wind speeds observed each hour, modal wind speed, mean temperature, mean percent relative humidity, mean percent cloud cover, mean sunniness, percentage of 15 minute periods which were 100 percent sunny, percentage of 15 minute periods which were 0 percent sunny and the percentage of 15 minute periods during which precipitation was recorded. Two additional variables, the number of young present in the nest and the distance, in meters, from the nest to the nearest open water were included in the regression for dependent variable (6).

For each dependent variable, the stepwise regression procedure was used to obtain a set of potentially "best" regression models. From among this set, the "best" model was defined as the one with the largest correlation coefficient when all independent variables included in the model had a significant

regression coefficient at about the 0.05 level (determined by partial F-test, Draper and Smith 1967, pp. 71-72).

RESULTS

The adults at all three nest sites quickly habituated to the presence of the camera and the adults at nest WE frequently perched adjacent to and within one meter of the camera. The presence of the equipment did not appear to prevent the adults from returning to the nest site or have any other meaningful impact on the bird's behavior. During 18.8 hours of observation over a period of 5 days at nest WE prior to camera set up, the rate of food delivery averaged 0.45 deliveries per hour (standard error=0.206). On 23 May, the day after the camera was installed, the nest was observed for 11.2 hours. The observed delivery rate of 0.18 deliveries per hour was not significantly different from the rate of food delivery prior to camera set up ($t=1.057$, $0.4>P>0.2$). The observed delivery rate during 107.8 hours of observation over a period of 10 days with the camera in place averaged 0.37 deliveries per hour (standard error=0.047) and was not significantly different from the observed delivery rate prior to camera installation ($t=0.515$, $0.9>P>0.5$). Assuming that the size distributions of prey items brought to the nest before and after camera installation were similar, the above data suggest that the presence of the video camera in the nest tree did not significantly affect the amount of food supplied to the young.

At nest WE, the sex of the adult birds could usually be determined on the basis of size; overall time use for these adults

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is summarized in Table I.

There was no significant difference between the percentage of time spent perched near nest WE by the adult male and female, nor was there a significant difference in the percentage of time spent perched near the nest during the four observation periods (two-way analysis of variance, $P=0.07$, $P=0.23$ respectively; see Table II; the eight variances were not significantly heterogeneous, Barlett's test, $0.9>P>0.5$). The results of the stepwise regressions which included the percentage of time spent perched near nest WE by the adults are presented in Table III. The percentage of time spent perched near the nest by the adult male and adult female each had a significant negative regression coefficient with the absolute day of the year. These relationships explained 13.6 percent and 35.6 percent of the variation in percent time spent perched near the nest by the male and female respectively. The percentage of time during which one or both adults were present at or near the nest also had a significant negative regression coefficient with the absolute day of the year. This relationship accounted for 49.3 percent of the variation in the percentage of time during which one or both adults were present. These results are also presented graphically in Figures 1, 2 and 3.

Although sizes could not be recorded for all prey items, it appeared that the individual size distributions of prey delivered

Table I

Time use by the adult male and female bald eagles at nest WE-79-01 based on 126.6 hours of observation between 27 April and 23 June 1980.

Behavior		Male		Female	
		No. Observations	% time used	No. Observations	% time used
present at or near nest		–	25.29	–	36.63
Depart	Return				
with nothing	with prey	17[a]	15.95	20	23.38
with nothing	with nothing	18	25.11	15	23.69
with nothing	with nest mat.	2	0.86	0	0.00
unobserved[b]	with prey	7	11.40	4	7.35
unobserved[b]	with nothing	3	6.80	1	0.97
with nothing	unobserved[c]	10	10.97	6	4.10
unobserved[b]	unobserved[c]	1	3.62	1	3.88
			100.00		100.00

[a]Includes one fish brought to the nest and consumed entirely by the male.

[b]Adult not present when observations began.

[c]Adult not present when observations ended.

Table II

Mean percentage of time the adult male and female bald eagles spent perched near nest WE-79-01 during each observation period. Based on 122.1 hours of observation.

Time	Male	Female	One or Both Adults
05:30-09:00	12±7.6 (7)[a]	20±9.8 (7)	30±12.0 (7)
09:00-13:00	28±11.9 (9)	35±10.0 (9)	54±12.4 (9)
13:00-17:00	31±7.6 (12)	38±10.5 (12)	59±10.1 (12)
17:00-20:30	24±7.6 (10)	52±12.1 (10)	64±11.1 (10)
Overall	25±4.4 (38)	38±5.6 (38)	54±5.8 (38)

[a]Mean ± standard error (no. of observation periods).

Table III

Results of stepwise regression; percentage of time the adult male and female bald eagles spent perched near nest WE-79-01 during each observation period (see text for discussion of variables).

Dependent variable: percent time adult male perched near nest $R^{2a} = 0.136$

	df	sum of squares	mean square	F	Prob<F
regression	1	3243	3243	5.34	0.0270
error	34	20630	607		
total	35	23872			

Significant independent var.	$\beta \pm$ s.e.[b]	F	Prob<F[c]	intercept
absolute day of year	-0.7 ± 0.30	5.34	0.0270	132.8

(continued)

(continued)

Table III

Dependent variable: percent time adult female perched near nest $R^{2a} = 0.356$

	df	sum of squares	mean square	F	Prob<F
regression	1	12853	12853	18.80	0.0001
error	34	23239	684		
total	35	36092			

Significant independent var.	$\beta \pm$ s.e.[b]	F	Prob<F^c	intercept
absolute day of year	-1.4 ± 0.32	18.80	0.0001	252.6

(continued)

(continued)

Table III

Dependent variable: percent time one or both adults perched near nest R^{2a} = 0.493

	df	sum of squares	mean square	F	Prob<F
regression	1	21047	21047	33.07	0.0001
error	34	21638	636		
total	35	42686		---	

Significant independent var.	$\beta \pm s.e.^b$	F	Prob<F^c	intercept
absolute day of year	-1.8 ± 0.31	33.07	0.0001	330.7

[a] $(Correlation\ coefficient)^2$; (proportion of variation of dependent variable explained by the variation in the significant variables)

[b] Regression coefficient ± standard error; (slope of regression line)

[c] Probability that regression coefficient=0

Figure 1

Percentage of time spent perched near nest WE-79-01 by the adult male during each observation period vs. the absolute day of the year. The average approximate age of the young is indicated on the lower scale. The average approximate hatching date was 12 April, 1980. See Table III for details of the regression analysis. See text for discussion of variables. (●=1 obs. per., ▲=2 obs. per., ■=4 obs. per.)
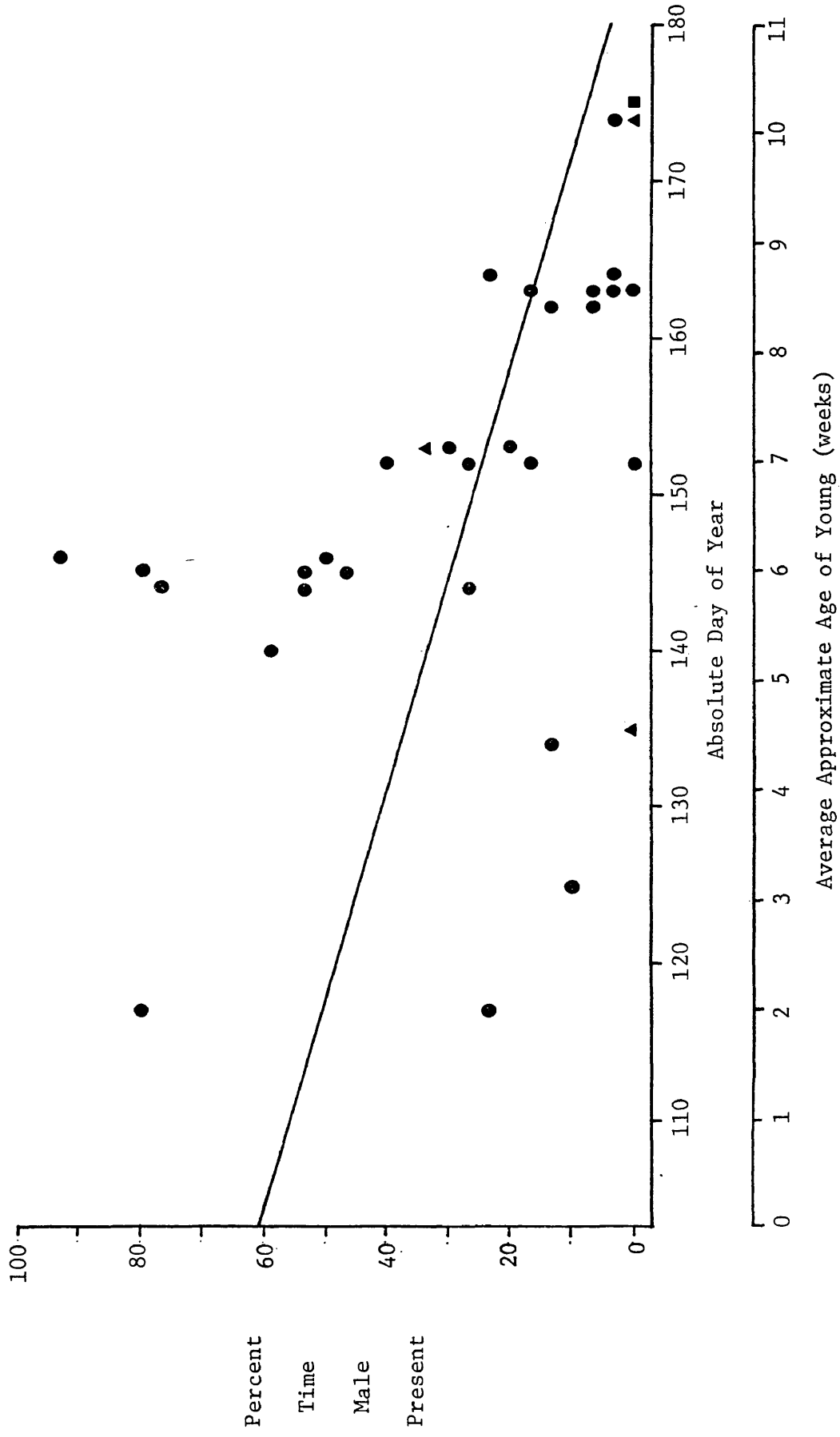
Figure 2

Percentage of time spent perched near nest WE-79-01
by the adult female during each observation period
vs. the absolute day of the year. The average ap-
proximate age of the young is indicated on the lower
scale. The average approximate hatching date was 12
April, 1980. See Table III for details of the re-
gression analysis. See text for discussion of var-
iables. (● =1 obs. per., ▲ =2 obs. per.)
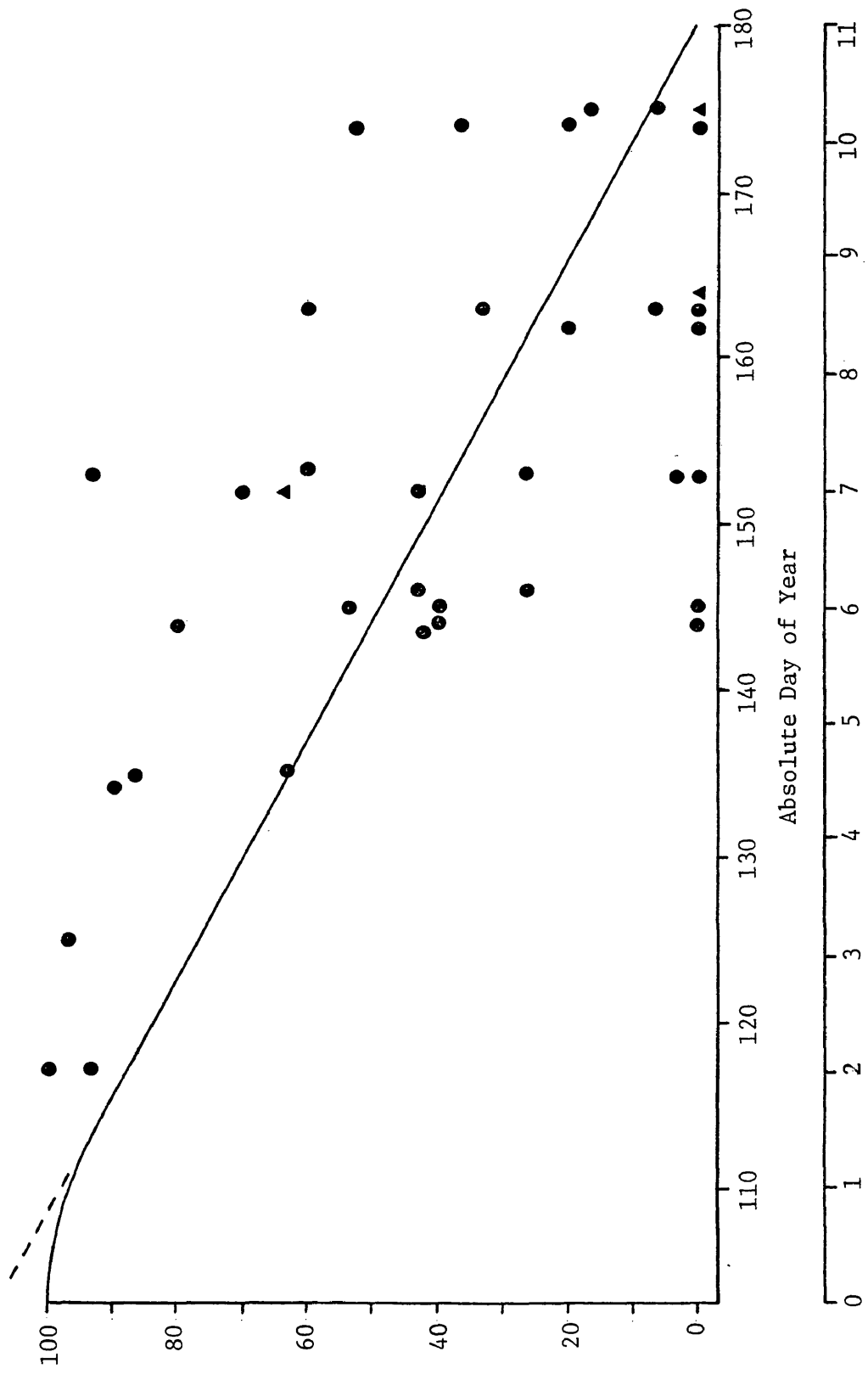
Percent
Time
Female
Present

Absolute Day of Year

Average Approximate Age of Young (weeks)

Figure 3

Percentage of time spent perched near nest WE-79-01 by one or both adults during each observation period vs. the absolute day of the year. The average approximate age of the young is indicated on the lower scale. The average approximate hatching date was 12 April, 1980. See Table III for details of the regression analysis. See text for discussion of variables. (●=1 obs. per., ▲=2 obs. per.)

Percent
Time
One or
Both
Adults
Present

Absolute Day of Year

Average Approximate Age of Young (weeks)
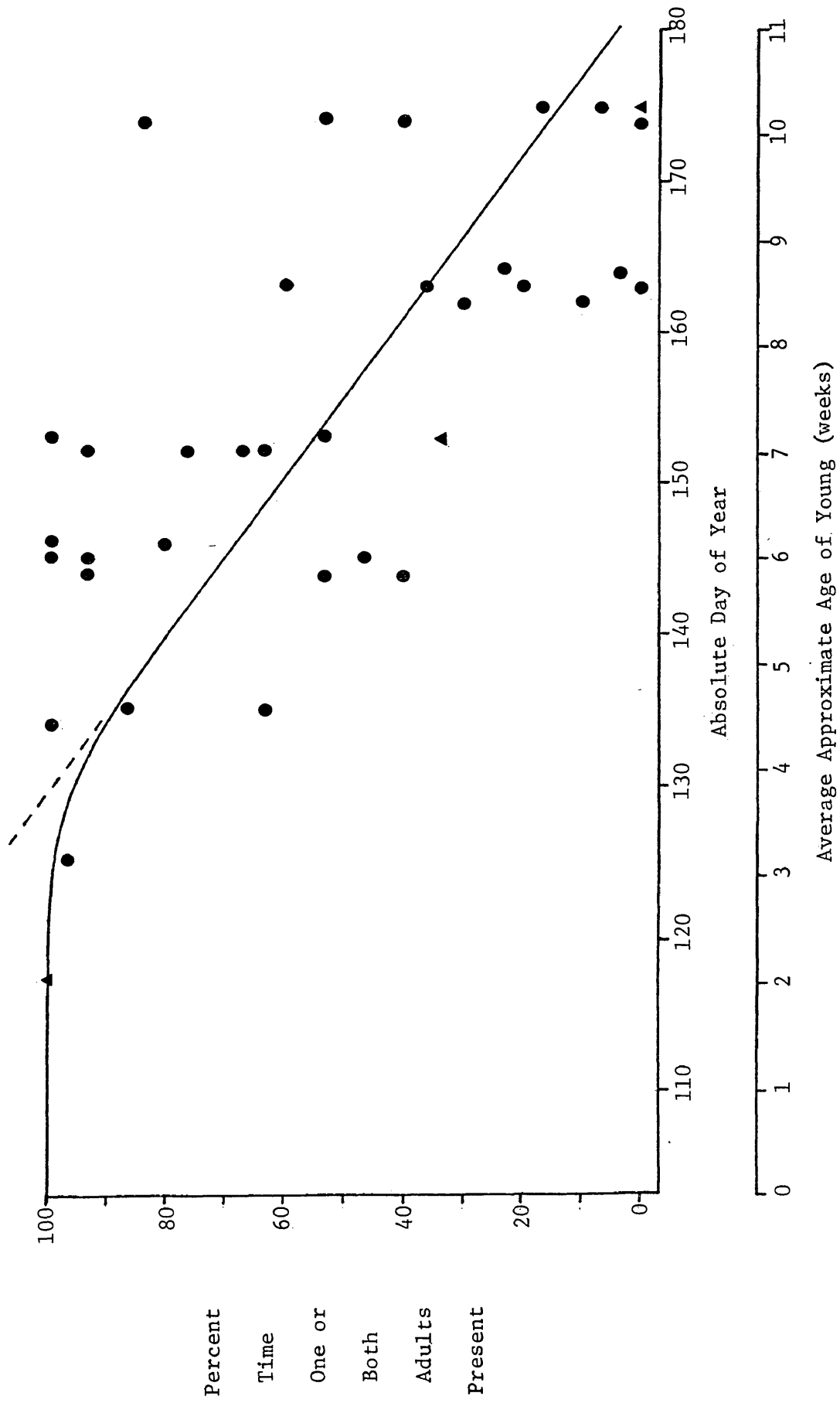
to each nest were similar. Of those prey items which could be confidently identified, 60 out of 61 were fish, with menhaden (Brevoortia tyranus) and american eel (Anguilla rostrata) as the most common species. A single eastern gray squirrel (Sciurus carolinensis) was also brought to a nest.

The average delivery rate at each nest site, during each observation period is shown in Table IV. The twelve variances were significantly heterogeneous (Bartlett's test, P<0.005) and therefore the effect of nest site and observation period on delivery rate was analyzed separately using Kruskal-Wallis tests. Although there was no significant difference between the average delivery rates during each of the four observation periods (P=0.568, but see results of Table V below), the rates of food delivery at the three nest sites were significantly different (P=0.001). Nests KG and WE each contained two young while nest MI contained one young. When delivery rates are calculated on the basis of deliveries/hour/young, the rates at the three nests (WE=0.19, KG=0.11, MI=0.09) were also significantly different (Kruskal-Wallis test; P=0.017). Assuming that the size distributions of prey items at each nest were similar, these data suggest that the young at nest WE recieved substantially more food than the young at nests KG and MI.

The rate of food delivery (deliveries per hour) during each observation period had significant regression coefficients with

Table IV

Mean rate (deliveries/hour) at which adult bald eagles brought prey to unfledged young at three nest sites during each observation period.

Time	KG-79-02[a]	WE-79-01[a]	MI-80-01[b]	Overall
05:30-09:00	0.26±0.161 (5)[c]	0.56±0.214 (7)	0.12±0.125 (4)	0.36±0.115 (16)
09:00-13:00	0.28±0.054 (14)	0.26±0.084 (9)	0.12±0.094 (8)	0.24±0.043 (31)
13:00-17:00	0.12±0.057 (11)	0.35±0.098 (12)	0.08±0.042 (9)	0.20±0.047 (32)
17:00-20:30	0.19±0.061 (9)	0.41±0.161 (10)	0.04±0.039 (7)	0.23±0.071 (26)
Overall	0.21±0.035 (39)	0.38±0.068 (38)	0.09±0.035 (28)	0.24±0.031(105)

[a]Nest produced two young.

[b]Nest produced one young

[c]Mean ± standard error (no. of observation periods)

the number of young in the nest (positive), the absolute day of the year (negative), the mean wind speed observed during the observation period (positive) and the dummy variable for the 05:30-09:00 period (positive). These four factors explained 21.7 percent of the variation in the delivery rate during each observation period (Table V).

The inverse relationship between the overall rate of prey delivery and the absolute day of the year (Table V) is probably an artifact of the time span during which each nest was observed and the delivery rate at each nest. Observations at nest WE, the nest with the highest rate of prey delivery (Table IV), started earlier in the year (27 April) and ended earlier in the year (23 June) than did observations at nest MI (19 June - 4 July) and nest KG (27 May - 10 July). When the data from each nest site were analyzed separately, the absolute day of year did not have a significant regression coefficient with the rate of prey delivery at nests KG and WE. At nest MI, the absolute day of the year had a significant, positive regression coefficient with the rate of prey delivery.

The positive relationship between the rate of food delivery during an observation period and the value of the dummy variable for the 05:30-09:00 period (Table V) indicates a higher rate of prey delivery during this period than during the other periods of the day. That this relationship was significant in spite of the

Table V

Results of stepwise regressions; rate of prey delivery (deliveries/hour) by adult bald eagles to unfledged young at three nest sites during each observation period (see text for discussion of variables).

Dependent variable: delivery rate during an obs. per. $R^{2a} = 0.217$

	df	sum of squares	mean square	F	Prob<F
regression	4	1.7614	0.4404	5.61	0.0005
error	81	6.3633	0.0786		
total	85	8.1248			

Significant independent var.	$\beta \pm s.e.^b$	F	Prob<F[c]	intercept
number of young	0.15 ±0.082	3.34	0.0711	
absolute day of year	-0.0043±0.00217	4.02	0.0483	
mean wind speed	0.032 ±0.0132	5.78	0.0185	
dummy var. for 05:30-09:00 per.	0.28 ±0.088	10.41	0.0018	0.4945

(continued)

(continued)

Table V

Dependent variable: dummy variable for the event of prey del. during an obs. per.

$R^{2a} = 0.113$

	df	sum of squares	mean square	F	Prob<F
regression	2	2.4171	1.2085	5.26	0.0071
error	83	19.0713	0.2298		
total	85	21.4884			

Significant independent var.	$\beta \pm s.e.^{b}$	F	Prob<F^{c}	intercept
number of young	0.32 ± 0.133	5.82	0.0181	
mean sunniness	0.0034 ± 0.00160	4.66	0.0337	-0.3281

[a](Correlation coefficient)^{2}; (proportion of variation of dependent variable explained by the variation in the significant independent variables)

[b]Regression coefficient ± standard error; (slope of regression line)

[c]Probability that regression coefficient=0

fact that the observed, overall, rate of prey delivery during each period was not significantly different (Table IV), seems curious. However, this result can occur because of the relationship between wind speed and delivery rate. There was a significant difference in the observed wind speeds among the four different observation periods (analysis of variance, $P=0.0068$). The four variances were not significantly heterogeneous (Bartlett's test, $P=0.28$). Observed wind speeds during the 05:30-09:00 period were significantly lower than the observed wind speeds during the ramainder of the day (Duncan's multiple range test, $P<0.05$). The reduction in the rate of prey delivery resulting from these lower wind speeds early in the morning tends to mask the relationship between time of day and delivery rate (Table V) when the effect of wind speed is not considered (Table IV).

The dummy variable for the event of food delivery during each observation period had a significant regression coefficient with the number of young (positive) and the average sunniness (positive). These two factors explained only 11.3 percent of the variation in the event of food delivery during each observation period (Table V).

At nest WE, there was no significant difference between the rate of food delivery by the male (mean=0.20 deliveries per hour, standard error=0.051, n=38 observation periods) and the female (mean=0.17 deliveries per hour, standard error=0.040, n=38

observation periods;   t=0.438,   0.9>P>0.5).   The female   fed the young following 17 of her 24 observed food deliveries.   In contrast, the male fed the young on only 11 occasions following his 23 observed food deliveries. More importantly, on 7 occasions following a food delivery by the male, the female took possession of the prey item and fed the young.   On 4 of these 7 occasions, the female was brooding the young when the male arrived,   on 2 occasions the female was perched in the nest tree and on 1 occasion the female was already feeding the young when the male arrived. Six of these seven observations were made when the young were less than five weeks old,   suggesting that the female may do most of the feeding of the young during the early phase of the nestling period.

The duration of successful hunting flights at nest WE by the adult male (mean=71 minutes, standard error=25, n=17 flights) and female (mean=89 minutes, standard error=30, n=20 flights) were not significantly different (t=0.456, 0.9>P>0.5). Sample size was not sufficient to examine the duration of successful hunting flights during each of the four observation periods. The overall duration of a successful hunting flight for both adults at nest WE averaged 81 .minutes (standard error=19, n=37 flights,   range: 5-607 minutes).   Since many of the prey items brought to the nest had already been partially consumed,   the average time required to obtain a prey item must actually be somewhat less than 81 minutes.

The overall rate of food delivery at nest WE averaged 0.382 deliveries per hour (Table IV). Given the average overall rate of prey delivery and the average duration of a successful hunting flight, it is possible to calculate the average percentage of the daylight hours which the breeding pair must spend foraging to provide for their young (0.382 deliveries per hour X 81 minutes per delivery X 1 hour per 60 minutes=0.516). Since there was no significant difference between the rates of prey delivery by the male and female, this suggests that each adult must spend an average of 25.8 percent of the daylight hours foraging. This estimate is consistent with the observation that flights when the male and female returned to the nest with a prey item accounted for 27.35 and 30.73 percent of the total observation time, respectively (Table I).

The combined data for the duration of successful hunting flights at nest WE by the male and female had significant regression coefficients with the maximum wind speed (positive), the minimum wind speed (negative), and the average difference between the maximum and minimum wind speeds recorded each hour during the adult's absence (negative) (Table VI). These relationships accounted for 60.2 percent of the variation in the duration of successful hunting flights by the adults (Table VI).

The elapsed time between successive deliveries had a significant regression coefficient with the distance from the nest

Table VI

Results of stepwise regression; duration of successful hunting flights by the adults at nest WE-79-01 (see text for discussion of variables).

Dependent variable: duration of a successful hunting flight $R^{2a} = 0.602$

	df	sum of squares	mean square	F	Prob<F
regression	3	289352	96450	14.10	0.0001
error	28	191592	6842		
total	31	480945			

Significant independent var.	$\beta \pm s.e.^b$	F	Prob<F^c	intercept
maximum wind speed	75 ± 12.9	33.74	0.0001	
minimum wind speed	-71 ± 11.7	36.80	0.0001	
mean diff. between max. & min. wind speeds	-61 ± 22.3	7.40	0.0111	6.354

^{a}(Correlation coefficient)^2; (proportion of variation of dependent variable explained by the variation in the significant independent variables)

^{b}Regression coefficient ± standard error; (slope of regression)

^{c}Probability that regression coefficient=0

to the nearest open water (positive), the maximum wind speed since the previous delivery (positive), the minimum wind speed since the previous delivery (negative), and the average difference between the maximum and minimum wind speeds during each hour since the previous delivery (negative) (Table VII). These relationships accounted for 69.8 percent of the variation in the elapsed time between successive deliveries (Table VII).

Table VII

Results of stepwise regression; time between successive prey deliveries by adult bald eagles to unfledged young at three nest sites (see text for discussion of variables).

Dependent variable: time between successive prey deliveries R^{2a} = 0.698

	df	sum of squares	mean square	F	Prob<F
regression	4	947182	236796	24.87	0.0001
error	43	409343	9520		
total	47	1356526			

Significant independent var.	$\beta \pm$ s.e.[b]	F	Prob<F[c]	intercept
maximum wind speed	52 ± 6.7	59.35	0.0001	
minimum wind speed	-58 ± 7.9	53.14	0.0001	
mean diff. between max. & min. wind speeds	-52 ± 15.8	10.59	0.0022	
distance to open water	0.07 ± 0.030	5.82	0.0202	-18.88

[a](Correlation coefficient)^2; (proportion of variation of dependent variable explained by the variation in the significant independent variables)

[b]Regression coefficient ± standard error; (slope of regression line)

[c]Probability that regression coefficient=0

DISCUSSION

Influence of Absolute Day of Year:

The decrease in the percentage of time that the adults spent perched near nest WE as the season progressed (Table III, Figures 1, 2 and 3) may result from a decrease in parental attentiveness as the young become older.   Although few data were collected during the first six weeks after hatching,   it appears that at least one adult is present at the nest site almost constantly until the young are four to five weeks of age (Figure 3). At this point adult attendance at the nest began to decline linearly. Although there was no significant difference in the overall percentage of time that each adult spent perched near the nest (Table II), this may be true only during the four to six weeks prior to fledging; the period during which the majority of these data were collected.   The female seemed to spend substantially more time attending the nest than the male during the first three to four weeks of the nestling period (Figures 1 and 2). Although these data are limited and based on observations at only one nest site, very similar patterns of adult nest attendance have been reported by Retfalvi (1965),   for nests in Washington and by Herrick (1933), for Ohio bald eagle nests.

As with the nest attendance data, the similarity in the rates at which the male and female delivered prey to nest WE may hold only during the four to six weeks prior to fledging. The rates at

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which the male and female delivered prey to the nest did not have significant regression coefficients with the absolute day of the year. However, if the trend suggested by Figures 1 and 2 during the first two to three weeks after hatching is accurate — the female present at the nest approximately 90% of the time and the male present approximately 50% of the time — then perhaps the male supplies most of the prey during this period. The rate of prey delivery by the female may then gradually increase during the third and fourth weeks until the adults are delivering prey at similar rates during the later half of the nestling period. Retfalvi (1965) also found virtually identical rates of prey delivery by the adult male (mean=0.073 deliveries per hour, standard error=0.0137, n=9 weeks) and female (mean=0.071 deliveries per hour, standard error=0.0118, n=9 weeks; t=0.110; P>0.9; values calculated from his table 14, p. 101) at two nest sites during the later half of the nestling period. Herrick (1924) also presents data concerning the rate of prey delivery at a nest site during the last two weeks of the nestling period. Although his data are difficult to interpret, it appears that there is no significant difference in the rate at which prey were delivered by the adult male (mean=0.067 deliveries per hour, standard error=0.0166, n=14 days) and female (mean=0.126 deliveries per hour, standard error=0.0278, n=14 days; t=1.821; 0.10>P>0.05; values calculated from his table I, pp. 401-403, all

deliveries followed by a "?" excluded.   Data from 16 June and 22 June could not be used since the duration of the observation period was not given).

As discussed previously, the inverse relationship between the overall rate of prey delivery and the absolute day of the year (Table V) appears to be an artifact of the time span during which each nest was observed and the overall delivery rate at each nest. Furthermore, Markle (1976) reported that the size of fish populations in the York River and lower Chesapeake Bay increase from spring to mid summer. Since similar increases in fish populations probably occur throughout the Chesapeake Bay region, the low rates of prey delivery at the nests which were observed later in the season were probably not caused by lower prey availability at this time of year.

The weight of fish which adult ospreys bring to nests containing unfledged young increases with increasing absolute day of the year (Stinson 1978).   Stinson (1978) attributed this relationship to growth of the prey as the summer progressed. Data on prey weights in the present study were not sufficient to test for a similar trend.   However, it seems likely that bald eagle prey also experience growth as the summer progresses.   Therefore, although the rate of prey delivery to bald eagle nests may remain constant as the summer progresses,   nestling bald eagles may in fact experience an increase in the amount of food delivered to the

nest as a result of an increase in the average size of the prey items which are brought to the nest.

Influence of Time of Day:

The increased rate of prey delivery during the 05:30-09:00 period (table V) was probably a result of bald eagles being hungrier in the morning, after not eating all night, than at other times of the day. Jaffee (1980) found that the foraging frequency of adult bald eagles is highest during the early morning hours (05:30-07:00). These data, however, are also consistent with the hypothesis that prey may be easiest to obtain early in the day. Stinson (1978) noted that adult ospreys also deliver food to nests with unfledged young at a significantly higher rate during the early morning hours (05:00-09:00). However, since he found no significant difference in the duration of successful hunting flights during the different observation periods, Stinson concluded that the high rate of food delivery during the morning is probably the result of ospreys being hungrier in the morning rather than an indication of higher food availability. In the present study, data concerning the duration of successful hunting flights during each of the four observation periods were not sufficient to reliably distinguish between these hypotheses. Although morning hunger probably does contribute to higher delivery rates early in the day, a higher availability of carrion early in the morning may also contribute to these higher delivery

rates. During the day, the activities of bald eagles and other avian scavengers probably prevent substantial accumulations of dead and moribund fish. At night, in the absence of the activities of these avian scavengers and in spite of the shoreline activities of mammalian scavengers, dead and moribund fish probably accumulate and may be most abundant during the early morning hours.

Influence of Weather:

Wind speed affects the foraging activities of ospreys (Grubb 1977, Stinson 1978), some terns (Dunn 1973) and bald eagles (Jaffee 1980). Wind may either affect foraging activities directly, by influencing the predator's flying ability (Dunn 1973, Stinson 1978), or indirectly, by influencing water surface conditions and hence interfering with the predator's ability to spot potential prey (Dunn 1973, Grubb 1977, Jaffee 1980). Bald eagles often use shoreline perches to locate prey (Edwards 1969, Kussman 1976, Jaffee 1980, Southern 1964, Retfalvi 1965) and hunting forays initiated from perches appear to be more successful than those initiated from flight (Hehnke 1973, Jaffee 1980). Gerrard et al. (1980) reported that a color marked, non-breeding adult bald eagle which they observed selected shoreline fishing perches which faced into the wind. They suggested that such perches may have been selected because wind sweeping across an open expanse of water may carry dead and moribund fish towards the

waiting eagle. The observed increase in the rate of food delivery associated with increasing wind speeds (Table V) is consistent with this hypothesis. Similarly, the observed decrease in both the duration of successful hunting flights (Table VI) and the time between successive food deliveries (Table VII) associated in both cases with increased minimum wind speed and increased wind speed variability is also consistent with the Gerrard et al. (1980) hypothesis. In contrast, increased maximum wind speeds are also associated with an increase in both the duration of successful hunting flights (Table VI) and time between successive food deliveries (Table VII). These latter relationships, however, are consistent with Jaffee's (1980) finding that the foraging frequency of adult bald eagles is significantly reduced when water surface conditons are rough, a condition which is related to high wind speeds. It seems likely that wind can act both to improve foraging conditions, by increasing the rate at which dead and moribund fish are moved past a perched eagle, and to worsen foraging conditions as wind speeds increase to the point that water surface conditions become rough and begin to impair the eagle's ability to spot potential prey. Tidal movement may act to further improve or worsen foraging conditions, depending on the wind direction relative to the tidal flow. Wind blowing with an incoming or outgoing tide will produce a fast current combined with relatively calm water surface conditions. Winds blowing

against an incoming or outgoing tide will result in extremely rough water surface conditions.

The foraging frequency of subadult bald eagles is significantly reduced when the sun is occluded (Jaffee 1980). A similar relationship exists for all age classes of bald eagles combined but not for the adult age class alone (Jaffee 1980). Similarly, the rate at which ospreys were able to capture fish is significantly reduced when the sun is occluded (Grubb 1977). Both authors suggested that fish may be easier to spot under sunny conditions. The observed increase in the value of the dummy variable for the event of food delivery under sunny conditions (Table V) seems consistent with this hypothesis. Furthermore, Gerrard et al. (1980) reported that a bald eagle they observed selected fishing perches facing away from the sun. They suggested that these perches were selected to reduce glare from the water surface; a condition which might make it more difficult to locate prey.

Grubb (1977) reported a sixfold variation in the fishing success rates of ospreys over a range of cloud cover and water surface conditions. In contrast, Stinson (1978) found that these factors did not significantly influence the rate at which adult ospreys delivered prey to unfledged young or the duration of successful hunting flights by the adults. Overall, wind speed variability was the only weather condition to significantly

influence the time use of foraging ospreys in Stinson's (1978) study. This relationship accounted for less than 20 percent of the variation in the duration of successful hunting flights. Similarly, although variations in the foraging activities of Sandwich terns and common terns are correlated with variations in windspeed and sea surface conditions (Dunn 1973), variations in these weather conditions account for only 3.4 percent and 11.1 percent, respectively, of the variation in the growth rates of the chicks (Dunn 1975). The results of these studies seem to suggest that the total foraging process is "designed" to absorb and even out environmentally imposed fluctuations in capture rates so that the end result of the foraging process -- the rate at which food is delivered to the nest -- is not markedly influenced by environmental fluctuations. Similarly, although weather conditions have been shown to affect the foraging frequency of bald eagles (Jaffee 1980), weather conditions account for less than 20 percent of the variation in the overall rate of prey delivery to the nest site (Table V). However, in contrast to Stinson's (1978) findings, weather conditions accounted for a high percentage of the variation in the duration of successful hunting flights (Table VI) and the time between successive prey deliveries (Table VII) by bald eagles. The reason for these differences may be related to the fact that ospreys actively search for prey from the wing (Grubb 1977) while bald eagles generally search for prey

from a fishing perch (Wright 1953, Southern 1964, Edwards 1969, Kussman 1976, Jaffee 1980) and therefore may rely on winds and tidal action to move dead and moribund prey past the fishing perch (Gerrard et al. 1980, this study). That is, while ospreys generally move around in search of prey, bald eagles frequently remain stationary and wait for dead and moribund prey items to be blown past.

Influence of Habitat:

Snyder and Snyder (1973) found considerable variation between nest sites in the average rate of prey delivery by adult Cooper's hawks (Accipter cooperi). They attributed this variation to differences in habitat quality among nest sites. They also reported a positive correlation between brood size and the rate of prey delivery and provided experimental evidence suggesting that this relationship results from an adjustment of brood size to match the feeding capacities of the adults. They therefore suggested that variation in habitat quality, through it's effect on the rate of prey delivery, may be responsible for the variation in brood size observed in their study. If differences in habitat quality are also responsible for the observed differences in delivery rate between nest sites in the present study (Table IV), then the observed positive relationship between the rate of prey delivery and brood size (Table V) suggests that larger broods should tend to be associated with higher quality nesting habitat.

Recognition of these habitat induced variations in productivity are of course hindered by additional factors which may also influence productivity (e.g. predation, weather, pesticides) and result in year to year fluctuatiions in productivity. Hence, the high rate of food delivery at nest WE in 1980, relative to the observed delivery rates at the other nests, suggests that the adults at this nest may have been capable of adequately providing for three young. Although no prey delivery data were collected during the 1981 breeding season, nest WE was in fact one of only two nests in Virginia to produce three young during the 1981 breeding season (K. Cline, pers. comm.). In spite of year to year variations in productivity, nests located in patches of high quality habitat should show significantly higher productivity rates (number of young per active nest) and significantly higher success rates (percent of active nests producing young) than nests located in habitat of lesser quality. Nest WE is one of four bald eagle nesting territories located along a 14 km section of river shoreline. The mean productivity rate at these four nesting territories during the 1977 through 1981 breeding seasons (mean=1.4 young/active nest, standard error=0.30) was, in fact, significantly greater than the mean productivity rate at all other Virginia bald eagle nesting territories during the same period (mean=0.68 young/active nest, standard error=0.127; $t=2.366$, $0.05>P>0.02$). The mean success rate at these four nesting

territories during the 1977 through 1981 breeding seasons (mean=75% of active nests successful, standard error=11.2) was not, however, significantly different from the mean success rate at all other Virginia bald eagle nesting territories during the same period (mean=53% of active nests successful, standard error=6.4; t=1.681, 0.2>P>0.1; productivity and success rate figures compiled from Clark and Lincer 1977, Dittrick and Clark 1978, Pramstaller and Clark 1979, 1980, M. Pramstaller pers. comm.; see Appendix II for details). Success rate figures indicate the proportion of breeding pairs capable of producing young. Although productivity rate figures (no. young/active nesting territory) are also based to a certain extent on the proportion of breeding pairs which are successful, productivity rates also take into account the number of young produced by each successful breeding pair. The fact that these four nest sites had a higher productivity rate (no. young/active nesting territory) but not a higher success rate than all other Virginia nesting territories may indicate that the likelihood of rearing young is influenced to a greater degree by factors other than those which determine the number of young that can be reared. The ability of a breeding pair to successfully rear young may be influenced primarily by internal factors such as the pair's age, experience, physiological condition and their history of exposure to chlorinated hydrocarbons. Sprunt et al. (1973) have shown that

success rates are the most important value for assesing the extent of pesticide related reproductive problems within a population. In contrast, the number of young that a breeding pair is capable of rearing may be influenced to a greater degree by factors related to the quality of their nesting and foraging areas. Although the evidence is circumstantial, the high rate of prey delivery observed at nest WE in 1980 and the significantly higher productivity rate of nests in this area would seem to suggest that this may, in fact, be an area of exceptionally high quality bald eagle nesting habitat.

In Virginia, and elsewhere, it appears that bald eagle nest sites near water are being abandoned in favor of nest sites located farther from water, perhaps in response to increased human activity along the shoreline (Jaffee 1980, Juenemann 1973, Whitfield et al. 1974). Although proximity to water does seem to influence nest site selection, proximity to water does not significantly affect the success (i.e. whether or not a nest produces young) of nesting attempts in Virginia (Jaffee 1980). In the present study, although the rate of prey delivery did not have a significant regression coefficient with the proximity of a nest site to open water, there was a significant, positive relationship between the proximity of a nest site to water and the time between successive prey deliveries (Table VII). Since these results are based on data collected from only three nest sites, the importance

of this relationship is unclear. The relationship between foraging behavior and the proximity of the nest site to water needs to be examined at a larger number of nest sites before any firm conclusions regarding the importance of this factor can be made.

When combined with the results of previous studies (Gerrard et al. 1980, Jaffee 1980), the relationships between foraging behavior and weather observed in the present study suggest that the abundance of fishing perches and their distribution relative to the prevailing winds should be examined as a possible factor contributing to the quality of bald eagle nesting habitat.

Appendix I

The six figure, alpha-nimeric nest codes were assigned to each nest by members of the Chesapeake Bay Bald Eagle Recovery Team during their study of the breeding population in this region. The first two letters indicate the county in which the nest is located. The numbers indicate the year during which the nest was first located and the order of discovery of nests in that county during that year. Bald eagle nest sites in the Virginia portion of the Chesapeake Bay region have previously been described by Jaffee (1980). Nest site descriptions for each nest discussed in the current investigation were compiled from Appendix I of Jaffee (1980). Nest MI-80-01 was not described by Jaffee. Nest site description data for this nest were collected using methods described by Jaffee.

Nest ID	River[1]	Year	No. Young	Tree[2] sp.	Tree Height (m)	DBH[3] (cm)	Nest Height (m)	Canopy Height (m)	Mean Foliage Den. (%)	Dist. Water (m)	Dist. Road (m)
KG-79-02	Pot.	1979	2	P.t.	35	61.5	28.9	35	88	240	3095
WE-79-01	Pot.	1980	2	L.t.	25.9	90.2	19.8	18.3	77.5	960	880
MI-80-01	Rapp.	1980	1	P.t.	22.9	53.4	18.3	13.7	99	1725	400

[1]Rivers: Pot. - Potomac R.; Rapp. - Rappahannock R.

[2]Tree sp. key: P.t. - Pinus taeda; L.t. - Liriodendron tulipifera

[3]Nest tree diameter at breast height

Appendix II

Productivity data for bald eagle nest site in Virginia during 1977
-1981. Data compiled from Clark and Lincer (1977), Dittrick and
Clark (1978), Pramstaller and Clark (1979, 1980) and M. Pramstaller
(pers. comm.).

Productivity data for nests WE-77-01, WE-79-01, WE-71-04, WE-79-05,
and WE-78-01. Nests WE-77-01 and WE-79-01 are alternate nest sites
located within the same nesting territory.

	1977	1978	1979	1980	1981
# active nests	2	2	3	4	4
# successful nests	2	1	3	2	3
% nests successful	100	50	100	50	75
# young	5	2	3*	4	7
# young/active nest	2.50	1.00	1.00*	1.00	1.75

*Does not include the single captive reared young added to each of
two nest sites in addition to the single wild young already pre-
sent.

Productivity data for all nest sites in Virginia except WE-77-01,
WE-79-01, WE-71-04, WE-79-05, and WE-78-01.

	1977	1978	1979	1980	1981
# active nests	29	35	31	31	35
# successful nests	15	14	12	21	24
% nests successful	51.7	40.0	38.7	67.7	68.6
# young	13	15	17	31	34
# young/active nest	.448	.428	.548	1.00	.971

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