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A NESTING STUDY OF THE RED-TAILED HAWK
IN SOUTHERN MICHIGAN.

Michigan State University, Ph.D., 1976
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A NESTING STUDY OF THE RED-TAILED HAWK
IN SOUTHERN MICHIGAN

By

Glenn Young Belyea

A DISSERTATION

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ABSTRACT

A NESTING STUDY OF THE RED-TAILED HAWK IN SOUTHERN MICHIGAN

By

Glenn Young Belyea

Habitat analyses were conducted in the vacinities of 45 red-tailed hawk (Buteo jamaicensis) nests in a 93.2 square kilometer study area in Ingham County, Michigan. Information on habitat factors which might influence nest site selection, population density, reproductive success, nestling growth rates, and food habits was collected.

Fifty-six percent of the nests were in mature beech (Fagus grandifolia) and sugar maple (Acer saccharum) trees. Mean nest height was 17.2 ± 3.2 meters in trees averaging 23.6 ± 3.3 meters tall. Ninety-four percent of the nest trees were within woodlots. Thirty percent of the woodlots were less than 5 ha in size and 67 percent were less than 15 ha. Eighty-four percent of the woodlot nests were within 65 meters of an edge. Nests occurred with equal frequency in woodlots surrounded by croplands and in those encircled by fallow fields.

Within the study area, 41 percent of red-tailed hawk nests were reoccupied a second year and 13 percent a third year. Nesting success had no apparent relationship to reoccupancy. While several nests were located within 0.37 kilometers of an occupied dwelling, the mean distance was 0.53 ± 0.15 kilometers.

During 1971-1975, the number of nesting pairs fluctuated between 10 and 15, with a mean of 13. The mean density was one nesting pair per 7.2 square kilometers. Fifty-three percent of the nests were successful, with a mean of 1.4 young fledged per successful nest. The overall recruitment rate was 0.75 young fledged per breeding pair.

Remnants of 16 different prey species were found in red-tail nests. Of these, eight were mammals, 4 were birds, 2 were amphibians and 2 were reptiles.

No red-shouldered hawks were found on the study area, but great horned owls were a common occupant of old red-tail nests.

Increased urbanization is considered a major threat to the red-tailed hawk population in southern Michigan. The resulting reduction in nesting habitat together with increased disturbance by humans evidently will cause a reduction in nesting red-tail numbers -- at least in townships urbanizing as rapidly as Alameda.

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INTRODUCTION

The red-tailed hawk (Buteo jamaicensis) occurs throughout most of North America. While it often nests on cliffs or cactus tops in the western portion of its range (Bent 1937:168), it is almost exclusively a tree-nesting species in the East. Studies of nesting populations (Fitch et al. 1946, Orians and Kuhlman 1956, Craighead and Craighead 1956, Hagar 1957, Luttich et al. 1971) have generally concluded that the red-tailed hawk is not very specific in its selection of nest sites. Its nest locations range from dense, remote woodlands to single trees in open fields close to human habitation.

This study was made to determine (1) the reproductive status of the red-tailed hawk in southern Michigan and (2) some of the factors affecting nest site selection. Data on population density, nestling growth rates, food habits, effects of urbanization, and relationships with other raptors also were collected.

STUDY AREA DESCRIPTION

This investigation was conducted in and around Alaiedon Township, Ingham County, Michigan (42° 38' N, 84° 25' W). Alaiedon Township is a 93.2 square kilometer tract (36 square miles) located 4.8 kilometers south of East Lansing. Interstate Highway 96 crosses the northern portion of the township and, like most other townships in southern Michigan, it is gridded by an extensive network of county roads.

The area is typical southern Michigan farmland, with about 65 percent of the land under cultivation and about 14 percent in small scattered woodlots (Figure 1). These woodlots are predominantly beech-maple (Fagus - Acer) associations, but some are oak-hickory (Quercus - Carya) associations. Common tree species are American beech (Fagus grandifolia), sugar maple (Acer saccharum), red maple (A. rubrum), red oak (Quercus rubra), white oak (Q. alba), shagbark hickory (Carya ovata), American basswood (Tilia americana), American elm (Ulmus americana), black cherry (Prunus serotina) and white ash (Fraxinus americana). Small woodlots and extensive farm lands on flat to gently rolling topography gives the township a decidedly open appearance. Only one small (16 hectare) lake and two narrow creeks lie within the study area, but it does contain several marshes and some rather extensive wooded swamps.

In addition to the red-tailed hawk, other raptors seen on the study area were the turkey vulture (Cathartes aura), red-shouldered

hawk (Buteo lineatus), Cooper's hawk (Accipiter cooperii), marsh hawk (Circus cyaneus), sparrow hawk (Falco sparverius), great horned owl (Bubo virginianus), screech owl (Otus asio) and long-eared owl (Asio otus).



Figure 1. Aerial photograph of Alaiedon Township, Ingham County, Michigan, July, 1970.

METHODS

Searches for red-tailed hawk nests were conducted in March and April of each year from 1971 through 1975. A large proportion of the study area was open farm land which was covered quickly and thoroughly by automobile. All woodlots within the study area were systematically searched on foot. Nest locations were plotted on topographic maps. Because of the dispersion of woodlots, the large size of the nests, and the mainly deciduous forest cover, it is believed that all nests within the township were found.

In 1971, 1972 and 1975, nests were checked to determine reproductive success. The 1971 nests were checked shortly after the eggs were laid and regularly thereafter until all young had fledged. Rather complete data on eggs laid, young hatched and nestling mortality were obtained. In 1972 and 1975, in an effort to eliminate the possible influence of climbing-disturbance on reproductive success, nest trees were climbed only once, just prior to fledging. Counts of eggs laid and young hatched were not made and, therefore, those figures and those derived from them represent minimum values.

Growth data for nestlings were gathered weekly during the 1971 nesting season. Young hawks were lowered to the ground in a canvas basket, weighed on a single-pan dial scale (Figure 2), and hoisted back to the nest. Red fingernail polish, applied on the legs, was used to mark individual nestlings. Because of the need for frequent climbing to nests, eight-inch twisted steel spikes were driven into

the trees to form a permanent ladder. Leg-iron tree climbers were used for less-frequently climbed trees. To lessen the possibility of human scent attracting predators to nest trees, ladder sections were used to bypass the lower portion of the trunk. Napthalene balls also were scattered around each tree base.

During each of the 1972-1975 seasons, nests were visited only twice, once when the occupied nests were first located and again just before the young fledged. On the first visit, nest trees were approached only as close as necessary to confirm occupation. On the second occasion, the trees were climbed and nests checked. Nestlings present were banded using Fish and Wildlife Service leg bands.

During the summer of 1972, habitat evaluation studies were carried out at 45 red-tailed hawk nest sites in and around Alameda Township. While all nests were known to have been built by red-tails (Figure 3), they were not necessarily active during the study. The inclusion of both old and new nests was necessary to obtain a sufficient sample.

Nest site evaluations were conducted on plots 30.5 m (100 feet) in radius around each nest tree. The sampling technique was a modification of the rangefinder circle method recommended by Lindsey et al. (1958:441) and was similar to that employed by James (1971:215). A white pole encircled by two conspicuous rings 68.6 cm apart was placed vertically near the base of the nest tree. This pole was sighted by holding a tree caliper (or short stick) at arms length (63.5 cm) and aligning two marks 1.25 cm apart on it with the two marks on the pole. The two sets of marks aligned perfectly when viewed from 30.5 m, and provided an efficient means of determining the perimeter of the circle to be sampled. The area of each such circular plot was 0.29 ha.

Within the nest plots, the total number, species and diameter at breast height (dbh) of trees greater than ten centimeters dbh were tallied and used to calculate tree basal area per hectare. The height and location of each nest and the height, species and dbh of each nest tree were also recorded. The mean canopy height at each nest site was determined by measuring the height of the dominant trees. A Haga hypsometer was used to measure nest and tree heights.

Distances from the nest to the nearest occupied dwelling and to the nearest edge of the woodlot also were recorded, as well as the directional exposure of those nests situated within 40 meters of an edge. The directional exposure is the cardinal compass direction faced by the closest woodlot edge.

Also, habitat types on 72 and 388 ha circular plots about each nest site were evaluated. The 72 ha plots were selected to examine the habitat types more immediately surrounding the nest sites. The 388 ha plots are circular approximations of the home range of southern Michigan red-tailed hawks during the nesting season (Craighead and Craighead 1956:257). Ground inspections combined with aerial photographs were used in constructing a color-keyed habitat map showing seven categories: cropland, woodland, abandoned field, pasture, residential, marsh and open water. A polar planimeter was used to compute areal measurements for each type on each plot. Comparisons of habitat types between nest sites were then made on plots of both sizes in attempts to discern similarities. Comparisons of habitat types were also made with 72 and 388 ha plots surrounding five woodlots which were unused by red-tails, but which appeared to be suitable as potential nest sites.



Figure 2. Five week old red-tailed hawk being weighed on a single pan dial scale.



Figure 3. Typical red-tailed hawk nest, Alaiedon Township, Ingham County, Michigan, April, 1971.

RESULTS

Nest Sites

The nests were situated in nine species of deciduous trees, but beech and sugar maple were by far the most often selected (Table 1). The height of nests above the ground varied between 10.4 and 25.0 m, with a mean of 17.2 ± 3.2 m. Thirty six of the nests were built in crotches of the main trunk, with the remainder in forks of large branches.

Most nest trees were large, averaging 23.6 ± 3.3 m high and 52.3 ± 15.0 cm in diameter at breast height (dbh). Only 27 percent of the nest trees were the tallest tree in their respective .29 ha plots, but a total of 78 percent were equal to the mean canopy height of that plot. All nests were situated in the upper half of the nest tree, 71 percent in the upper third, and 44 percent in the upper quarter.

Sixty (94 percent) nests were situated in woodlots, with four (6 percent) in lone trees outside the woodlots. The woodlots ranged in size from 1.0 to 103.6 hectares, with a mean of 18.6 ± 26.4 ha. Thirty percent of the nests were in woodlots of less than 5 ha, while 67 percent were in woodlots of less than 15 ha (Table 2).

Nests were usually close to a woodlot edge. Only 13 percent of them were over 65 meters from an edge (Table 3). Seventy percent were within 40 meters of the edge and 15 percent were precisely on the edge. Tree densities within the .29 hectare plots surrounding nests in the interior of woodlots, determined through calculations of the basal area

Table 1. Tree species utilized by red-tailed hawks for nest sites, Ingham County, Michigan, 1971-1975.

Tree species	Nests	
	Numbers	Percent
Beech (<u>Fagus grandifolia</u>)	20	31.2
Sugar maple (<u>Acer saccharum</u>)	16	25.0
White oak (<u>Quercus alba</u>)	8	12.5
Red oak (<u>Quercus rubra</u>)	7	10.9
Red maple (<u>Acer rubrum</u>)	6	9.4
White ash (<u>Fraxinus americana</u>)	3	4.7
American elm (dead) (<u>Ulmus americanus</u>)	2	3.1
Boxelder (<u>Acer negundo</u>)	1	1.6
Shagbark hickory (<u>Carya ovata</u>)	1	1.6
Total	64	100.0

Table 2. Size of woodlots containing red-tailed hawk nests, Ingham County, Michigan, 1971-1975.

Woodlot size (ha)	Numbers of nests	Percent
1-5	18	30.0
6-15	22	36.7
16-25	9	15.0
26-50	5	8.3
51+	6	10.0
Total	60	100

Table 3. Distances of red-tailed hawk nests from woodlot edge,
Ingham County, Michigan, 1971-1975.

Distance from woodlot edge (meters)	Numbers of nests	Percent
On edge	9	15.0
1-15	5	8.3
16-40	28	46.7
41-65	10	16.7
66+	8	13.3
Total	60	100

per hectare, were significantly ($P < 0.05$) lower than those of the nests within 40 meters of the edge (77.2 m vs 115.0 m).

Chi-square tests showed no significant differences ($P > 0.1$) between the numbers of nests facing various directions.

During the five years of study, distances from occupied red-tailed nests to the nearest inhabited human dwelling ranged from .37 to .74 kilometers, with a mean of $.53 \pm 0.15$ kilometers.

Habitat Types

Abandoned fields and croplands made up most of the habitats within the 72 ha and 388 ha circular plots surrounding the nest sites (Table 4). Woodland habitat comprised 14.4 percent of the 72 ha plots and 9.8 percent of 388 ha plots. The distribution of habitat types in the 72 ha plots was quite similar to that of the 388 ha plots. The percentages of habitat types in circular plots centering on each of five woodlots unused as nest sites (Table 5) were very similar to those in the plots surrounding the nest sites (Table 4). The wide range in values of each habitat type appears to indicate that the surrounding habitat types have little influence in nest site selection.

Nest Use

During the five years of this township-wide study, 47 different red-tailed hawk nests, both occupied and unoccupied, were found (Table 6). An average of 22 nests constructed by red-tailed hawks were present each year (Table 7) of which 13 were occupied by red-tails, 4 were used by great horned owls and 5 remained empty. Following the 1971 year of base data collection, 51 nests were found to be occupied by red-tailed hawks (Table 8) and of these 22 (43 percent)

Table 4. Habitat types in circular plots surrounding forty-five red-tailed hawk nests, Ingham County, Michigan, 1970-1972.

Habitat types	Percentages	
	Median	Range
<u>388 ha plots</u>		
Cropland	41.7	4.6-76.1
Woodland	9.8	3.0-30.1
Abandoned field	16.8	2.4-58.4
Pasture	8.5	0.3-40.9
Residential	11.0	2.6-49.5
Marsh	0.0	0.0-12.9
Open water	0.3	0.0- 3.7
<u>72 ha plots</u>		
Cropland	40.3	0.0-86.3
Woodland	14.4	1.4-53.2
Abandoned field	15.1	1.4-59.7
Pasture	7.2	0.0-54.0
Residential	5.8	0.0-63.3
Marsh	0.0	0.0-22.3
Open water	0.0	0.0- 3.6

Table 5. Habitat types in circular plots surrounding five woodlots unused* by red-tailed hawks as nest sites, Alameda Township, Ingham County, Michigan, 1970-1972.

Habitat types	Percentages	
	Median	Range
<u>388 ha plots</u>		
Cropland	59.4	44.6-73.1
Woodland	11.7	4.5-14.0
Abandoned field	4.3	3.6-11.2
Pasture	13.4	1.3-32.7
Residential	7.2	4.3- 8.3
Marsh	0.0	0.0- 1.4
Open water	0.0	0.0- 0.3
<u>72 ha plots</u>		
Cropland	66.9	32.4-82.7
Woodland	17.3	12.2-26.6
Abandoned field	3.6	0.0-18.0
Pasture	5.0	0.0-41.0
Residential	1.4	0.0- 2.9
Marsh	0.0	---
Open water	0.0	---

* 3 used in later years

Table 6. History of use of nests built by red-tailed hawks, Alaiadon Township, Ingham County, Michigan, 1971-1975. Subscripts denote the numbers of young fledged from successful nests. Other symbols: RT, Red-tailed hawk; GH0, Great horned owl; E, Empty; D, Destroyed; -, Not present.

Nest	Year				
	1971	1972	1973	1974	1975
1	E	E	RT	RT	RT ₁
2	RT ₁	E	D	-	-
3	RT ₁	E	D	-	-
4	GH0	GH0	GH0	GH0	D
5	RT ₂	GH0	E	D	-
6	RT ₁	E	D	-	-
7	GH0	D	-	-	-
8	RT ₁	E	D	-	-
9	E	E	D	-	-
10	RT	E	D	-	-
11	GH0	D	-	-	-
12	RT	E	E	D	-
13	E	GH0	D	-	-
14	RT	GH0	GH0	GH0	RT ₂
15	RT	GH0	D	-	-
16	RT	E	GH0	D	-
17	GH0	D	-	-	-
18	E	D	-	-	-
19	E	RT	D	-	-
20	E	RT	GH0	GH0	RT ₁
21	RT	RT	RT	RT	RT ₂
22	RT	RT	RT	D	-
23	RT	RT	E	D	-
24	-	RT	RT	D	-
25	-	RT ₁	RT	GH0	GH0

Table 6. Continued

Nest	Year				
	1971	1972	1973	1974	1975
26	-	RT 2	E	D	-
27	E	RT 1	E	D	-
28	GHO	RT 2	RT	RT	D
29	-	-	RT	RT	GHO
30	-	-	RT	D	-
31	-	-	RT	RT	E
32	-	-	RT	E	RT
33	-	-	RT	RT	D
34	-	-	RT	D	-
35	-	-	RT	RT	RT 2
36	-	-	RT	RT	D
37	-	-	RT	RT	E
38	-	-	-	RT	E
39	-	-	-	RT	GHO
40	-	-	-	RT	RT 2
41	-	-	-	RT	GHO
42	-	-	-	-	RT 1
43	-	-	-	-	RT
44	-	-	-	-	RT
45	-	-	-	-	RT
46	-	-	-	-	RT 2
47	-	-	-	-	RT

Table 7. Use of red-tailed hawk nests present in Alaiadon Township, Ingham County, Michigan, 1971-1975.

Nest use	Numbers of nests					5-year means
	1971	1972	1973	1974	1975	
Occupied by red-tailed hawks	13	10	15	13	13	12.8
Occupied by great horned owls	5	5	4	4	4	4.4
Empty	7	9	5	1	3	5.0
Total nests present	25	24	24	18	20	22.2

Table 8. Previous-year's history of occupied red-tailed hawk nests, Alameda Township, Ingham County, Michigan, 1972-1975.

Previous-year's history	Total nests occupied by red-tails in current year				4-year totals	Percent of total
	1972	1973	1974	1975		
	<u>Number</u> <u>Percent</u>	<u>Number</u> <u>Percent</u>	<u>Number</u> <u>Percent</u>	<u>Number</u> <u>Percent</u>		
Occupied by red-tailed hawks	3* 30	5 33	9 69	4 31	21	42
Occupied by great horned owls	1 10	0 --	0 --	2 15	3	6
Empty	3 30	1 7	0 --	1 8	5	9
Newly constructed	3 30	9 60	4 31	6 46	22	43
Totals	10	15	13	13	51	

* Example: 3 nests occupied by red-tailed hawks in 1972 were occupied by red-tailed hawks in 1971.

had been newly-built, 21 (41 percent) had been occupied by red-tails the previous year, 3 (6 percent) had been used by great horned owls the previous year and 5 (10 percent) had been empty the previous year. Previous occupancy evidently was not related to nesting success. A third of successful nests were newly built, a third had been occupied by red-tails the previous year, while 25 percent were previously used by great horned owls and 9 percent were empty the previous year (Table 8). Unsuccessful nests were very similar to successful nests with respect to their previous-year's history (Table 9).

While 84 percent of occupied red-tailed nests survived until the following year, only 20 percent of those used by great horned owls and merely 7 percent of the empty nests persisted until the following spring (Table 10). Though 41 percent of red-tailed nests were still present the third year, only 7 percent of those used by great horned owls remained for a third season. No unused nest survived for more than two years from the time it was abandoned.

Nesting Density

The distribution of nesting red-tail pairs on the Alaiedon Township study area from 1971 through 1975 was mapped (Figures 4-8). The numbers of nesting pairs fluctuated between 10 and 15, with a mean of 13 (Table 11). Nesting density correspondingly varied from 6.2 square kilometers to 9.3 square kilometers per nesting pair (Table 11). The mean density was one pair per 7.2 square kilometers. The distance between two occupied nests in any one year ranged from .56 to 4.09 kilometers, with a mean over the five years of 1.96 kilometers (Table 12).

Table 9. Success¹ of red-tailed hawk nests as compared with previous-year's usage, Alaledon Township, Ingham County, Michigan, 1972 and 1975.

Previous-year's history	Successful		Unsuccessful	
	Numbers	Percent	Numbers	Percent
Occupied by red-tailed hawks	4	33	3	27
Occupied by great horned owls	3	25	0	0
Empty	1	9	3	27
Newly constructed	4	33	5	46
Total	12	100	11	100

¹ Having fledged at least one young

Table 10. Longevity of red-tailed hawk nests, Alameda Township, Ingham County, Michigan, 1971-1975.

	Occupied at least 1 year	Occupied 2 consecutive years	Occupied 3 consecutive years	Occupied 4 consecutive years
	<u>Number</u>	<u>Number</u> <u>Percent</u>	<u>Number</u> <u>Percent</u>	<u>Number</u> <u>Percent</u>
Nests occupied by red-tails	51	43 84	21 41	6 12
Nests occupied by great horned owls	15	3 20	1 7	0 0
Nests not reoccupied by any raptor	14	1 7	0 0	0 0



Figure 4. Location of 1971 red-tailed hawk nests, Alameda Township, Ingham County, Michigan.

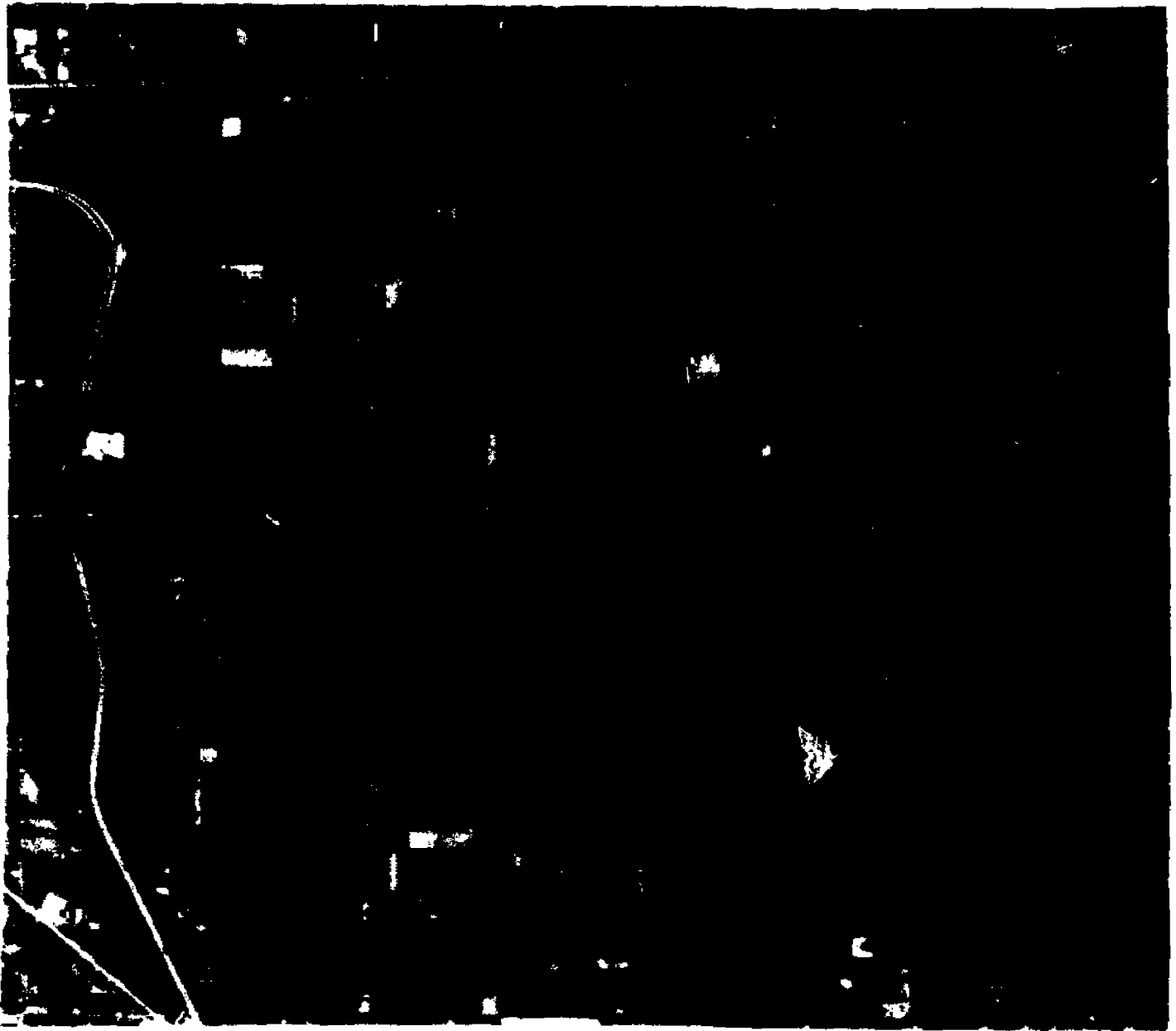


Figure 5. Location of 1972 red-tailed hawk nests, Alaledon Township, Ingham County, Michigan.



Figure 6. Location of 1973 red-tailed hawk nests, Alaledon Township, Ingham County, Michigan.



Figure 7. Location of 1974 red-tailed hawk nests, Alaiedon Township, Ingham County, Michigan.



Figure 8. Location of 1975 red-tailed hawk nests, Alameda Township, Ingham County, Michigan.

Table 11. Nesting densities of red-tailed hawks in Alameda Township, Ingham County, Michigan, 1971-1975.

	1971	1972	1973	1974	1975	5-year means
Nesting pairs	13	10	15	13	13	13
Square kilometers per pair	7.2	9.3	6.2	7.2	7.2	7.2
Pairs per square kilometer	.14	.11	.16	.14	.14	.14

Table 12. Mean and extreme distances between occupied red-tailed hawk nests, Alaledon Township, Ingham County, Michigan, 1971-1975.

Year	Mean distance (km.)	Range (km.)
1971	2.32	2.09 - 2.56
1972	1.72	.95 - 2.70
1973	1.69	1.38 - 2.72
1974	2.03	1.30 - 4.09
1975	2.03	.56 - 4.09
Five year period	1.96	.56 - 4.09

Reproduction

The reproductive chronology of southern Michigan red-tails was calculated for the 1971 nesting season (Table 13). While most red-tails began incubation about 30 March, a few began as early as 23 March. Most eggs had hatched by 4 May and most nestlings had fledged by 16 June. One pair of nestlings did not leave the nest until 29 June.

In 1971, thirteen pairs laid 20 eggs for an average of 1.54 eggs per nesting pair (Table 14). Eight nests contained 2 eggs and four held 1 egg. In addition, one nest was abandoned before any eggs were laid and the pair did not attempt to reneest. Thirteen young were hatched, an average of 1.0 young per nest. Of the young hatched, eight (62 percent) were fledged. The total loss, from eggs laid to young fledged, was 60 percent. Only seven (54 percent) of the thirteen nests were successful in fledging at least one young.

Only ten nests were known to be active within the township in 1972. Eight young were known to have hatched, for an average of 0.80 young per nest. That year, only four (40 percent) of the nests were successful and only six hawks were fledged, an average 1.50 young per successful nest.

The 1975 nesting season was the most successful during the three years that nesting success was appraised. Five (38 percent) of the 13 nests failed, but 14 young were hatched and 13 were fledged from the remaining 8 nests. With five (62 percent) of the eight successful nests fledging two young, there was an average of 1.62 survivors per successful nest for a lower nestling loss than in the other two years (Table 14).

Overall during the 1971, 1972 and 1975 seasons, 53 percent of the

Table 13. Dates of red-tailed hawk reproductive activity, Alameda Township, Ingham County, Michigan, 1971.

Reproductive activity	Mean date	Range
Initiation of incubation	30 March	23 March - 5 April
Hatching	4 May	26 April - 17 May
Fledging	16 June	8 June - 29 June

Table 14. Reproductive success of red-tailed hawks, Alaledon Township, Ingham County, Michigan, 1971, 1972 and 1975.

	1971	Years 1972	1975	3-year means
Total nesting pairs	13	10	13	12
Total eggs laid	20	10*	14*	14.67
Total young hatched	13	8*	14*	11.67
Total young fledged	8	6	13	9
Nests fledging at least one young	7	4	8	6.33
Eggs laid per nesting pair	1.54	1.00*	1.08*	1.22
Young hatched per nesting pair	1.00	0.80*	1.08*	0.97
Young fledged per nesting pair	0.62	0.60	1.00	0.75
Young fledged per successful nest	1.14	1.50	1.62	1.42
Percentages of successful nests	54	40	62	53

* Minimum numbers

nests were successful. Twenty-seven young were fledged from the 19 successful nests, an average of 1.42 young per successful pair. Eleven (58 percent) of successful nests produced one fledgling each and eight (42 percent) produced two each (Figure 9). Five (62 percent) of the eight successful nests fledging two young occurred in 1975, the most productive nesting season. The overall recruitment rate for 1971, 1972, and 1975 was 0.75 young fledged per nesting pair.

Nestling Mortality

Of five eggs failing to hatch during the 1971 and 1972 nesting seasons, two were collected and analyzed for pesticides at the Michigan Department of Agriculture laboratory. Levels found (Table 15) appeared to be insignificant by the standards of Stickel (1973:276-278) and Snyder et al. (1973:302-304).

Eight nestling red-tails died during the study (Figure 10). Only one was found when sufficiently fresh to enable pathological examination. It had died of starvation due to a blockage of the gizzard and proventriculus by numerous small bits of cellophane -- an indication of new hazards to which wildlife are subjected and whose effects are rarely observed.

Of the other seven young, one was found partially decomposed in the nest, one was found partially eaten by an unknown predator on the ground nearly 25 meters from the nest tree, and one was cannibalized presumably by its sibling. Even though nest checks were made every 4 days, the other four disappeared without a trace.

Infestations of the larvae of a blood-sucking fly of the genus Protocalliphora were encountered frequently on the red-tailed hawk nestlings. Maggots were found in the ears of nearly all nestlings but

Table 15. Analysis of two unhatched red-tailed hawk eggs collected in Alaiedon Township, Ingham County, Michigan, June, 1972.

Residue	Level (ppm)	
	Egg 1	Egg 2
DDT	0.30	1.05
DDE	1.00	6.54
DDD	0.21	1.25
Dieldrin	0.26	0.57
PCB	3.05	*

* Egg accidentally broken after being placed in plastic bag, PCB level not reliable



Figure 9. Red-tailed hawk nest containing two five-week old nestlings, June, 1971.

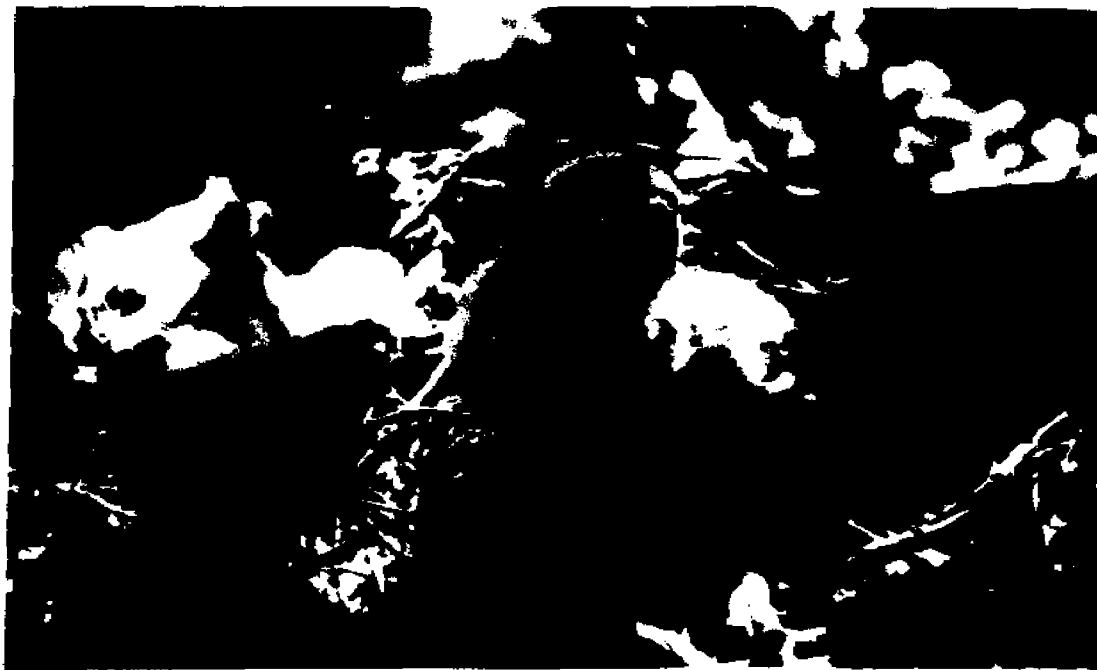


Figure 10. Red-tailed hawk nest containing two three-week old nestlings, one of which had died.

appeared to have little effect on the birds. Attempts to rear the parasites from samples of nest debris were unsuccessful.

Nestling Growth Rates

During the 1971 season, five nests containing two nestlings each were visited at approximately weekly intervals to procure growth data. The exact hatching date was known for only three of the nestlings. These weighed 45, 48 and 40 grams, respectively, just after hatching. Despite the differences in hatching weights, their weights were nearly identical during the first six days (Figure 11). The weights of these known-age birds were used as a basis to estimate the ages of the other seven nestlings. Three of the seven subsequently died, but the growth patterns of the four which fledged were graphed (Figure 12).

The paired ages and weights of all ten nestlings were combined to compute an average linear regression equation $Y = 0.0952 + 0.0343X$ (Figure 13). The age in days, the independent variable, was purposely placed along the Y axis in Figures 11 and 12 to facilitate comparisons with the regression in Figure 13 where age is the dependent variable.

Food Habits

During the weekly visits to the five red-tail nests in 1971, remains of 31 food items, representing 16 different species, were found (Table 16). These were freshly-killed prey or older food fragments in the nest debris. The four most common species, accounting for 52 percent of the items, were meadow voles (16 percent), garter snakes (13 percent), toads (13 percent), and red-winged blackbirds (10 percent). By number, mammals constituted 48 percent, birds 26 percent, reptiles 13 percent and amphibians 13 percent.

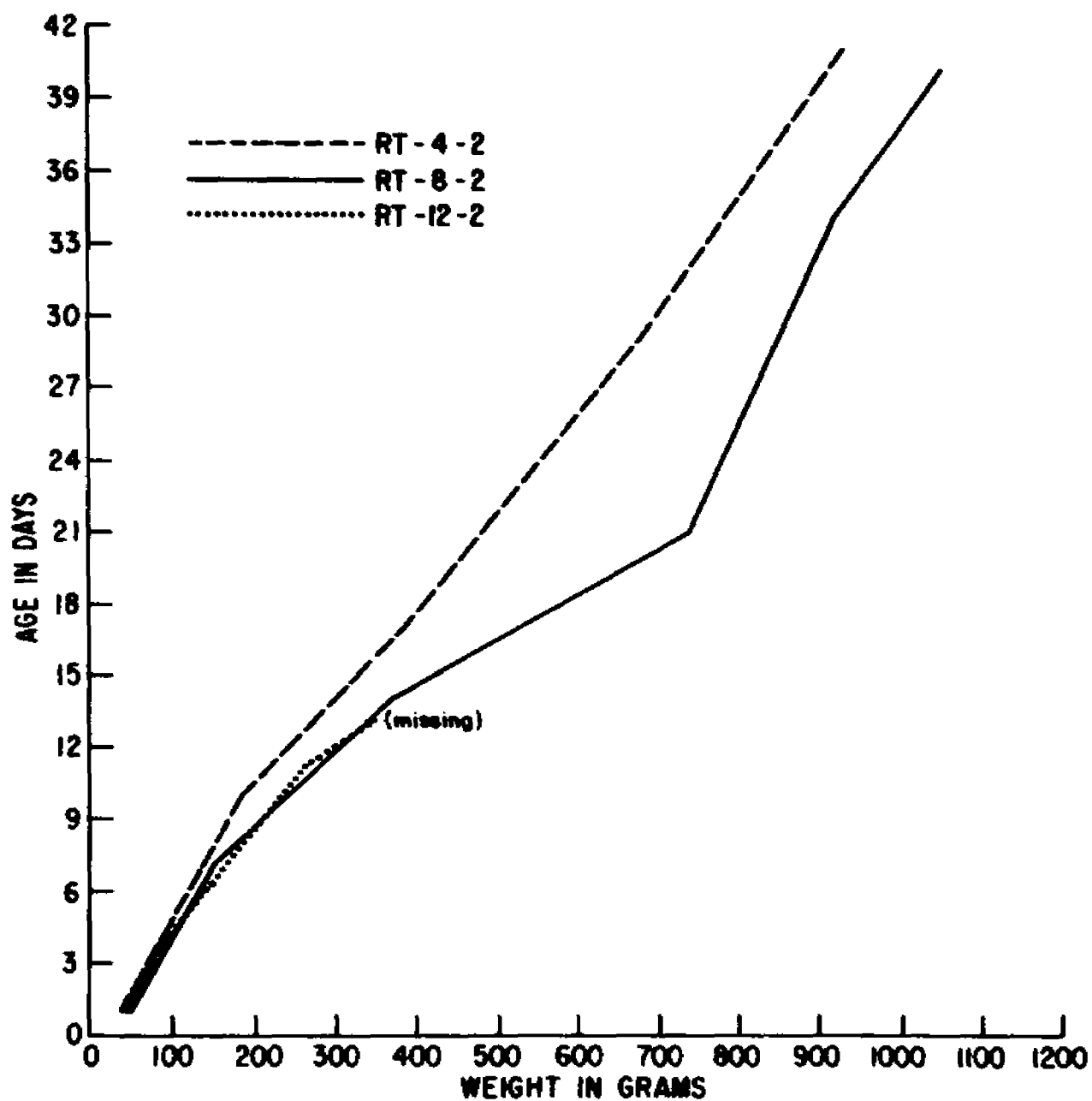


Figure 11. Growth of three known age nestling red-tailed hawks, Alaledon Township, Ingham County, Michigan, 1971.

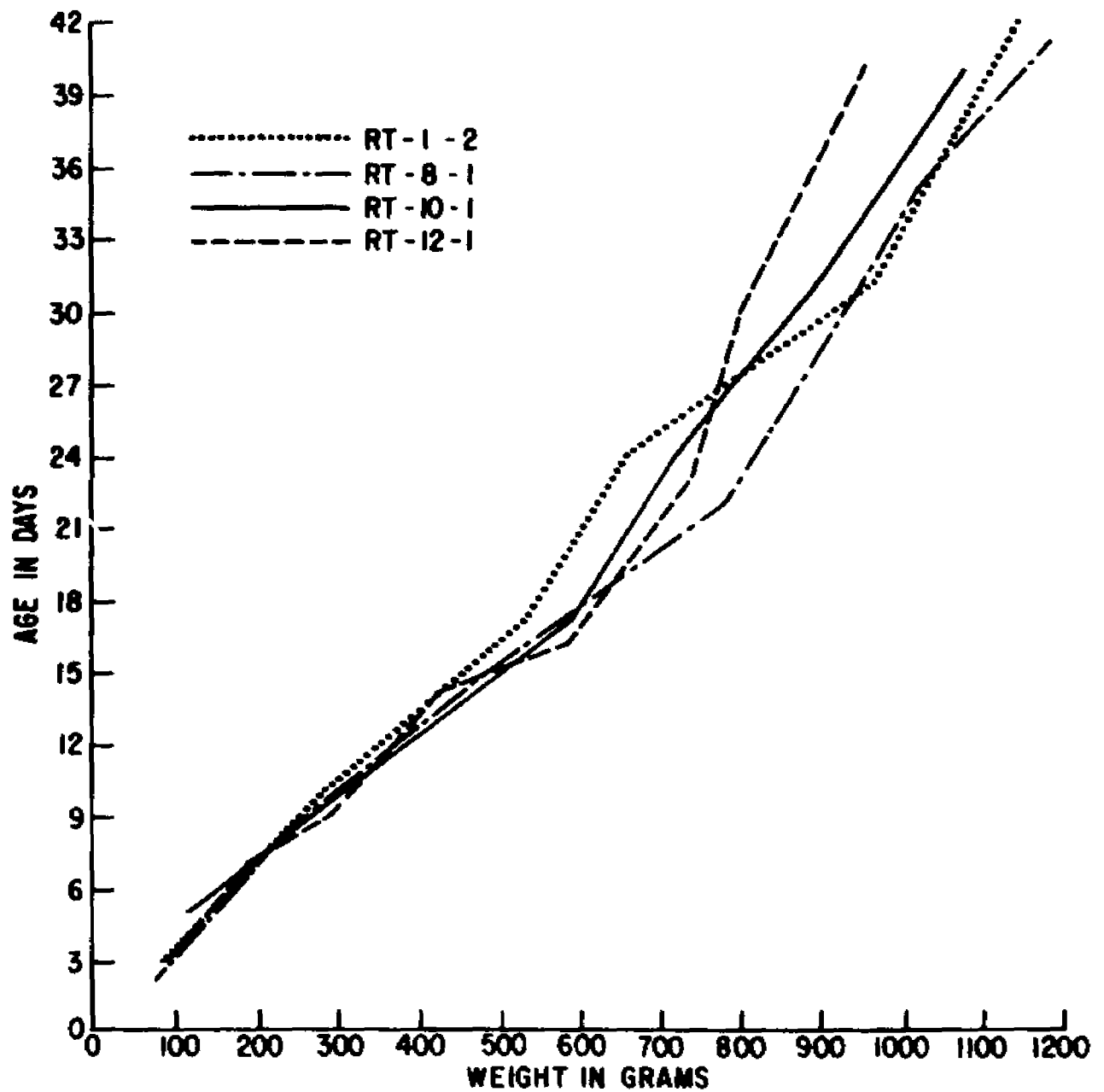


Figure 12. Growth of four nestling red-tailed hawks which survived through fledging, Alaieton Township, Ingham County, Michigan, 1971.

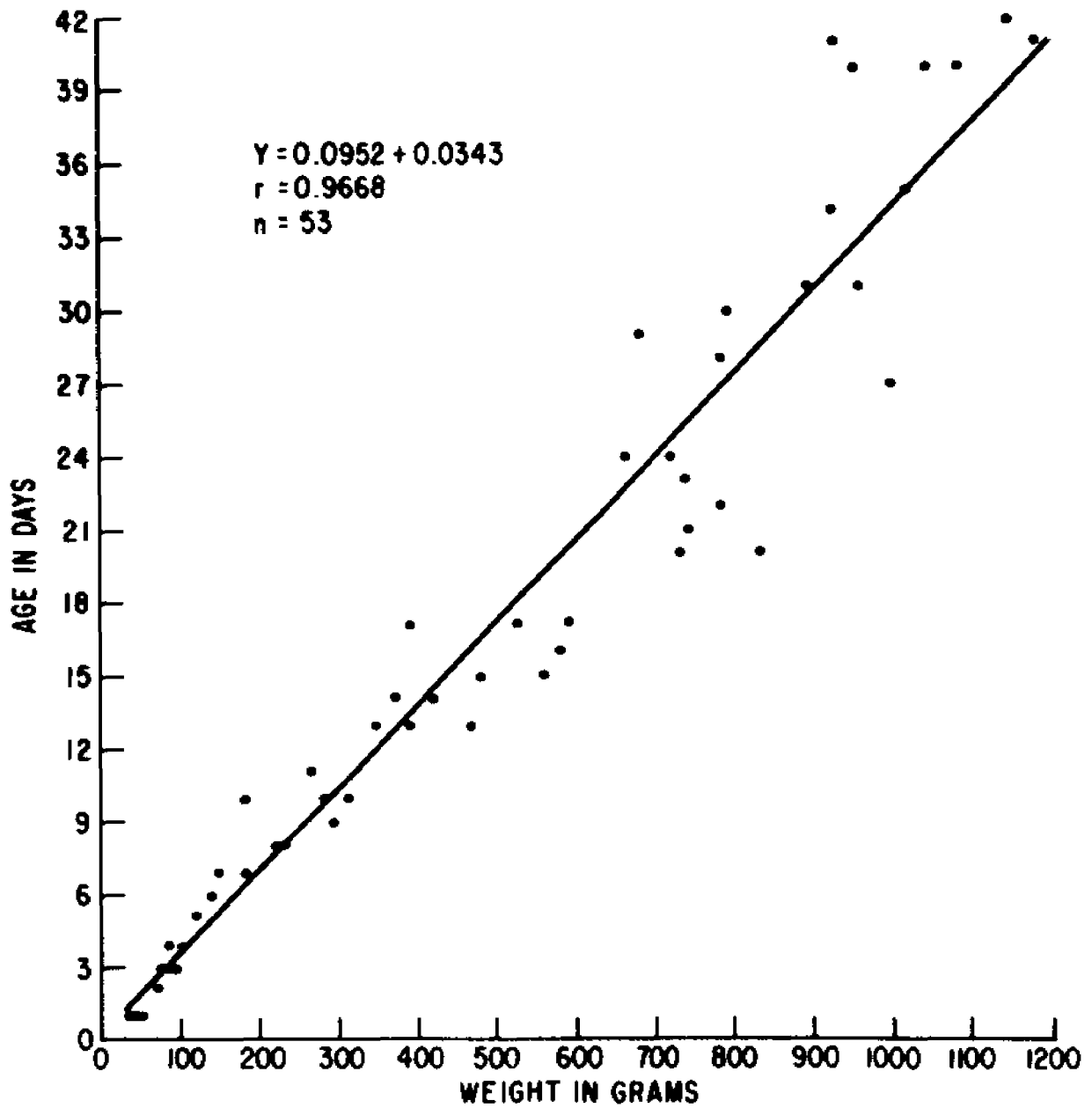


Figure 13. The linear regression of the age of ten nestling red-tailed hawks on body weights, Alaiodon Township, Ingham County, Michigan, 1971.

Table 16. Prey remains found on 32 visits to five red-tailed hawk nests, Alaiedon Township, Ingham County, Michigan, 1971.

Prey	Numbers identified	Percent occurrence
Mammals		
Meadow vole (<u>Microtus pennsylvanicus</u>)	5	16
Muskrat (<u>Ondatra zibethica</u>)	2	7
Fox squirrel (<u>Sciurus niger</u>)	2	7
Cottontail rabbit (<u>Sylvilagus floridanus</u>)	2	7
Eastern mole (<u>Scalopus aquaticus</u>)	1	3
Meadow jumping mouse (<u>Zapus hudsonius</u>)	1	3
Thirteen-lined ground squirrel (<u>Spermophilus tridecemlineatus</u>)	1	3
Short-tailed shrew (<u>Blarina brevicauda</u>)	1	3
Birds		
Red-winged blackbird (<u>Agelaius phoeniceus</u>)	3	10
Starling (<u>Sturnus vulgaris</u>)	1	3
Crow (<u>Corvus brachyrhynchos</u>)	1	3
Hairy woodpecker (<u>Dendrocopus villosus</u>)	1	3
Ring-necked pheasant (<u>Phasianus colchicus</u>)	1	3
Green heron (<u>Butorides virescens</u>)	1	3
Reptiles and amphibians		
Garter snake (<u>Thamnophis sirtalis</u>)	4	13
American toad (<u>Bufo americanus</u>)	4	13
Total	31	100

DISCUSSION

Nest Sites

On the farmland of Alaiedon Township, the typical nesting habitat for red-tails seemed to be in or along the edge of mature upland woodlots. The tree species selected for nesting were usually the most common of the dominant trees, namely beech, sugar maple, red oak and white oak. The nest trees were not necessarily the tallest trees in the area, but they did tend to be one of the codominant species forming the woodlot canopy. The small number of nests situated in lone trees outside of the woodlots, even when many of these lone trees were available, indicates the red-tails preference for trees within woodlots. Protection from winds and other severe weather, as well as reducing the conspicuousness of the nests, may be reasons for this apparent preference.

Since 15 percent of the nests were located on woodlot edges, with 70 percent within 40 meters of the edge, red-tails evidently tend to select nest sites on or close to woodlot edges. With such nests, the birds would have an easy approach plus unobstructed views of the surroundings and any approaching dangers. Since interior nests were usually located in areas of reduced tree density, some degree of unobstructed view or approach seemed to be desired even though lone trees were not often selected.

McGahan (1968:4) suggested that nest site preference in golden eagles (Aquila chrysaetos) is influenced by the direction of the sun's

rays. Weston (1969:33) mentioned this also for ferruginous hawks (Buteo regalis). Camenzind (1969:13), however, failed to find any evidence for or against the effect of the sun as a determining factor in nest site selection in golden eagles. Similarly in this study of red-tails, although 40 percent of the nests had a southern exposure, this was not statistically significant from other directional exposures.

The location of occupied dwellings appeared strongly to influence red-tailed nest location. Although the hawks often flew near occupied human residences and sometimes even perched near them, no nests were ever located closer than .37 kilometers; and most of the near sites were shielded from human residences by being situated within or on the opposite side of a woodlot.

Habitat Types

Wide ranges in the percentages of different habitat types surrounding nest sites (Table 4), indicates that, except for avoiding the residential type, the habitat types surrounding the woodlots utilized for nest sites had little influence on the selection of these sites. Also, the similarity between the results of the habitat evaluations in the 72 and 388 ha plots (Table 4) indicates that evaluations of the smaller plots would be sufficient to characterize the habitat types. This would be of importance to any future habitat evaluations.

The five mature upland woodlots originally unused by red-tails were well away from both occupied dwellings and occupied red-tail nests and there were no obvious reasons for their being avoided. The habitat types surrounding these five woodlots were generally similar to those in the plots surrounding known nest sites and did not appear to affect their use by red-tails. In the four years after the habitat studies

were made, three of these five woodlots were utilized by red-tails as nest sites. Given the red-tails apparent proclivity towards changing nest sites, the other two woodlots may be occupied soon.

Nest Use

Early in March, each breeding pair of red-tails would begin constructing a new nest or rebuilding one used previously. Sometimes the previously-used nest had been destroyed by wind or was occupied by great horned owls. Often, however, the hawks constructed a new nest even though the previous year's nest remained intact and empty. The new nest might be only a few trees away or in an entirely different woodlot. There was no apparent reason for or pattern to this behavior. Hagar (1957:266) reported similar behavior in the red-tails on his New York study area. The replacement of a lost member of a pair may have caused some of it, but because individual birds were unmarked the turnover rate among mated pairs could not be determined.

Nests occupied neither by red-tails nor by great horned owls rarely remained intact for more than one year. A certain amount of yearly rebuilding, even the small amount done by great horned owls, seemed to be necessary in order to preserve nests. It is not surprising that nests occupied by red-tails lasted longer than those used by great horned owls. The nests were already at least a year old when first used by great horned owls and these birds do little if any nest repair (Orians and Kuhlman 1956:379).

Because great horned owls are large and aggressive birds and begin nesting a full month before the red-tails (Orians and Kuhlman 1956:379; Craighead and Craighead 1956:208), they probably have their pick of empty red-tail nests. Once they appropriated a nest, they usually

retained use of it until it blew down. Occasionally red-tails and great horned owls alternated their use of nests, but it is probable that even in these situations the owls decided the use.

No difference was found between the success rate of nests used for several years and that of nests used only once. Further, newly constructed nests were no more productive than older nests. Weather, available food supply and nesting experience of the pair may possibly play a more important role in nest success.

Relationship With Other Raptors

Next to the sparrow hawk, the red-tailed hawk is probably the most common diurnal raptor in southern Michigan. The red-tail shares the role of dominant avian predator with the great horned owl, its nocturnal ecological counterpart.

Great Horned Owl

Because of their use of old red-tailed nests, great horned owls are closely related ecologically to red-tails. Orians and Kuhlman (1956:379) reported that 65 percent of the great horned owl nests observed during their study were old red-tail nests. Hagar (1957:266) found 85 percent of his great horned owls in old red-tail nests. Many of the red-tail nests in the present study were later occupied by great horned owls (Figure 14). No evidence of interspecific competition for nests was observed, but because the great horned owl is a large, aggressive bird and nests a full month earlier than the red-tails (Craighead and Craighead 1956:208), it probably has its choice of old red-tail nests.

Because of their early nesting period the great horned owls often nested successfully in nests which red-tails had been forced to abandon

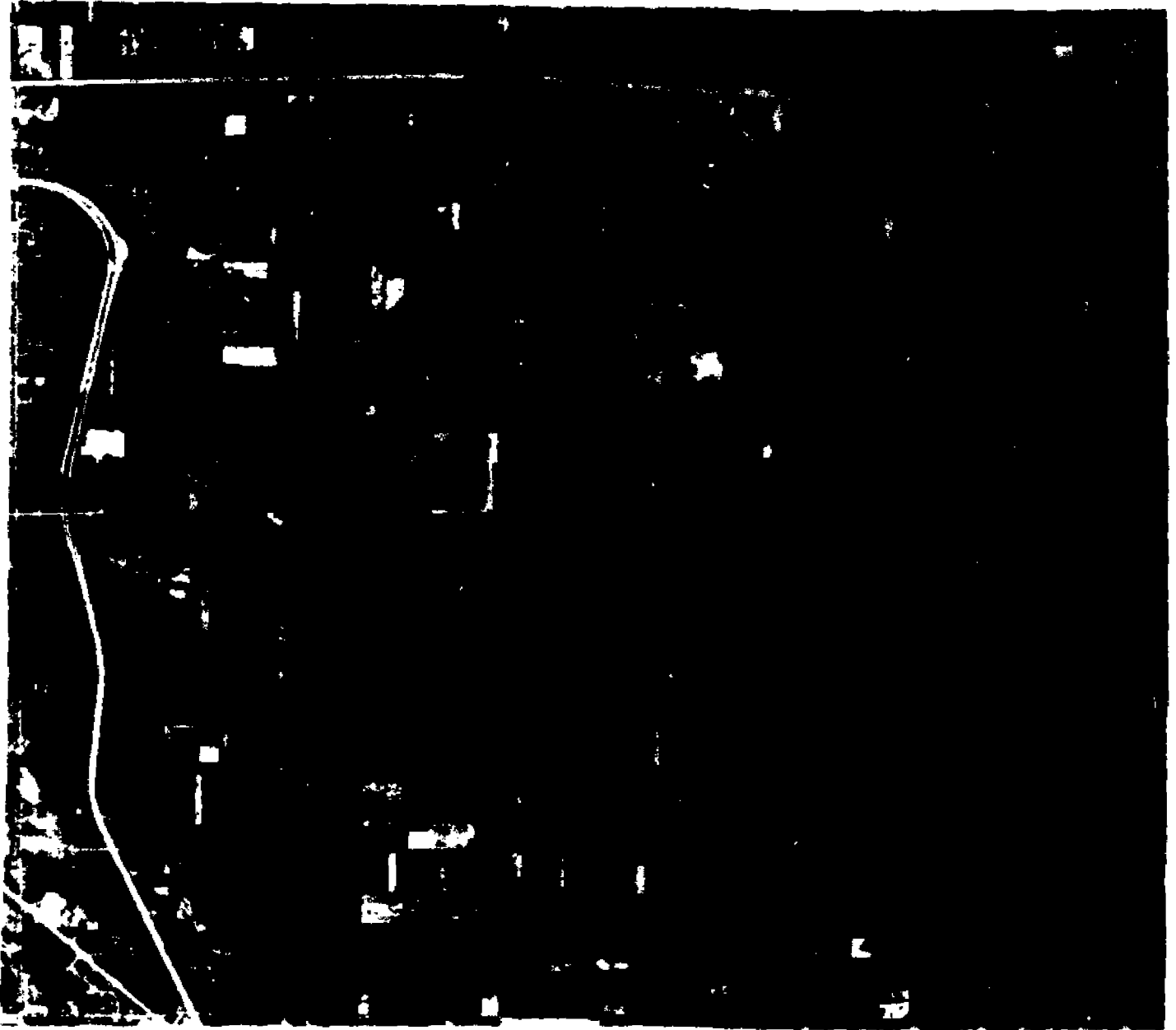


Figure 14. Nest sites of great horned owls using old red-tailed hawk nests, Alaledon Township, Ingham County, Michigan, 1971-1975.

the previous year. Great horned owls are well into their nesting cycle by early April when humans first start spring activities out-of-doors. Red-tails, however, were just beginning their nesting cycle and may not by then have developed a strong attachment to the nest site. Furthermore, red-tails appeared basically to be much more wary and perhaps thus more susceptible to disturbance. While great horned owls often remained on the nest until a climber had nearly reached it, red-tails usually flushed from the nest as soon as the observer entered the woodlot.

Besides their use of red-tail nests, great horned owls also act as predators on red-tails. Craighead and Craighead (1956:208) reported on several red-tailed and red-shouldered hawk nests which were destroyed by great horned owls. Several other investigators (Hamerstrom and Hamerstrom 1951:23; Luttich et al. 1971:82) also have reported great horned owl predation on nestling red-tails. In the present study several nestling red-tails disappeared and, while no definite evidence was found, predation by great horned owls was suspected. Conversely, several researchers (Fitch 1946:229; Orians and Kuhlman 1956:380) have found predation of nestling great horned owls by red-tailed hawks.

Red-shouldered Hawk

The red-tail has not always been the most common buteo in southern Michigan. Barrows (1912:273) reported the red-tail and red-shoulder to be equally abundant. During the early years (1941-1942) of the extensive study of southern Michigan birds of prey by Craighead and Craighead (1956:217), they found the red-shouldered hawk to be far more common than the red-tail. During the late 1940's, however, they noted a trend toward replacement of the red-shouldered by the red-tail.

The non-migratory behavior of the southern Michigan red-tails also appears to be of rather recent origin. In the early 1900's Barrows (1912:373-374) reported that rarely, if ever, was the red-tail found wintering in Michigan, but that the red-shoulder was a common winter species. In the 1940's, however, Craighead and Craighead (1956:217), as reported above, found the red-tail commonly wintering in southern Michigan as did Zimmerman and Van Tyne (1959:13).

The replacement of the red-shoulder by the red-tail appears to be nearly complete today. The red-shouldered hawk is quite scarce in southern Michigan. Only one was seen in the Alameda Township study area (on 3 April 1972) during the entire five years of the study. This replacement, according to the Craigheads (1956:217), probably relates to changes in habitat and to the non-migratory behavior of the red-tail. The reduction in numbers of the red-shouldered hawk occurred simultaneously with the extensive drainage of swamps and lowland forests and the general increase in intensive agriculture which occurred throughout southern Michigan. While such drainage has continued since settlement and statehood in the early 1800's, it has culminated in the continuing trend toward intensive and industrialized agriculture. It is obvious from their present relative status that, as Craighead and Craighead (1956:217) say, the red-tail is better adapted to small woodlots and cultivated land and thus is better suited to withstand the changes in land use occurring in southern Michigan.

Since the red-tail has become a permanent resident, establishing a year-round home range, the Craigheads (1956:217) felt that it has now a decided competitive advantage over the red-shoulder. Each spring when the red-shouldered hawks return, they encounter the already-

established red-tails and, these authors believe, may be forced to occupy less favorable territories.

Rough-legged Hawk

Several rough-legged hawks were observed during winter in Alaiedon Township, but no interspecific competition or interaction between these large buteos and the red-tails was observed. The rough-legs moved out of the township before the red-tail nesting season.

Urbanization And Land Use

Alaiedon Township, because of its proximity to Lansing, Michigan State University and nearby towns, is becoming increasingly urbanized. In the past, land use was primarily agricultural. Today, with the decentralization of the surrounding urban areas, much of this agricultural land is being developed for residential dwellings. The locations as well as the rapidly-increasing numbers of these residential dwellings seems to be having a detrimental effect on nesting red-tails.

While older homes were usually located close to the roads around the periphery of the sections of land, many new homes today are located well back from the main roads, near the centers of these sections, and in or close to the woodlots found there. The thought of having a home in the woods is appealing to many people. Many land developers are constructing access roads and placing whole subdivisions in these interior lands. Not only do these developments destroy many red-tail hunting areas but, more importantly, they disturb the nest sites.

Red-tails did not appear very tolerant of homes near their nests. A home built in or close to a small woodlot (Figure 15) traditionally used by red-tails invariably caused abandonment and/or relocation of the nest site the following year. The usefulness of a woodlot for

red-tail nesting can be lost without physical destruction of that woodlot.

In the study area, several of the mature sugar maple woodlots were utilized as "sugarbushes", that is the trees were tapped for sap to be processed into maple syrup. This intense activity in late winter and early spring eliminated these woodlots as nest sites even though they were undisturbed the remainder of the year. Here again, the usefulness of woodlots to nesting red-tails was lost without actual physical destruction of habitat.

Landowners periodically cut off merchantable timber in their woodlots, however, and may even clear small woodlots to increase the area of tillable land. The destruction of a rather large amount of wooded land also resulted, in one instance, from the expansion of a large sod farm (Figure 16). The demand for lawn and golf course turf is a further reflection of our urbanizing society which results in a loss of nesting habitat.

Nesting Density

The mean nesting density for red-tails was identical to that reported in Wisconsin by Orians and Kuhlman (1956:373) and was similar to densities found elsewhere. In Alberta, the figure was 7.0 square kilometers per pair (Luttich et al. 1971:77); in New York, 5.7 (Hagar 1957:268); in another Wisconsin study, 10.6 (Gates 1972:427); and in a third Wisconsin investigation, 5.7 (Petersen 1972:3). The highest density of all seems to be that found by Fitch et al. (1946:207) where one nesting pair per 1.3 square kilometers occurred in the wooded foothills of Madera County, California.

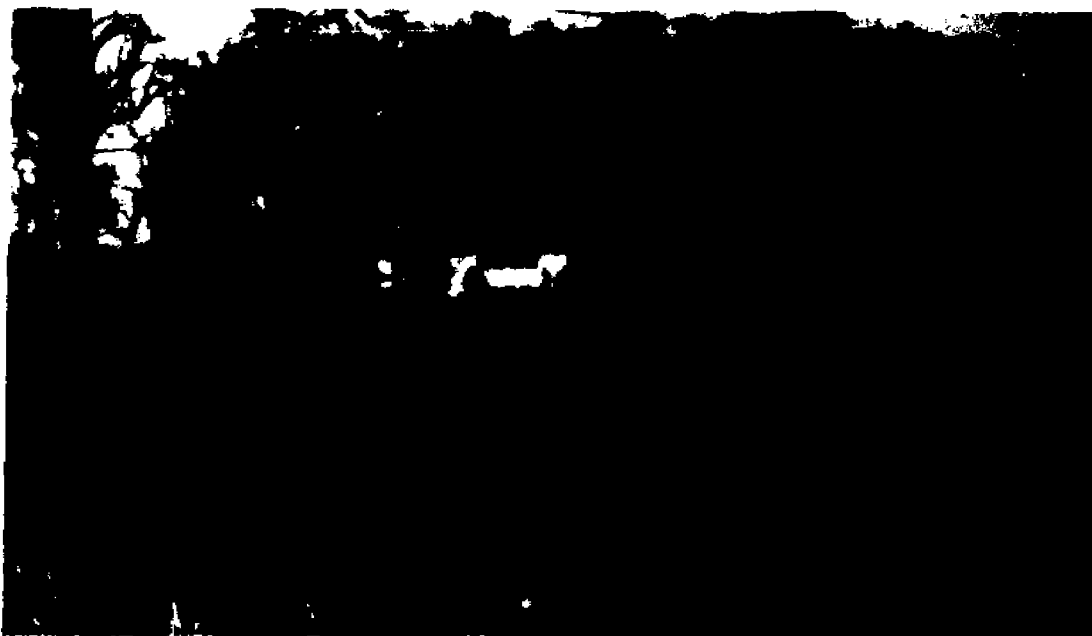


Figure 15. Newly constructed home located within a small woodlot, Alaiedon Township, Ingham County, Michigan, 1975.



Figure 16. Woodlot being cleared for sod farm expansion, Alaiedon Township, Ingham County, Michigan, 1973.

While the mean distance between occupied red-tail nests in Alaiedon Township was 1.96 kilometers (Table 12), distances ranged from as little as 0.56 to as great as 4.09 kilometers. Seidensticker and Reynolds (1971:409) reported a mean of 3.37 kilometers in Montana, with nests as close as 0.52 kilometers. Wiley (1975:134) reported a mean distance between nests of only 0.84 kilometers in California, with two nests being just 150 meters apart. These studies show that, at least within regional populations, nesting red-tails have a wide range of intraspecific tolerance. This may depend upon the aggressiveness of individual pairs, the available food supply, and the topography.

While Wood (1951:109) reported that only a few red-tails winter in the southern counties of Michigan, Craighead and Craighead (1956:41) stated that they commonly winter there. Many nesting pairs of red-tails in Alaiedon Township seemed to be year-round residents. Areas of known winter use were often found to contain nest sites the following spring.

Reproduction

While 47 percent of the nests failed during the three years of study, this is not out of line with other studies. Orians and Kuhlman (1956:374) found 26 percent in Wisconsin, Luttich et al. (1971:80) observed 26 percent in Alberta, Gates (1972:428) noted 35 percent in Wisconsin, Hagar (1957:271) determined 40 percent in New York, and Fitch et al. (1946:217) calculated 46 percent in California.

The 1.4 mean number of young fledged per successful nest was identical to the rate found in Alberta (Luttich et al. 1971:81), but considerably below that in other studies. In Wisconsin, Orians and Kuhlman (1956:374) reported 1.9 young per successful nest while Gates

(1972:428) reported 1.8. In New York, the mean was 1.9 (Hagar 1957:270), in Montana 1.7 (Seidensticker and Reynolds 1971:412), and in California 1.6 (Wiley 1975:135).

Complete reproductive data were gathered in Alaiedon Township in 1971 only. While it was insufficient for the drawing of definite conclusions, some possible reasons for the low rate of fledging perhaps can be interpreted (Table 14). If the normal clutch size of red-tailed hawks in Michigan is two (Bent 1937:153), then the 20 eggs laid by the 13 nesting pairs in Alaiedon Township was 6 below the expected number. Only 13 of the eggs hatched. Since none was found unhatched in the nest, it appeared that nest abandonment preceded or followed by egg predation was the major cause of loss. Thus, the two young per pair reproductive potential had already been reduced by 50 percent before the young even hatched. With the 38 percent loss of nestlings between hatching and fledging, the overall loss was 69 percent of the reproductive potential prior to fledging.

The overall recruitment rate of 0.75 young fledged per nesting pair in Alaiedon Township is well below the 1.35 rate which Henny and Wight (1972:245) concluded was necessary to maintain a stable population in North America north of 42° latitude. Their 1.35 recruitment rate, however, was based on an estimated 62 percent first-year mortality and a 20 percent second-year mortality and calculations show that only a rather small reduction of 15 percent in these values is required for the population to stabilize with this lower recruitment rate. Also, there exists the possibility that the 1971 and 1972 recruitment rates (0.62 and 0.60, respectively) were atypically low and the true recruitment rate for the Alaiedon Township red-tail population is near-

er the 1.0 rate recorded in 1975. If so, the mortality rates would need to be reduced by only 10 percent to achieve stability. There also exists the possibility of the ingress of breeding-age red-tails into the Alaiedon Township population. This would further bolster the apparently low recruitment rate.

Nestling Mortality

Eight nestlings were observed to have died during the study. The death of one of the eight can be attributed to juvenile cannibalism. The larger of two nestlings (Figure 17) consumed its sibling, leaving only the sternum, a portion of one wing and a nest full of plucked feathers. Juvenile cannibalism has been reported in red-tails (Hagar 1957:270, Petersen 1972:5) and several other raptor species (Heintzelman 1966:307, Ingram 1959:219) but is still a rather-infrequently reported occurrence. Perhaps juvenile cannibalism is more common than is realized.

Four of the eight nestlings simply disappeared. One can only speculate on the cause of their disappearance, but it seems quite possible that some were taken by owls. Great horned owls were common in the area and other studies have reported interspecific predation between them and red-tails (Hamerstrom and Hamerstrom 1951:23, Craighead and Craighead 1956:208). Luttich et al. (1971:82) felt that great horned owls were responsible for nearly all red-tail losses on the Rochester study area. It is possible too, however, that some of the missing nestlings on the Alaiedon area died and were subsequently removed from the nest by the adults.

Myiasis of the ears of nestling hawks is a common occurrence in many areas. Petersen (1975:3) reported that nearly 100 percent of the



Figure 17. Size disparity of sibling red-tailed hawks, May, 1971.

nestling red-tails in his Wisconsin study area were infested with fly maggots. Hamerstrom and Hamerstrom (1954:4) consider it to be a rather common disease of young hawks and not much more serious than measles among human beings, similarly running its course without specific treatment. These maggots seldom cause permanent disabilities or mortalities of their hosts. Infected nestlings are easily recognized. A black, tar-like exudate, the feces of the blood-sucking maggots, encrusts the nestlings' ear openings. The maggots reportedly drop from the nestling prior to its fledging. The flies pupate in the nest debris.

Although nearly all nestlings in the study were infected, no evidence of mortality due to myiasis was found. Apparently here in Michigan, as in other areas, the disease has little or no effect on the nestling red-tails.

Nestling Growth Rates

The growth rates of southern Michigan nestling red-tails (Figure 11 and 12) resemble closely those of the California red-tails studied by Fitch et al. (1946:215) and Sumner (1929:91). The growth rates of nestlings were nearly identical during the first two weeks in all three studies. After that time, the weights of individuals began to differ from each other and by the time of fledging they differed by as much as 300 grams. Since adult female red-tailed hawks weigh about 200 grams more than adult males (Craighead and Craighead 1956:427), the larger birds, weighing 1100 - 1200 grams, may be females and the smaller ones, weighing 900 - 1050 grams, may be males.

This sexual dimorphism limits the usefulness of calculating the regression of nestling red-tail weights against age (Figure 13).

During the first seven days, age can be determined quite accurately. Even up to fourteen days, there is reasonable accuracy. After that, however, the weights allow only the crudest age approximations. The discovery of a method to readily sex nestling red-tails might enable the establishment of separate growth curves and consequent weight determinations.

Food Habits

The prey items identified in this study undoubtedly represent only a few of the food species utilized by southern Michigan red-tails, yet they do illustrate the diversified diet of these birds. The large size and adaptability of the red-tailed hawk enable it to utilize a wide variety of prey. Orians (1955:9) believes that in time one would likely find at the nest the remains of all small and medium-sized mammals and birds in the locality. The prey items identified in this study (Table 16) resemble closely those found in three earlier food habits studies of southern Michigan red-tails (English 1934:233, Hamerstrom and Hamerstrom 1951:24, Craighead and Craighead 1956:276-277). They also are generally the same as those found in other red-tail food habit studies (Errington 1933:26-27, Fitch et al. 1946:222-223, Orians and Kuhlman 1956:376, Meslow and Keith 1966:99, Luttich et al. 1970:196-197, Gates 1972:430).

Nearly all these studies have revealed a high incidence of mammalian prey in the red-tail diet. Most have found birds to be an important component also. Several studies, in fact, (Orians and Kuhlman 1956:376, Gates 1972:429) have found birds, namely pheasants, to be the most common prey items. Both of these studies, however, were in areas of comparatively high pheasant abundance and may only reflect the red-

tail's ability to exploit the available prey in an area.

Fitch et al. (1946:222) reported that adult red-tails sometimes remove unused prey items from the nest site and English (1934:232) observed that smaller animals, particularly mice, were often eaten without leaving a trace. Thus, small mammals and passerine or other small birds are probably somewhat under-represented among prey remains at the nest.

Even though the prey remains found (Table 16) were gathered over the entire six week period between hatching and fledging, nearly all were found during the first three weeks. Apparently during the last three weeks, when the young are large and growing rapidly, prey items are consumed almost as soon as they are brought to the nest. This may further bias analyses of prey items toward the larger species.

CONCLUSIONS AND RECOMMENDATIONS

The typical nest site of the red-tailed hawk in southern Michigan appeared to be the upper half of large deciduous trees, usually beech, maple or oak, in or along the edge of a mature upland woodlot well-removed from occupied dwellings and not subjected to human disturbance. The vegetative habitats surrounding a nest site were mainly open types but, if there were different values between them, they were not evident. Nests occurred with equal frequency in woodlots surrounded by croplands and in those encircled by fallow fields. Since many of the factors of the vegetative habitat studied here did not appear to play an important role in nest site selection, further investigations might be made of the role of prey availability.

Nesting success had no relation to whether or not a nest had been occupied the previous-year. Nests were abandoned and new nests were constructed for no apparent reasons and with no discernable pattern. It is possible that replacement of the lost member of a pair influences this but in this study individual birds were unmarked and the mortality rates and stability of mated pairs are unknown. Further studies with marked birds would provide useful information on this behavior as well as on the ingress of breeding-age birds into the local population. The low recruitment rate of 0.75 young fledged per pair evidently resulted from both a high rate of nest failure and a low number of young fledged per successful nest. Studies of reproductive success in the Alameda Township red-tail population should be continued for several more years

to determine whether the rates over a longer period of years and to see if the 1971 and 1972 rates were unusually low.

Increasing urbanization is considered to be a major threat to the red-tail population in southern Michigan. As cities and towns expand into rural areas, woods are cut and new homes are constructed in or along many of the remaining woodlots. The resulting reduction in nesting habitat together with the increased disturbance by humans evidently will cause a reduction in nesting red-tails -- at least in townships which are urbanizing as rapidly as Alameda. Increasing urbanization is probably impossible to limit effectively and it must be expected that when it occurs red-tails and other species dependent upon woodlots and a minimum of disturbance will suffer drastic declines. Unless present trends change or new behavioral adaptations become established, some species may even be extirpated as reproductive populations over much of southern Michigan.

The great horned owl was a common and apparently thriving species on the study area. It appeared to be relatively compatible with the red-tail and well-adapted to present land use patterns. If urbanization continues, however, it can be expected to suffer the same fate as the red-tail and to decline over much of its present range in southern Michigan.

Only one transitory red-shouldered hawk was seen in the township during the five-year study. The red-shoulder, which once was very common in southern Michigan (Craighead and Craighead 1956:217) appears now to be completely replaced by the red-tail. The red-shoulder is now low in numbers and reproducing poorly throughout the northern states. Especially in view of the changing environment, there is no reason to believe that this species will again become common in southern Michigan.

SUMMARY

Habitat analyses were conducted around 45 red-tailed hawk nests in southern Michigan in an effort to determine the habitat factors which influence nest site selection. Population density, reproductive success, and nestling growth rates and food habits data also were collected.

Nests were situated in a variety of deciduous trees, but beech and sugar maple were the most common. Nest heights varied from 10.4 to 25.0 meters, with a mean of 17.2 ± 3.2 . Nest trees were large, averaging 23.6 ± 3.3 meters tall and 52.3 ± 15.0 cm in diameter at breast height, but they were not always the tallest tree in the area. The preferred nesting habitat seemed to be in or along the edge of mature upland woodlots. Ninety-four percent of the nests were situated in such woodlots.

The location of occupied dwellings appeared strongly to influence nest location. Nests were never located closer than 0.37 kilometers to an occupied dwelling.

In general, red-tailed hawk nests in southern Michigan are found in mature deciduous trees, usually beech, maple or oak, in or along the edge of mature upland woodlots which are well removed from occupied dwellings and not subjected to excessive human disturbance during the nesting period.

The physical destruction of woodlots, the growing number of resi-

dential dwellings, and increased human activities are all detrimental to red-tails. This increasing urbanization is considered a major threat to the red-tail population in southern Michigan.

Surrounding habitat types appeared to play little, if any, role in nest site selection. Nests occurred with equal frequency in woodlots surrounded by croplands and in those encircled by fallow fields.

While the destruction of a nest by wind or its use by great horned owls forced the hawks to construct a new one, they were often constructed for no apparent reason. Whether nests were old or new had no apparent relationship on nesting success.

Nesting densities varied from one pair per 6.2 square kilometers to one pair per 9.3 square kilometers, with a five-year mean of one pair per 7.2 square kilometers.

The number of young fledged per successful nest varied from 1.1 to 1.6, with a five year mean of 1.4. The overall recruitment rate was 0.75 young fledged per nesting pair. Both a high rate of nest failure and a low rate of young fledged from successful nests seem to be involved.

Sexual dimorphism and the inability to sex nestlings precluded the use of weight to age nestling red-tailed hawks beyond about fourteen days of age.

Remnants of 31 prey items, representing 16 different species were found in 5 red-tailed hawk nests. Mammals constituted 48 percent, birds 26 percent, reptiles 13 percent, and amphibians 13 percent of these food items. While they undoubtedly represent only a few of the prey species utilized by southern Michigan red-tailed hawks, they do illustrate the diversified diet of these birds.

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