RED-TAILED HAWK POPULATIONS AND ECOLOGY IN EAST-CENTRAL WISCONSIN

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THIS paper reports on a study of Red-tailed Hawk (*Buteo jamaicensis*) populations, reproductive success, and food habits in relation to Ring-necked Pheasants (*Phasianus colchicus*) in east-central Wisconsin. Information on the Redtail and other species of raptors was gathered as one phase of a population study of pheasants, concerned in part with pheasant mortality and with the possible influence of Red-tailed Hawk predation on pheasant survival (Gates, 1971). Although the Redtail is one of the most common birds of prey occupying the farmlands of the Midwest, comparatively few studies of its ecology have been published. In view of the alarming decline in population exhibited by many falconiformes in recent years, particularly in relation to biocides (Hickey, 1969), information on reproductive success and population density for all birds of prey is urgently needed as a reference point from which future population trends can be evaluated. Although Hickey (1969) still regards the Redtail as having normal reproductive success, Seidensticker and Reynolds (1971) have more recently uncovered evidence of post-DDT eggshell thinning in this species in Montana.

STUDY AREA

Observations of raptor ecology were made from December, 1959, to August, 1965, on the Waupun Study Area, a 42-square-mile tract in southwestern Fond du Lac County and adjacent parts of Green Lake and Dodge counties, Wisconsin (latitude 43° 45′ N; longitude 88° 53′ W). The topography of the area is level to gently undulating, with 78 per cent of the landscape under cultivation. Dairy farming is the principal farm enterprise; major crops include corn, oats, and hay. Twenty-two per cent of the land area is uncultivated, consisting largely of wetlands (10 per cent) and permanent pasture (7 per cent). Only 0.3 per cent of the area is covered by closed-canopy woodlots, predominantly bur oak (*Quercus macrocarpa*) and black oak (*Q. velutina*). Small groves of these species also occur in many pastures and on wetland edges. Most of the woodlots, and about half of the wetlands, are used to some extent for grazing. The most prevalent forms of wetland vegetation include sedge meadow (principally *Carex stricta*), canary grass (*Phalaris arundinacea*), and shrub swamps, the latter dominated by willow (*Salix* spp.) and dogwood (*Cornus stolonifera*; *C. Purpusi*).

In the winter of 1958–59 (December through March), observations were also made on the Springvale Study Area (15 square miles), approximately 3 miles northeast of the area described above. Except for greater abundance of woodlots on the Springvale Area (6 per cent), landscape features and cover composition were generally similar between the two.

To the best of my knowledge, use of insecticides during the period of study was light. I knew of only two crops that received regular foliar treatment—sweet corn (DDT) in late summer for control of corn earworm and peas (Parathion) in early summer for control

of pea aphids. Collectively, these crops constituted about 12 per cent of the land area, but treatment was not applied to the total acreage in any one season and was highly variable between years. Dicke (1960), quoted by Hickey (1961), reported that only 12 and 7 per cent, respectively, of the statewide acreage of these crops was treated in 1959. These figures fall well in line with my subjective evaluation of the intensity of insecticide use during the study, suggesting that Redtails at Waupun probably were not being heavily contaminated by insecticides through the local food chain. Furthermore, since it appeared that the adult segment of the population was to large extent non-migratory, I also doubt that breeding birds were carrying high levels of pesticide residues accumulated elsewhere. Unfortunately, no egg or tissue analyses were available to support these conjectures, however.

METHODS

On the Springvale Area in February, 1959, Red-tailed Hawk and Rough-legged Hawk (*Buteo lagopus*) populations were determined by direct search. On the Waupun Area in subsequent years, winter populations of these species were estimated by the car-count method (Craighead and Craighead, 1956). A 45-mile transect was driven by two observers on two or three closely spaced afternoons between mid-January and mid-February. Counts were made on snow-covered ground, with wind velocities below 10 mph, and temperatures above 0° F. All Redtails and Roughlegs observed on the ground, perched, or in flight within ¼ mile of the transect were recorded, giving approximately 50-per cent coverage of the study area. The number of each species observed on successive runs was averaged and doubled as an estimate of mid-winter population size. Because of the area's open terrain, near-level topography, and scarcity of large woodlots, this method probably gave a reliable estimation of winter buteo numbers. The main criticism of the method was the small number of censuses run. Successive counts for individual winters showed an average variability of 41 per cent. Because each winter's population estimate was accordingly subject to considerable sampling error, attention in this paper is largely confined to the mean level of population for all winters of study combined.

Winter population data for other birds of prey were obtained from a daily log of all raptors sighted, from which the number of individuals was later inferred from the distribution of sight records. Snowy Owls (*Nyctea scandiaca*) were so conspicuous that a complete inventory of this species was doubtless obtained. Cooper's Hawks (*Accipiter cooperii*) and Horned Owls (*Bubo virginianus*), by comparison, were more secretive, and estimates for these species were necessarily regarded as minimum figures.

The breeding population of Red-tailed Hawks was determined over the 3-year period 1962–64 by systematic coverage of the Waupun Study Area for active raptor nests. Search was conducted during late March and early April, either on foot or by scanning for potential nest sites through binoculars and spotting scopes. Nests tended to be highly conspicuous at this season, and I believe that a complete census of breeding pairs was obtained. No estimate was made of the number of non-breeding Redtails on the area.

Redtail nests were periodically checked between the time of nest discovery and the time the young were fledged. After initially determining that eggs had been laid, no nest trees were climbed until the young were hatched. Prey remains were identified at each nest visit.

WINTER POPULATIONS

Red-tailed Hawks.—The estimated winter population of Redtails at Waupun varied from a high of 21 individuals in 1961–62 to a low of 9 in 1964–65

TABLE 1

ESTIMATES OF MIDWINTER RAPTOR POPULATION DENSITY ON TWO STUDY AREAS IN EAST-CENTRAL WISCONSIN[a]

Winter	Study area[b]	Red-tailed Hawk	Rough-legged Hawk	Cooper's Hawk	Snowy Owl	Horned Owl
1958–59	Springvale	14	8	4	0	6
1959–60	Waupun (2)[c]	19	21	–	–	–
1961–62	Waupun (2)	21	5	3	4	4
1962–63	Waupun (3)	17	28	2	2	5
1963–64	Waupun (3)	16	13	2	2	3
1964–65	Waupun (2)	9	13	3	3	4

[a] No raptor-census data available in 1960–61.
[b] Springvale Study Area 15 square miles in size; Waupun Study Area 42 square miles.
[c] Figures in parentheses represent the number of car-count census runs from which Red-tailed and Rough-legged Hawk population estimates were derived.

(Table 1). The number of winter residents showed comparatively little fluctuation between 1959 and 1964, during which period the average winter density was 0.44 per square mile. On the Springvale Area, 14 Redtails were censused in 1958–59, a density of 0.93 per square mile. Because of its larger size and longer period of study, the Waupun Area probably furnished more representative information on the density of wintering Redtails for the region. These data show an average winter population of 0.39 per square mile based on five seasons of field study.

In February, 1962, an immature Redtail was found dead where it apparently had been struck and killed by a motor vehicle while feeding on the remains of a road-killed cottontail rabbit (*Sylvilagus floridanus*). Aside from this single individual, all winter observations of Redtails in this study consisted of adult (= red-tailed) birds. Orians and Kuhlman (1956) reported much greater frequency of immatures wintering in Green County, Wisconsin. Fourteen per cent of the Redtails they encountered consisted of immature individuals as a 2-year mean. (Green County is located approximately 80 miles south-southwest of the Waupun Study Area.)

In general, I believe that most of the wintering Redtails at Waupun were mated pairs that eventually bred on the area. Two lines of evidence suggested that the majority were permanent residents. (1) The population of breeding Redtails for the period 1962–64 (Table 2) was only eight birds greater (62 versus 54) than the corresponding population totals of the preceding winters (Table 1). (2) In February and March of 1962 and 1963, seven Redtail pairs were maintained under near-daily surveillance. After mid-February in both years, each of these pairs was observed with increasing frequency in the vicinity of old nest trees that were eventually occupied. Five of the seven

TABLE 2

SUMMARY OF RED-TAILED HAWK BREEDING POPULATIONS AND REPRODUCTIVE PERFORMANCE, WAUPUN STUDY AREA

Year	Number of active nests	Number of successful nests	Total number of young fledged	Young fledged per successful nest	Young fledged per nesting attempt
1962	9	7 (78)[a]	13	1.9	1.4
1963	10	7 (70)	11	1.6	1.1
1964	12	6 (50)	11	1.8	0.9
Totals and means	31	20 (65)	35	1.8	1.1

[a] Figures in parentheses represent the percentage of total active nests.

were observed one or more times at the nest site proper, and two were also seen carrying nesting materials. No influx of migrant Redtails or other raptors was noted during the period of these observations.

In California, Fitch et al. (1946) similarly reported that Redtail pairs were permanently resident in definite hunting and nesting territories. Orians and Kuhlman (1956), in Wisconsin, reported that resident birds were on territory by the end of February; however, some migrants were also present that traveled singly or in groups. In central Iowa, Weller (1964) most commonly observed wintering Redtails in areas in which active nests were later located.

The winter density of Redtails in Green County, Wisconsin, averaged 0.46 per square mile in 1953–54 and 1954–55 (Orians and Kuhlman, 1956). On a study area in Columbia and Dane counties, Wisconsin, the 3-year mean density was 0.76 per square mile (Kabat and Thompson, 1963). All three Wisconsin study areas on which winter Redtail censuses have been conducted are located in roughly the southeastern quarter of the state. Available evidence suggests that Redtails regularly winter in this region at densities approaching, and locally exceeding, 0.50 per square mile. This compares with 0.37 per square mile as the three-winter mean density observed by Craighead and Craighead (1956) in southern Michigan.

Other raptors.—Midwinter population estimates of Rough-legged Hawks tended to be highly variable (Table 1). Comparatively small numbers of these hawks were observed during the two winters of heaviest snowfall, 1958–59 and 1961–62. Since the Roughleg's winter diet consists almost exclusively of small mammals (Bent, 1937; Craighead and Craighead, 1956; and Weller, 1964), lower vulnerability of small-mammal prey with heavier snow cover probably encouraged a higher percentage of these migrants to continue southward. In both winters, my recollection is that larger numbers of Roughlegs were present in early winter before build-up of heavy snow cover.

The minimum density of Cooper's Hawks and Horned Owls at Waupun was 0.06 and 0.10 per square mile, respectively, as a 4-winter mean (Table 1). On the Springvale Area in 1958–59, densities were 0.27 and 0.40 per square mile. These differences in population level doubtless stemmed from the greater abundance of wooded habitat on the Springvale Area.

Snowy Owls were present at Waupun each winter that an attempt was made to estimate their numbers (Table 1). Occurrence of these owls over the short period of study demonstrated no evidence of periodicity. Other birds of prey observed in winter included one Sparrow Hawk (*Falco sparverius*) in 1962–63 and one Barred Owl (*Strix varia*) in 1963–64. Screech Owls (*Otus asio*) were present in unknown numbers each winter of study. Short-eared Owls (*Asio flammeus*) were found in several day-roosting concentrations as large as 15 or 20 birds throughout the open winters of 1960–61 and 1963–64; however, no more than five Shortears were believed present during any other season of study.

Collectively, the average density of large raptors (Red-tailed Hawks, Rough-legged Hawks, Cooper's Hawks, Horned Owls, and Snowy Owls) in this study was slightly less than 1.0 per square mile.

OBSERVATIONS ON WINTER ECOLOGY

Intraspecific interactions.—I observed no overt sign of intraspecific intolerance between wintering Redtails; however, it was my definite impression that the hunting ranges of individual pairs tended to be mutually exclusive. Out of 41 birds encountered on winter car counts, 24 (58 per cent) were sighted no more than 0.50 mile apart. This seemed to imply a high degree of aggregation in winter Redtail distribution, which could be explained by a tendency for pairs to share home ranges that did not overlap those of other pairs.

One series of observations was particularly instructive on this point. In mid-February of 1962, at which time over 2 feet of snow blanketed the area and small-mammal prey were virtually invulnerable to avian predation, one pair of Redtails over an 11-day span killed at least eight hen pheasants out of a flock of 85–100 wintering birds. These pheasants were particularly vulnerable to predation, since they were concentrated around a bait-trapping station in a 0.15-acre grove of willow brush adjacent to several black willow (*Salix nigra*) trees that made ideal hunting perches. It ultimately became necessary to remove these hawks to continue pheasant trapping at the site, and on 17 February both members of the pair were trapped and dispatched. Three days later, a single Redtail was perched at the site, and on 23 February it too was captured and removed from the area. On 27 February, another pair of Redtails appeared on the scene, whereupon pheasant trapping was suspended. I was able to recognize one member of this second pair by conspicuous plumage variation. Earlier in winter, this individual had been consistently

observed on a hunting range which centered approximately 1.7 miles northeast. At least in this particular instance, it seemed clear that removal of the original pair created a vacant hunting range that contained an attractive and highly vulnerable food source, and that this vacuum was almost immediately filled by individuals that were previously excluded from the site.

Interaction with pheasants.—Well before the conclusion of this study, I came to regard the Red-tailed Hawk as a skilled and highly capable pheasant predator. Out of 165 preyed-upon pheasants encountered in winter, 99 (61 per cent) were attributed to birds of prey. Of the 99, 50 were further assignable to individual species of raptor according to field sign described by Einarsen (1956) or from actual observations made at the kill site: Redtails 28, Horned Owls 11, Cooper's Hawks 9, and Roughlegs 2. At face value, these records suggested that Red-tailed Hawks were responsible for 55 per cent of all pheasants killed by avian predators and for 34 per cent of the overall winter predation loss. Twenty-one of the 28 Redtail records consisted of actual flushes from freshly made kills; in addition, I observed 2 successful and 17 unsuccessful attempts by Redtails on pheasants. From these observations, I believe that pheasants were an important component of the Redtail's winter diet, even though the actual percentage they comprised was not established through systematic food-habits investigation.

During the period 1959–65, winter (early January through late March) mortality of Ring-necked Pheasant hens at Waupun averaged 27 per cent. Predation accounted for 74 per cent of the winter loss (Gates, 1971), hence the kill by Redtails could be estimated at 7 per cent of the January pheasant population.

It is conceivable that this percentage was a somewhat inflated estimate. Because birds of prey generally do not cache prey remains, I believe that field evidence of avian predation tended to be more conspicuous than mammalian predation, probably leading to an over-estimate of the proportionate pheasant kill by raptors in general and Redtails in particular. Notwithstanding, I conclude that Red-tailed Hawks did in fact remove a substantial percentage of the hen pheasants at Waupun during the winter period.

The overall predation rate on pheasants, and I believe the Redtail rate individually, was highly variable between winters. During two winters of heavy snow cover (1958–59 and 1961–62), predation losses were calculated at 29 and 33 per cent, respectively, of the January population. Corresponding figures during two winters of virtually snowless conditions (1960–61 and 1963–64) were 2 and 17 per cent, respectively, and during three winters of intermediate snowfall (1959–60, 1962–63, and 1964–65) 13, 18, and 21 per cent, respectively (Gates, 1971). Of the 28 pheasant kills attributable to Redtails, 18 were recorded in 1958–59 and 1961–62.

During these particular winters, snow depths of 10 to 30 inches prevailed for at least a 70-day span between 1 January and 31 March. Pheasants during these periods were hard pressed for winter food and shelter, and virtually the entire population was concentrated at only 14 sites on the study area that still afforded protective cover. With small mammals well sheltered under the heavy snow canopy, it was clear that Redtails were taking full advantage of the increase in pheasant vulnerability. In February of 1962, for example, 13 out of 18 Redtails observed on winter car counts were sighted on hunting perches or in flight in the immediate vicinity of a pheasant concentration site. Although I could not measure the impact of Redtail predation on pheasants by individual winter of study, I conclude that it was highly variable between years, and that higher rates of pheasant loss resulted from a shift in food habits and hunting behavior as the small-mammal portion of the prey base became increasingly invulnerable with deeper snow cover.

Recent studies have characterized the Redtail as a versatile and highly adaptable predator, one capable of exploiting a wide variety of prey species (Craighead and Craighead, 1956; Orians and Kuhlman, 1956; and Luttich et al., 1970). For this reason, it doubtless enjoys considerable flexibility in adjustment of food habits to changes in prey vulnerability, at least in comparison with the more specialized feeders, e.g., the Rough-legged Hawk, which appears to be primarily a small-mammal specialist. The Redtail's ability to switch over to larger prey, including pheasants, during periods of heavy snow may be an important factor in this species' ability to successfully winter year after year in regions as far north as Waupun.

BREEDING POPULATIONS

Red-tailed Hawk.—The average number of active Redtail nests at Waupun during the breeding seasons of 1962–64 was 10.3, equivalent to one pair per 4.1 square miles or 0.54 breeding adults per square mile per year (Table 2). This was regarded as a minimum density, however, since no attempt was made to determine the number of non-breeding birds that may have been present. Of the 31 nesting pairs under observation, 30 comprised both adult (= red-tailed) individuals. The single remaining pair consisted of one adult paired with an apparent yearling (= brown-tailed) bird. The sex of the latter individual was unknown.

Breeding densities of the Redtail at Waupun were generally lower than reported elsewhere. In California (Fitch et al., 1946), New York (Hagar, 1957), Green County, Wisconsin (Orians and Kuhlman, 1956), and Alberta (Luttich et al., 1971), the number of breeding pairs averaged one per 0.5, 2.2, 2.8, and 2.7 square miles, respectively.

Other raptors.—One Horned Owl nest was found in 1963 and 1964; no

nests of this species were found in 1962. Even though search for raptor nests may have been undertaken too late in the year for a complete inventory of Horned Owls, my conclusion was that the breeding density of this species at Waupun was extremely low. A sufficient amount of field work was conducted in February and March each year that I believe that most, if not all, Horned Owl nests would have been discovered before the spring search. Scarcity of woodlots at Waupun seemingly represented poor breeding habitat for this species. Many of the owls present in winter probably were non-breeding individuals.

BREEDING SEASON ECOLOGY

Nest sites.—Nineteen out of 31 Redtail nests under observation were situated in black oaks, five in bur oaks, three each in American elms (*Ulmus americana*) and black willows, and one in quaking aspen (*Populus tremuloides*). Only four of the 31 were located in closed-canopy woodlots. Eighteen occurred in open groves, generally less than one acre in size, and nine were situated in isolated trees along fencelines and ditchbanks. Aside from a single nest in an aspen swamp, all nest trees were located on well-drained upland sites.

Reproductive success.—A nesting attempt was considered successful if at least one young eventually fledged. Of the 31 nests in which eggs were laid in 1962–64, 20 (65 per cent) succeeded (Table 2). The cause of nest failure was known for only six of the 11 unsuccessful nesting attempts. Three were partly dismantled and blown down by high winds in 1964, two were destroyed by unidentified predators, and one failed when one of the adults was shot.

A total of 35 young were fledged from the 20 successful nests, an average of 1.8 young per successful clutch. Seven of the 20 nests produced one fledgling apiece, 11 produced two fledglings, and two produced three fledged young. The rate of fledging success at Waupun compared favorably with populations investigated elsewhere. In southern Wisconsin, the mean was 1.9 young per successful nest (Orians and Kuhlman, 1956); in New York, 1.9 (Hagar, 1957); in Montana, 1.7 (Seidensticker and Reynolds, 1971); and in Alberta, 1.4 (Luttich et al., 1971). I made no attempt to determine clutch size, nor brood size at hatching, for each of the nests under observation, hence information was not available on rates of egg mortality or nestling survival. From the average number of fledged young per successful clutch, however, rates of rearing success at Waupun appeared satisfactory.

The overall rate of reproductive success was 1.1 fledged young per breeding pair. Based on North American productivity and mortality data for the Redtail, Henny and Wight (in press) concluded that between 1.3 and 1.4 young must be raised per nesting attempt to maintain a stationary population. At Waupun, it might therefore be inferred that Redtail productivity was inadequate for population maintenance. If so, the problem seemed to center on

the high rate of nest failure, since rearing success was very near the maximum recorded in the literature. Orians and Kuhlman (1956) reported 1.4 young raised per breeding pair in southern Wisconsin during 1953 and 1954.

Summer food habits.—Nineteen species were represented among the aggregate prey remains identified at seven Redtail nests (Table 3). These seven nests were visited at approximately weekly intervals between hatching and fledging. It is possible, however, that prey remains were collected too infrequently for a completely unbiased sample of summer food habits. Fitch et al. (1946) reported that adult Redtails sometimes remove unused prey items from the nest site, and English (1934) observed that smaller animals, particularly mice, were often eaten without leaving trace. Of the prey species listed in Table 3, I suspect that *Microtus*, passerine birds, and invertebrates were somewhat under-represented in the food-habits sample.

The five leading items of prey, which accounted for 63 per cent of the observed nesting-season diet, consisted of pheasants (23 per cent), *Microtus* (17 per cent), cottontail rabbits (11 per cent), Red-winged Blackbirds (8 per cent), and domestic chicken (5 per cent). Birds constituted 58 per cent of the observed diet by frequency of occurrence, mammals 38 per cent, and invertebrates 5 per cent.

Most other studies have revealed a higher incidence of mammalian prey than I observed in the Redtail's summer diet at Waupun. In Wyoming (Craighead and Craighead, 1956), Alberta (Luttich et al., 1970), and Michigan (Craighead and Craighead, 1956), mammals accounted for 93, 66, and 40 per cent, respectively, of the prey species taken. In southern Wisconsin, 85 per cent of diet reported by Errington (1933) consisted of mammals, among which thirteen-lined ground squirrels, *Microtus*, and cottontail rabbits were most important. The nesting-season prey of a single pair of Redtails observed in Michigan by English (1934) included 76 per cent mammals and 24 per cent birds.

It is interesting to note the close correspondence between Redtail food habits at Waupun and those observed in Green County by Orians and Kuhlman (1956). From evidence at nest sites, pheasants in their study also ranked as the leading item of prey (33 per cent), followed by cottontail rabbits (19 per cent), domestic chicken (14 per cent), crows (6 per cent), and *Microtus* (6 per cent). Sixty-five per cent of the nesting-season diet was made up of birds and 35 per cent of mammals.

To my knowledge, these two studies provide the only available information on Redtail food habits in areas that also represent good pheasant habitat. Green County, at the time of Orians and Kuhlman's investigation, was an area of comparative pheasant abundance by Wisconsin standards, as was the Waupun Area during the course of the present study. Although mammals seem

TABLE 3

FREQUENCY OF OCCURRENCE OF PREY REMAINS COLLECTED AT SEVEN RED-TAILED HAWK NESTS, WAUPUN STUDY AREA, 1963–64

Item	Number identified	Per cent occurrence
Birds		
Ring-necked Pheasant (*Phasianus colchicus*)	40	22.7
Red-winged Blackbird (*Agelaius phoeniceus*)	14	8.0
Domestic Chicken	9	5.1
European Partridge (*Perdix perdix*)	5	2.8
Crow (*Corvus brachyrhynchos*)	5	2.8
Yellow-shafted Flicker (*Colaptes auratus*)	4	2.3
Mourning Dove (*Zenaidura macroura*)	3	1.7
Common Grackle (*Quiscalus quiscula*)	3	1.7
Catbird (*Dumetella carolinensis*)	2	1.1
Blue Jay (*Cyanocitta cristata*)	2	1.1
House Sparrow (*Passer domesticus*)	1	0.5
Unidentified passerine remains	14	8.0
Mammals		
Meadow mouse (*Microtus* spp.)	29	16.5
Cottontail rabbit (*Sylvilagus floridanus*)	19	10.8
Thirteen-lined ground squirrel (*Citellus tridecemlineatus*)	8	4.5
Muskrat (*Ondatra zibethicus*)	4	2.3
Fox squirrel (*Sciurus niger*)	4	2.3
Norway rat (*Rattus norvegicus*)	2	1.1
Invertebrates		
Unidentified beetle remains (*Coleoptera*)	3	1.7
Unidentified crayfish remains (*Astacidae*)	5	2.8
Totals	176	99.8

to predominate in the Redtail's diet over much of its North American range, it is clear that this hawk is capable of exploiting pheasants as a major part of the spring and summer diet when this prey species is available in reasonable numbers.

Interaction with pheasants.—In 1963 and 1964, an attempt was made to determine the rate of predation on pheasants by nesting Redtails. Two procedures were relied upon. First, the number of marked hen pheasants recovered at Redtail nests was compared with the number of marked individuals present on the study area on 1 May. Pheasant marking was accomplished by leg bands and backtags. Pheasants were captured by autumn nightlighting and winter bait trapping, and estimates were made each year of the number of

marked hens surviving on the area on 1 May (Gates, 1971). As an alternative procedure, the total number of hen pheasants identified at Redtail nests, including both marked and unmarked individuals, was compared with the 1 May census total for the study area at large.

In both years of study combined, 13 Redtail nests produced young and were periodically checked for pheasant marks. Twenty-seven sets of leg bands and/or backtags appeared at these sites, 6 per cent of the 443 marked individuals that I estimated to be alive on the area on 1 May. A total of 81 hen pheasants was represented among the aggregate prey remains identified. The 1 May hen population for the area in 1963–64 was 1,863, from which a predation rate of 4 per cent was calculated.

For two reasons, these percentages could not be accepted as unbiased estimates: (1) It is conceivable that backtagged pheasants were more vulnerable to Redtails than unmarked birds, which may have accounted in part for the higher rate of exploitation indicated by the first as compared with the second method. (2) In addition, proof was obtained that some of the pheasant hens whose remains appeared at Redtail nests had originally died or were seriously injured by mortality factors other than hawk predation. Leg bands from one marked hen that I initially found as a freshly made kill at the entrance to an active fox den I later recovered beneath a Redtail nest. Two other backtags were found at Redtail nests which belonged to hayfield-nesting hens that I knew had lost at least one leg as a result of hay-mowing accidents (the identity of these birds was established from leg bands attached to amputated legs at the nest site). The fact that some of the apparent Redtail kills actually represented carrion, and that certain other hens were severely incapacitated before being preyed upon, meant that both methods of calculation probably led to a somewhat exaggerated estimate of the rate of Redtail predation.

On the other hand, these findings applied exclusively to the nestling period when adult Redtails were rearing young. No allowance was possible for pheasants preyed upon outside the nesting season, nor for the kill by unsuccessful or non-breeding pairs. On balance, I conclude that Red-tailed Hawks probably removed close to 5 per cent of the spring population of pheasant hens in 1963–64.

The following figures perhaps provide some perspective in evaluating the overall impact of Redtail predation on pheasants. The average annual mortality rate of hen pheasants in this study between 1 October and 30 September was 76 per cent (Gates, 1971). Of those hens surviving in early January in an average winter, 27 per cent died before the end of March. Calculations suggested that a maximum of 7 per cent of the January population, or 26 per cent of all hens dying during the interval, were preyed upon by Redtails. Among those hens surviving on 1 May, 41 per cent disappeared by early

August (Gates, 1971). The estimated rate of Redtail predation on the 1 May population was approximately 5 per cent, equal to 12 per cent of the total loss.

Because predation rates were measured at only two seasons of the year, it is impossible to assess quantitatively the year-round importance of Redtail predation. I believe that this study has conclusively demonstrated, however, that where Red-tailed Hawks and Ring-necked Pheasants coexist, pheasants may comprise a significant proportion of the Redtail's winter and nesting-season diet, and that Redtail predation, in turn, may account for an appreciable fraction of the losses sustained by a pheasant population at these seasons. Under conditions of the present study, the number of pheasants killed by Redtails was nevertheless a modest fraction of total mortality, and the possible role of Redtail predation in regulation of pheasant density would have to be evaluated in context of other mortality factors which collectively accounted for a much larger proportion of total deaths.

SUMMARY

A study of Red-tailed Hawk populations, ecology, and predation on Ring-necked Pheasants was conducted in east-central Wisconsin in 1959–65. The average winter density of Redtails on a 42-square-mile tract was 0.39 per square mile; the average breeding density over a 3-year span (1962–64) was 0.54 per square mile. Wintering Redtails consisted almost exclusively of adults, the majority of which appeared to be paired and permanently resident.

Redtail nest success was 65 per cent, and the average number of young fledged per successful clutch was 1.8. The overall rate of productivity was 1.1 fledged young per breeding pair, well below the threshold of 1.3 to 1.4 young reportedly required for population maintenance in this species (Henny and Wight, in press). Rearing success was close to the maximum reported in the literature, the main limitation to breeding success being the high rate of nest mortality prior to hatching.

Pheasants were the leading item of prey in an analysis of spring and summer food habits. Pheasants were also preyed upon in winter, but the percentage they comprised of the winter diet, though considered substantial, was not quantitatively evaluated. Over a seven-winter period (1958–65), Redtails removed an estimated 7 per cent of the hen pheasant population between early January and late March. In 1963–64, Redtail predation during the spring and summer period was estimated at 5 per cent of the 1 May population. Under conditions of the present study, it was concluded that the Red-tailed Hawk was a highly capable predator on pheasants, and that Redtail predation accounted for a significant percentage of year-round pheasant mortality.

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