A CONTRIBUTION TO
THE NATURAL HISTORY OF
THE SPARROW HAWK, FALCO SPARVERIUS

by
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Dean of Graduate School

Date thesis is presented    April 30, 1954

Typed by Colette Roest
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Last, but not by any means least, I am grateful to my wife for her patience, her freely offered time, for discussions, and her many constructive criticisms.
Table of Contents

Introduction ................................................. 1
Methods ..................................................... 2
Taxonomic Position and Distribution ..................... 4
Habitat ....................................................... 7
Description of Adults ........................................ 9
Annual Cycle ................................................ 13
  Pre-Nesting Behavior ..................................... 13
  Nest Sites .................................................. 17
  Eggs and Incubation ....................................... 20
  Nestlings and Development ................................ 24
  Care of Young .............................................. 32
  Migration .................................................... 35
  Molting ....................................................... 38
  Abnormal Plumages ........................................ 41
Other Aspects ................................................ 42
  Hunting and Flight ......................................... 42
  Feeding ....................................................... 45
  Voice ........................................................ 51
  Sexual Differences ......................................... 51
  Interspecific Relations ..................................... 55
Behavior of Captives ......................................... 57
  Breeding in Captivity ....................................... 64
Mortality and Disease ......................................... 66
Population Dynamics .......................................... 69
Discussion .................................................... 80
Index to Tables and Graph in the Text

Table:
I - Weights of Adult Sparrow Hawks ........................................ 12
II - Nesting Dates ..................................................................... 14
III - Nest Sites Used by Sparrow Hawks ................................... 18
IV - Height of Nest Above Ground ........................................... 20
V - Food of the Sparrow Hawk .................................................. 48
VI - Mortality of Banded Sparrow Hawks ................................. 71
VII - Age of Captive Sparrow Hawks ........................................ 72
VIII - Sparrow Hawks Seen on Trips ......................................... 74
IX - Wintering Sparrow Hawks in Oregon ................................. 75
X - Institutions Where Questionnaires Were Sent ................... 77

Graph: Weight Increase of Growing Sparrow Hawks ................. 31
A CONTRIBUTION TO THE NATURAL HISTORY
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Introduction

Birds of prey, by virtue of their size and predatory habits, have attracted the interest of man for thousands of years. At least as early as 2000 B.C., various species were trained to aid in the hunt in Persia (75, p. 2), a sport that continued to be practised for hundreds of years, but which largely disappeared with the advent of firearms. Numerous nations, including the United States, have in the course of their history taken an eagle or other large bird of prey as a national symbol, or included one as part of their coat-of-arms.

This interest has changed and become antagonistic within modern times, especially in areas where man raises domestic animals of types which are acceptable prey to these birds. In many parts of this country hawks are shot on sight, regardless of species, and in consequence have become wary and difficult of approach. The behavior and habits of hawks are probably less known today than they were in Europe during the Middle Ages, where falconry was at that time the most popular and respected of sports.

Modern knowledge of birds of prey in this country is largely restricted to detailed food studies, based on stomach analyses, brief, general nesting accounts,
and distribution data. A considerable amount of data on other aspects of raptor natural history occurs in scattered notes throughout the literature, but because of its random nature remains largely inaccessible.

The present study is an attempt to fill in some of the gaps in our knowledge of one relatively common species. Emphasis has been placed on those aspects which have received least attention in the past, primarily behavior and the development of the young.

Methods

The American kestrel, or sparrow hawk (*Falco sparverius*), was selected as a subject because, of all the raptors, it is the most abundant and easily observed. In addition, the author had kept two as pets prior to this investigation, and was at least partially acquainted with some of the problems to be met.

The literature concerning the species was first examined in order to organize it and determine more exactly the deficiencies of our knowledge. This literature included reports from all parts of the wide range of the sparrow hawk. The Braly Egg Collection of the Oregon State College Museum of Natural History was also analyzed, and provided much information on nest sites and eggs.
The information so obtained was supplemented by over two years of observation, both of wild birds in the field and of captives. The majority of field data was obtained in Oregon, particularly in the vicinities of Corvallis and Bend. In addition, observations were made in California, New York, and Virginia. A total of over 1000 hours was spent in the field during the past three years, plus additional observations made prior to 1950. Since sparrow hawks, although common for a bird of prey, are not nearly so abundant as robins or sparrows, much of this time was consumed in looking for hawks, so that actual time spent in observation amounts to less than a third of the total time involved.

During 1952 five young sparrow hawks from a nest near Corvallis were marked with colored plastic leg bands, and in 1953 ten birds were banded with Fish and Wildlife Service bands. Through the kindness of the workers at the record office (Patuxent, Maryland) for the bird banding program conducted by the Fish and Wildlife Service, the 210 recovery reports on banded sparrow hawks were made available. These have provided considerable information on age, mortality, and migration which has not previously been analyzed.

In an effort to secure information on sex ratios, longevity, abnormal plumages, and breeding in captivity,
questionnaires were sent to thirty museums and thirty-five zoos throughout the nation. Twenty-five of the former and thirteen of the latter replied, their combined reports representing over 2027 specimens, both dead and alive.

Four males and four females were observed as captives for periods ranging from six weeks to two years, being kept by tethering them to block perches with a leash and jesses (short leather straps) attached to their legs. Later in the course of the investigation, a pair of large cages were constructed, and the birds released in these during the night, being returned to their perches for the day. In this way they were kept safe from prowling cats, but suffered a minimum of damage from flying into the wire mesh of the cage. They were fed principally on stewing beef, but occasional mice, birds, or insects were also provided, especially when the feathers were growing.

Taxonomic Position and Distribution

Falco sparverius is the American representative of a group of small falcons found throughout most of the world, and which collectively constitute the subgenus Tinnunculus. Falco tinnunculus, the old world form occurs in the form of several subspecies in Europe, Asia, Africa, and Australasia, and has been recorded as an accidental in
Massachusetts. It differs from *Falco sparverius* in lacking the black and white facial markings, and in the male the head and tail are gray.

The new world *Falco sparverius* comprises at least twenty-two subspecies ranging from Alaska to Patagonia, and from the Pacific to the Atlantic, and also occurring on the larger islands of the West Indies.

The taxonomic position of *Falco sparverius* is indicated below, and the various subspecies, with their distribution, are listed (after Bond (10), Friedmann (35), Peters (71), and Wolfe (93)).

Class - AVES: Birds
Order - FALCONIFORMES: Diurnal birds of prey
Suborder - FALCONES: True birds of prey
Family - Falconidae: Falcons and caracaras
Sub-family - Falconinae: True falcons
Genus - *Falco* Linnaeus
Subgenus - *Tinnunculus* Vieillot


*F. s. peninsularis* Mearns. Lower California from latitude 28° southward.

*F. s. guadelupensis* Bond. Guadelupe Island, Lower Calif.
F. s. paulus (Howe and King). S. Alabama (probably also Mississippi) to South Carolina, south over the Florida peninsula.

F. s. tropicalis (Griscom). Guatemala; apparently confined to the Motagua Valley.

F. s. sparveroides Vigors. Cuba and the Isle of Pines.

F. s. dominicensis Gmelin, Hispaniola.

F. s. loquaculus (Riley). Puerto Rico and the adjacent islands east to the Anegada Passage.

F. s. caribaearum Gmelin. Lesser Antilles: common on northern, rare on southern islands.

F. s. isabellinus Swainson. Coastal districts of northern South America from the Santa Marta region of Colombia to Cayenne.

F. s. brevipennis (Berlepsch). Islands of Curacao, Aruba, and Bonaire.

F. s. margaritensis (Cory). Margarita Island.

F. s. intermedius (Cory). Eastern slope of the central Andes of Colombia, n. to Antioquia, e. to Venezuelan border and the llanos of eastern Colombia.

F. s. ochraceus (Cory). Mountains of northern and western Venezuela.

F. s. perplexus (Cory). Known definitely only from type locality: lower Essequibo River, British Guiana.

F. s. caucae (Chapman). Cauca Valley region of western Colombia.

F. s. aequatorialis Mearns. Subtropical and temperate zones of Ecuador south to the Rio Chanchan.

F. s. distinctus (Cory). Range and status not fixed. Type locality Boa Vista, Rio Branco, Brazil.

F. s. eidos (Peters). Eastern Peru, e. Bolivia, and the greater part of Brazil south of the Amazon.
F. s. cearae (Cory). Type locality Quixada, Ceara, Brazil. Unique; perhaps synonymous with eidos.

F. s. peruvianus (Cory). Southwestern Ecuador and n. Peru south to Huanuco.

F. s. cinnamominus Swainson. Chile, s. Bolivia, Paraguay, Uruguay, and Argentina south to Tierra del Fuego.

F. s. fernandensis (Chapman). Juan Fernandez Islands.

Jourdain (56) records the accidental occurrence of F. s. sparverius in Denmark.

Falco sparverius sparverius, the Eastern Sparrow Hawk, and the only one occurring throughout the greater part of the United States, was the form studied. Although its wide range covers nearly all of North America north of Mexico, it is restricted by habitat preferences to certain areas within that range.

Habitat

As are all the true falcons, the sparrow hawk is an open country resident, being found primarily in regions of grassy plains, open woodland, cut-over timber, cultivated land, desert, coastal plain, and the like. As it takes its food primarily from the ground, it cannot exist where heavy forest or thick brush are the principal vegetation types. In addition, nesting sites must be available in the form of cavities in trees. Trees with cavities are always the first choice for nesting sites, but other types of sites may be accepted, especially in parts of the west.
where trees are absent.

Miller (65, p. 535), in his analysis of bird distribution in California, records the sparrow hawk as being found in all life zones from Lower Sonoran to Hudsonian. It favors the savannah type plant formation, and also occurs with decreasing frequency in regions of oak woodland, grassland, riparian woodland, pinon-juniper, montane forest, subalpine forest, desert scrub, sagebrush, and coastal forest. He does not record it from chaparral, alpine meadow, or marsh areas.

In Oregon the sparrow hawk has been observed in the rimrock country of the eastern part of the state and over the adjacent rangeland, as well as in the juniper country of central Oregon. The Willamette Valley supports a good population, and seems to be the most favorable habitat in the state. From the valley the sparrow hawk has moved into the large burned over areas of the Cascades and Coast Range, and is, for example, common in the Tillamook Burn. A few are found along the coast where open country occurs, such as golf courses and cleared land now used as pasture. Ecologically, it fills the daytime niche occupied by the ubiquitous screech owl at night, just as the red-tailed hawk and horned owl are equivalent forms among the larger predators.

Altitudinally the sparrow hawk occurs from sea-level
to at least 7000 feet (88, p. 157) and probably could be found higher in suitable habitat.

Little is known of its distribution in time. It has been found in the upper Pleistocene of southern California (51).

**Description of Adults**

The American sparrow hawk is a small falcon, having the characteristic toothed upper mandible, long pointed wings, and relatively long tail of this group. The adults are nine to thirteen inches long, with a wingspread of twenty to twenty-four inches. The males average slightly smaller than the females in all dimensions, but the difference is not obvious in the field except in cases of extremes, or where male and female are side by side - an unusual situation.

The center of the crown, back, and tail of the adult male are rufous in color. The tail has a black sub-terminal band and an off-white terminal tip, the outermost feathers being more or less white, barred with black. The wings are bluish-gray in appearance when folded, but when spread have a barred effect, since the exposed primaries and secondaries are black with varying amounts of white. The relatively large, rounded head shows white cheeks above a white throat. A black bar extends through each
eye, and another marks the posterior edge of the cheeks. The back of the head is marked by two black spots, with a third, between them, at the nape. These three give the appearance of another set of eyes and a bill pointing to the rear. The chest is cinnamon, shading to whitish on the belly, with scattered black markings, thickest on the flanks. With age, the cinnamon of the chest becomes darker and richer, and may extend over the entire ventral surface. The black markings on back and chest decrease in size and number, and some individuals may be immaculate over these areas. The cere, flesh around the eye, and feet and legs are yellow, with black claws. The bill is gray with a black tip.

A considerable amount of individual variation exists in regard to pattern details and shades of color among males. Friedmann (35, p. 723) comments on this, and mentions two specimens from the United States National Museum which illustrate the extremes in tail patterns:

"U.S.N.M. No. 293641: All but the central pair of retrices white crossed by the broad subterminal, and four narrower, but yet broad, black bands anterior to it, their basal third or less suffused with rich hazel, the median pair with the hazel more extensive, covering nearly half its length, the distal half slate crossed by three very incomplete and much narrower black bands and of course, by the broad subterminal one. U.S.N.M. No. 309410: The outermost pair of retrices white on the outer webs only which have four lengthwise black marks next to the shaft corresponding in position and length to the width of the bars of the preceding specimen, the inner web very pale cinnamon
rufous with a broad subterminal black band; all the other retrices rich hazel with a broad subterminal black band, all the feathers tipped with white. Between these two extremes, one finds all stages of intergrades."

In most falcons, the sexes are like in plumage; but the sparrow hawk is an exception. The female is much less brightly colored than the male, upperparts being dull brownish, heavily marked with narrow black bars, and the tail is barred with black. Underparts are pale tan, streaked heavily with brown. Head markings are similar to those of the male, and flesh parts, claws, and bill are identical. Older females show less streaking on the ventral surface.

Although the male is usually smaller than the female, an insufficient number have been measured and weighed to determine the exact relationship. Table I shows comparative weights of adults, but cannot be accepted as a complete picture, as young birds in general seem to weigh more than older ones, and the presence or absence of food in the digestive tract affects actual weight considerably. Time of day, general condition of the bird, and if dead, how long dead, are other variables. From the data given, males average 113.4 grams, females 119.0 grams, the males showing greater variation in this respect. In linear measurements, males are consistently from one to two inches shorter in length, and have a wingspread two to
Table I - Weights of Adult Sparrow Hawks
Combining data and literature references
(* indicates living bird)

Males

<table>
<thead>
<tr>
<th>Date</th>
<th>Weight (gm)</th>
<th>Date</th>
<th>Weight (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug. 21, 1951</td>
<td>83.0</td>
<td>Oct. 6, 1953</td>
<td>128.5*</td>
</tr>
<tr>
<td>Oct. 12, 1951</td>
<td>89.0</td>
<td>Feb. 7, 1952</td>
<td>135.0</td>
</tr>
<tr>
<td>Jan. 1, 1951</td>
<td>101.0</td>
<td>Dec. 28, 1951</td>
<td>143.0</td>
</tr>
<tr>
<td>no date</td>
<td>101.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Esten (31)</td>
<td>102.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imler (52)</td>
<td>106.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no date</td>
<td>103.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imler (52)</td>
<td>109.0*</td>
<td>Esten (31)</td>
<td>103.4</td>
</tr>
<tr>
<td>Esten (31)</td>
<td>112.4</td>
<td>Jan. 7, 1952</td>
<td>105.0*</td>
</tr>
<tr>
<td>Sept. 11, 1952</td>
<td>117.4*</td>
<td>June 7, 1953</td>
<td>119.5*</td>
</tr>
<tr>
<td>Imler (52)</td>
<td>124.0</td>
<td>Stewart (78)</td>
<td>123.0</td>
</tr>
<tr>
<td>no date</td>
<td>125.0</td>
<td>Aug. 15, 1953</td>
<td>125.5*</td>
</tr>
<tr>
<td>Oct. 6, 1953</td>
<td>127.0*</td>
<td>Esten (31)</td>
<td>132.6</td>
</tr>
<tr>
<td>Imler (52)</td>
<td>127.0*</td>
<td>Imler (52)</td>
<td>140.0</td>
</tr>
</tbody>
</table>

Females

<table>
<thead>
<tr>
<th>Date</th>
<th>Weight (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>no date</td>
<td>103.0</td>
</tr>
<tr>
<td>Imler (52)</td>
<td>109.0</td>
</tr>
<tr>
<td>Esten (31)</td>
<td>112.4</td>
</tr>
<tr>
<td>Sept. 11, 1952</td>
<td>117.4*</td>
</tr>
<tr>
<td>Imler (52)</td>
<td>124.0</td>
</tr>
<tr>
<td>no date</td>
<td>125.0</td>
</tr>
<tr>
<td>Oct. 6, 1953</td>
<td>127.0*</td>
</tr>
<tr>
<td>Imler (52)</td>
<td>127.0*</td>
</tr>
</tbody>
</table>

Average for males: 113.4 gm. Average for females: 119 gm.

four inches less than that of females. Hill (49) has found that the wing of the male is about 86% that of the female, but the tarsus is relatively longer - 105% that of the female.

This size dimorphism is characteristic of most birds of prey, and is especially noticeable in some of the falcons. Early falconers even denoted the male peregrine falcon (Falco peregrinus) as the 'tiercel', a term derived from the notion that the male was one third smaller than the female.
Annual Cycle

The preceding pages have outlined the best known features of our knowledge of the sparrow hawk - its classification, description, and distribution. Attention will now be directed to those topics about which there is little or no information, such as courtship, molting, and care and development of the young. The simplest approach is to describe the complete annual cycle, beginning with the return of the birds to their nesting areas.

Spring brings the first resident hawks to the country around Bend during the last weeks of March (Mar. 17-Mar. 30), with males preceding females by only a few days. By the first week in April the resident population has arrived, and pair formation commences almost immediately.

Pre-Nesting Behavior

The nesting season begins at different times in different regions, as is to be expected, and actual dates depend to a great degree on local weather conditions. The accompanying table (Table II) illustrates the variation.

Even at different latitudes, the general nesting season is remarkably uniform, both Florida and Canada being represented by dates in the second week of April. In favorable years it is safe to state that the nesting season
may begin in early April almost anywhere within the range of the sparrow hawk.

The complete process of pair formation is a phase of the life cycle that has never been observed, but the following observations give an indication of what takes place.

Mr. Donald Dunlap, of Bend, Oregon told me of a group of sparrow hawks he had seen in a dead tree near Pullman, Washington, early in 1952. There were four hawks, three of them moving about continuously in one part of the tree, churring almost constantly, while the fourth sat quietly in the opposite side of the tree. Such a group was probably congregated for the same reason as the one reported by Childs and Mossman (19), on March 12, 1949. As a group of five hawks were watched milling about a building in Berkeley, California, two different males were each seen

Table II - Nesting Dates

<table>
<thead>
<tr>
<th>Region</th>
<th>From</th>
<th>To</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thonotosassa, Fla.</td>
<td>April 11</td>
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<td>Braly collection</td>
</tr>
<tr>
<td>Charlottesville, Va.</td>
<td>May 1</td>
<td></td>
<td>Personal notes</td>
</tr>
<tr>
<td>California</td>
<td>March 27</td>
<td>May 16</td>
<td>Braly collection</td>
</tr>
<tr>
<td>Butte Co., Calif.</td>
<td>March 31</td>
<td>May 9</td>
<td>Braly collection</td>
</tr>
<tr>
<td>Swarthmore, Penn.</td>
<td>May 12</td>
<td></td>
<td>Braly collection</td>
</tr>
<tr>
<td>Salt Lake Co., Utah</td>
<td>June 8</td>
<td></td>
<td>Braly collection</td>
</tr>
<tr>
<td>Oregon</td>
<td>May 7</td>
<td>June 3</td>
<td>Braly collection</td>
</tr>
<tr>
<td>Corvallis, Oregon</td>
<td>April 25</td>
<td></td>
<td>Personal notes</td>
</tr>
<tr>
<td>Bend, Oregon</td>
<td>April 25</td>
<td>May 7</td>
<td>Personal notes</td>
</tr>
<tr>
<td>Custer, S. D.</td>
<td>May 25</td>
<td></td>
<td>Braly collection</td>
</tr>
<tr>
<td>Larchmont, N. Y.</td>
<td>June 8</td>
<td></td>
<td>Personal notes</td>
</tr>
<tr>
<td>Pullman, Wash.</td>
<td>May 4</td>
<td></td>
<td>King (pers. lett.)</td>
</tr>
<tr>
<td>Canada</td>
<td>April 12</td>
<td>June 26</td>
<td>Braly collection</td>
</tr>
</tbody>
</table>
to copulate twice with the same female.

The display flight is apparently reserved for after the formation of a pair, and has been described by a number of observers. Brewster (12) reports on the flight of the male as follows: "the male . . . would mount high in the air to fly very rapidly, in a wide circle over and around where the other (the female) was perched, bending the tips of his wings downward and quivering them incessantly, at the same time uttering a shrill, clamorous kee-kee cry, oft repeated." Bishop (7) describes it as a flight high in the air comprising "spirals, short dashes, and a rapid drop ending on the back of the female." According to him, the female may take the initiative in mating, and he reports an instance where she called persistently until the male arrived. He also mentions that the aerial gymnastics of the male sometimes occur after copulation.

Copulation is referred to by Bent (6) as a "noisy, boisterous proceeding, accompanied by a good deal of wing flapping on the part of the male bird." Personal notes provide the following description, dated April 25, 1953, from near Bend.

"Time, about 6 PM. A male sparrow hawk perched in a dead pine. In a few minutes the female arrives, and both hop around among the branches for a few minutes. The female flies off, chased by the male, but both quickly return. The male flies off to a nearby snag (the nest was located in an old flicker hole near its top) about 35 ft.
high, preens there for two or three minutes, and returns to the dead pine. Again both birds hop about from branch to branch, finally coming to rest on the same one about two feet apart. The female turns her back toward the male and flips her tail up and down a few times. The male watches, flips his tail also, and moves up until the two birds are side by side. The male quickly mounts as the female holds herself horizontally and copulation occurs, with some gentle wing fluttering on the part of the male to maintain his balance. Copulation lasts about twenty or thirty seconds, after which the male moves over to another branch. Both birds preen. After about two minutes the male flies off, leaving the female still preening. The whole process lasts no more than ten minutes.

In the above description, the female initiated copulation by bobbing her tail and assuming a horizontal position on the branch.

From the descriptions on pages 14 and 15, it would seem that polyandry may occur in the sparrow hawk. Fast and Barnes (32) report another apparent instance.

Either during or after pair formation, territories are established. This can easily be determined by the frequent observation of sparrow hawks in certain areas, on favorite perches, etc. Determination of territorial size is another matter, as along the supposed boundary lines there are no methods for determining which birds come from which territory. Any marking system which would clarify this situation involves capture of the birds first, a difficult task when food is abundant, as at this time. By mapping nest sites and places where males and females are seen it is possible to achieve an approximation of the
size of each territory. In the vicinity of Corvallis this is about one and a quarter square miles for each pair, while at Bend it is closer to two square miles.

What little has been learned concerning territories seems to indicate they are not strongly defended, at least by the females. On May 20, 1953, while watching a female near Tumalo, Oregon, a second female was seen to fly by the first not more than ten feet from it, heading for a nearby nesting area. Neither paid the slightest attention to the other. It is possible that one of the two was unmated, but this seems unlikely in the light of other information (see Sex Ratios, p. 76).

Nest Sites

The site selected for a nest is almost always a cavity of some sort, unlike that for most other birds of prey. Natural cavities in trees and old flicker holes are the most usual sites. In some areas, such as parts of southern California, where trees with cavities are scarce and magpies occur, old magpie nests may be used. In arid regions of the west, absence of both trees and magpies forces the sparrow hawk to use holes in cliffs or bluffs (5). Nuttall (67) and Bailey (3) report the use of old crow nests in some areas. In many cities throughout the United States the species has become sufficiently accustomed
to man to make use of crevices or ledges around buildings (7, 19, 32). Stoner (81) mentions a nest in the chimney of a deserted shack, and Bailey (3) refers to the use of old dove cotes. The only such instances in Oregon known to the writer are the nests in the grandstand of the old Oregon State College football stadium (now torn down) and in the Dairy Building, at Corvallis, plus a few nests in little used barns in various parts of the state.

The most frequently used site appears to be an old flicker hole, with natural cavities coming a close second. Table III illustrates the data obtained from personal data and the Braly egg collection.

Table III - Nest Sites Used by Sparrow Hawks

<table>
<thead>
<tr>
<th></th>
<th>Natl</th>
<th>Flkr</th>
<th>Wdpkr</th>
<th>Magpie</th>
<th>Cliff</th>
<th>Bldg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal data:</td>
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<td></td>
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</tr>
<tr>
<td>Oregon</td>
<td>2</td>
<td>4</td>
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<tr>
<td>Virginia</td>
<td>1</td>
<td>1</td>
<td></td>
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</tr>
<tr>
<td>New York</td>
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<td></td>
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<tr>
<td>Braly col.:</td>
<td></td>
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</tr>
<tr>
<td>Oregon</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>1</td>
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<tr>
<td>California</td>
<td>12</td>
<td>15</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>1</td>
<td>13</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals:</td>
<td>19</td>
<td>36</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Only very rarely does the sparrow hawk select a nest site which is unroofed in some fashion or other, and the more enclosed it is, the more it seems to be preferred. In regard to this Rockwell (74) says that "Sparrow hawks
nesting in this manner (open nest) are much more timid than those nesting in cavities, and whereas it is a common occurrence to find a brooding female so fearless that it is necessary to remove her from the eggs in a cavity, it is seldom that one can approach an open type nest. Personal experience bears this out to a degree, but sparrow hawks as a group seem to be much more suspicious and wary of man today than in Rockwell's time. Only once during this study was a female caught on the nest. Cavity nesting birds seem to remain longer in the nest as the tree is approached and climbed than, for example, the birds which nested in the relatively open nest in the Oregon State football stadium, formed by the junction of several large beams just below the roof.

The height of the nest above the ground varies with the cavity selected, but is rarely very high. The most usual elevation is between ten and fifteen feet. Bent (6) mentions one nest at a height of 81 feet, the highest reported. Personal data and the Braly collection material are summarized in Table IV (p. 20).

No nesting material is normally added to any which may exist in the cavity. It is frequently possible to determine the original (or at least earlier) inhabitants of the cavity by examining the rubble at the bottom. Such
Table IV - Height of Nest Above Ground

<table>
<thead>
<tr>
<th>Height (Feet)</th>
<th>Personal Data</th>
<th>Braly Collection</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 to 9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 to 14</td>
<td>2</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>15 to 19</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>20 to 24</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>25 to 29</td>
<td>1</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>30 to 34</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>35 to 39</td>
<td>3</td>
<td>3</td>
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</tr>
<tr>
<td>40 to 49</td>
<td></td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>50 plus</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

debris as old feathers, infertile eggs, and ancient honey combs may be found, giving evidence of the previous occupants.

Two possible exceptions to the 'no new material' rule may be mentioned. In the Braly egg collection a set of eggs collected near Swarthmore, Pennsylvania, on May 12, 1909, from a dead chestnut stub (type of cavity not specified), is reported as having grass in the nest. This of course may have been brought in by a previous occupant.

Audubon Magazine (1), in its summary "The Seasons" for 1945, mentions a sparrow hawk "carrying nesting material" near Banning, California, on March 28. This may be a case of mistaken identity regarding the material being carried.

Eggs and Incubation

The eggs of the sparrow hawk are short for their diameter, often oval, with the small end rounded rather than
pointed. The shells are smooth, without gloss. In color, they may be white or creamy with a varying amount of cinnamon in the form of numerous tiny dots providing an overall brownish effect. Frequently the cinnamon dots are concentrated around the larger end. Occasionally the eggs may have a ground color of light pinkish cinnamon, and the dots may be arranged in blotches or spots. The markings vary from "Mars brown" to lavender. A few eggs may be immaculate (6).

The number of eggs in a clutch averages five, with four also a frequent figure. Lumping personal data with data from the sets in the Bruly collection, 38 sets have five eggs, 13 have four, 3 have six, and 1 has three. Bent (6) reports "ordinarily four or five eggs, occasionally three, and very rarely six or seven". Nuttall (67) reports five to seven eggs as a normal clutch, while Williams and Matteson (92) mention a set of eight at a nest near Ft. McKinney, Wyoming. A case of two successive sets of eggs laid by one female during a single nesting season is reported by Seibert (66).

The eggs average 35 by 29 millimeters, with extremes of 32 x 22, 21 x 28, and 33 x 26 millimeters (Bent, 6, from a series of 169 eggs in the United States National Museum). Sumner (84) gives the weight as 14 and 15 grams, and personal field notes show weights of 11.5 and 15 grams.
In an average clutch incubation does not begin until after the fourth or perhaps the fifth egg has been laid. The incubation period varies somewhat with the locality. Sherman (77) reports incubation to last 29 and 30 days for different eggs in the same clutch, in Ohio. Williams and Matteson (92) set the time at three weeks, which seems rather short. Data from Bend indicates a period of 30-31 days.1

The time of laying and hatching are also variable according to locality. In the vicinity of Bend eggs are laid at the beginning of May (May 3-5) and hatch the first week in June (June 4-7). In Virginia, hatching time for one set was May 12, in New York, June 1, and at Corvallis, April 29-30. In southeastern Washington the eggs hatch about June 4 (Letter from James R. King dated Jan. 28, 1953).

The female performs most of the incubation, the male assisting her by bringing food or by taking over the night shift. At one nest near Bend, at about 2 PM on May 7, 1953, the male was seen to bring food (a lizard) to the female. As he arrived he cried out "kree-kree", and the female popped out of the nest to snatch the lizard from

1. In this light it is interesting to note that Fisher (33, p. 46) gives four weeks as the incubation period for the kestrel (F. tinnunculus) in England.
him, and flew off to feed on it. The male dropped down and looked into the cavity, but soon flew away without entering, perhaps disturbed by the presence of the observer.

At two nests near Bend, an apparent nest-changing schedule was observed in the evening. At one of them, on May 1, 1953, about one-half hour before sundown, the male of the pair arrived in the vicinity of the nest and moved about from tree to tree, occasionally swooping halfheartedly at a passing bird. Finally the female looked out of the nest hole and uttered a soft "kree-kree". The male then flew over to a nearby juniper, searched about among the branches, and flew back to the nest tree with the hind-quarters of a field mouse, *Microtus*. He began plucking fur from it and fed a little. By now the sun was down, although it was not yet dark. Soon the female left the nest and flew up into the tree close to the male. The male came down near her with the mouse, whereupon the female moved over and took it from him, and began to eat. The male remained near her for about ten minutes, while she fed, but he then dropped down and entered the nest cavity. After five minutes he emerged again, but reentered after a short time. The female continued feeding until it was almost dark, and then flew off to a nearby tree. The male had not come out of the nest cavity by
the time observation ceased, with complete darkness.

At another Bend nest, a similar pattern was noted on May 3, 1953. Shortly before sundown the male was observed perched near the nest tree. The female came out of the hole and flew off, returning in about five minutes. She perched in the nest tree as the male came down to her and held the hind portion of a lizard out to her, which she accepted. He then flew to a higher branch, where he remained while she flew away, returning in a few minutes to enter the nest cavity again. Later the male flew off. In this case, the male did not take over at the nest, but the vesper ceremony of feeding nevertheless took place.

Nestlings and Development

The eggs all hatch within about forty-eight hours, indicating that incubation probably commences when the next-to-last egg is laid. At hatching the young hawks are wet, tired, and almost completely helpless, with eyes closed, but have dried out within an hour or so. At this time they are covered with sparse white down through which pinkish skin is visible. Most parts without down show the same pink shade, although the legs have a hint of yellowish, and the bill, claws, and cere are white. The body bears sparser down over most of the abdominal and perineal regions, and the former, after feeding, definitely
protudes as a pot-belly. The wings resemble downy flippers. The egg tooth is quite prominent, projecting in some individuals as much as two millimeters. Although the bill lacks a hook at the end, the typical falcon tooth is present.

Within a short time the eyes can be partially opened with an obvious effort, and are dark bluish-black. A faint buzzy cheeping noise is uttered when the young hawks are disturbed. The feet show a feeble grasping reflex, but have no strength. The birds cannot sit erect, but can raise their heads shakily and open their beaks. Weights range from thirteen to twenty-two grams, probably depending to a large degree on how recently the individual has been fed. Sizes range accordingly, although they are all so small that five can easily be held in one hand. See Graph, p.31.

Sherman (77), the only observer who has noted the development of wild sparrow hawks in the literature, states that at the age of two or three days the young bite vigorously at a finger which touches their bills. Birds personally observed did not show this action, but had obviously been recently fed, having full crops. In addition, Miss Sherman mentions two vocal efforts besides that noted above, a faint cry suggestive of the 'killy-killy' of the adult, uttered when expecting food, and a "third cry,
difficult to describe, which they uttered when fed." At nests near Bend, with young three days old, the buzzy cheeping previously heard had been replaced by a chirp, and the immature 'killy-killy' mentioned by Sherman was noted. At the age of five days one young male was able to sit up, turning about so as to face away from the sun.

By the end of the first week the skin under the down has begun to turn bluish on the wings, shoulders, back, and crown. The claws are beginning to darken, and the egg tooth, although still present, is considerably smaller. It seems to wear off, rather than dropping off as a unit. The wing quills have just commenced to develop. The eyes are wide open, a dark chocolate brown iris with a deep cloudy blue pupil, and the nictitating membrane now functions. When a card or hand is waved slowly in front of the young falcons they are now able to follow its movement visually. As yet they show no real fear, but become excited when handled, and display the characteristic defense attitude of young hawks, rolling over on their backs and presenting taloned feet in readiness to strike at the intruder. They sit erect on the perineal area, legs spraddled forward as props, and between the legs the pot-belly protrudes. Belly and perineal area are completely bare, the down having been rubbed off. Body temperatures average 101° F. (air temperature 68° F.).
At this age Sherman (77) noted the first appearance of fear, but states that such a reaction (flattening down on the bottom of the nest) was rare for several days thereafter. The nest she observed was in an open cavity so situated that she could look directly into the nest from her blind. With this advantage she was able to describe the process of feeding by the parents. Until they were a week old, the young congregated in the center of the nest and were fed there. At seven or eight days they ranged themselves along the sides of the nest, leaving the center available for the adult and the individual being fed.

At one nest near Bend a female, aged ten days, was heard to make an aspirant hissing noise, similar to but much softer than that of a goose. She made only this one sound the rest of the time she was under observation in the nest, and then only when handled. None of the other birds observed at any nest uttered anything resembling this hiss. In contrast, they typically uttered a soft 'chrrrrr' and achieved a cry with the promise of an adult 'killy-killy' in it.

At the age of two weeks feathers have sprouted over the entire body, but are thickest on the wings, tail, back, chest, and crown of the head. The bill has developed pigment at the end, where a small hook has appeared.
The egg tooth is completely gone. Sexes can now be guessed at by comparative sizes, the females being larger. In slightly older birds sufficient feathers have sprouted to permit sexing with accuracy, males having grayish, and females brownish, wings. The youngest birds (downiest) have tail feathers two to three centimeters long, and of this about one third has broken from the sheath.

All show some defiance, yelling 'killy-killy-killy', churring, rolling over on their backs to present taloned feet, or even by biting a preferred finger. They can run about easily, but prefer to squat. Captives at this age may sleep either in the squatting position, or lying on their ventral surfaces, tucking their heads between the sprouting shoulder feathers in both cases.

By the age of sixteen days the young hawks spend most of their waking hours on their feet. When prodded or teased however, they revert to the squatting position, from which they can quickly roll over on their backs to present actively kicking feet to the intruder. When teased to this extent they may also utter a typical 'killy-killy' cry, although some individuals are silent. When being fed they emit a cheeping sound, with bill closed, resembling the peeping of baby chicks.

Sherman (77) noted the first appearance of a marked difference in the behavior of males and females at this
age, a topic which will be discussed in detail later (see Sexual Differences, p. 51).

Four days later (age twenty days) the young falcons are well feathered, the remaining down being concentrated on the head and along the radius and ulna of the wing. Males show black spots on the breast, gray-blue primaries and secondaries; females have brown streaked breasts and brown wing feathers. The tail feathers are six to six and a half centimeters long, and those of the males are lighter and redder in color than the females'. When tired or relaxed they nestle down on their ventral surfaces. At this time a favorite occupation seems to be preening and cleaning the developing feathers, and time spent in this activity increases in the following days.

At twenty-six days the birds can be quite active. Although under natural conditions they are still restricted by the cramped quarters of the nest cavity, captives spend much time exercising their wings, and run about easily, holding head and tail in the same horizontal line. They can also fly from ten to fifteen feet, when encouraged to do so by some stimulus, such as returning them to their box in the evening. Some down clings to the feather tips. By this time the difference in behavior between the sexes is considerable.

The young hawks leave the nest about thirty or thrir-
ty-one days after hatching. This time may vary somewhat, since birds at nests that are relatively high above the ground seem to spend longer in the nest before trying their wings. The wings are practically full grown, but the tail is still decidedly shorter than that of the adult. A few tendrils of down usually cling to the head feathers, where they cannot be easily reached in preening.

The accompanying graph (p. 31), showing the change in weight as the young develop, illustrates the typical 'S' type curve exhibited by most young birds. Growth is relatively slow at first, but after the first week weight is added rapidly. The rate is slowed about the time that feathers begin sprouting in numbers, and levels off to a peak when the young are ready to leave the nest. This peak is higher than the average weight of adults. Apparently the young birds build up a certain amount of reserve food in the form of fat just before they leave the nest, which no doubt aids them in successfully passing the difficult stage of learning to fly and obtain food themselves. Just how important is this extra weight is difficult to determine, since in this species at least, the young are fed for a few days after they are on the wing, by their parents. It may be an important factor in insuring the final growth of feathers while most food being consumed
In general, males weigh less than females after the age of five days. Variations are to a certain extent due to how recently the birds have been fed.

at this time is utilized to provide the extra muscular energy required for flight.

The first flight from the nest is usually accompanied by much flapping, which ceases as the objective is approached, terminating in a glide. Under normal conditions it is almost invariably short, to some nearby tree, and the landing point is usually lower than the nest site. Occasionally the first outing may be to a nearby branch in the
nest tree. The young falcon rests upon reaching its first destination, and after awhile will climb upward, hopping and scrambling from branch to branch, to a higher vantage point from which to make another flight. The young do not seem to return to the nest at all once they have left it, but are fed and sleep wherever night overtakes them, usually less than a hundred yards from the nest. Much time is spent just sitting quietly on a branch, resting and looking about, or perhaps waiting to be fed by the parents.

Care of Young

The nestlings are cared for primarily by the female, although the male assists in obtaining food. During the earlier part of the nesting season, both male and female are usually present at the nest. The male protests against nest inspection vociferously with a shrill 'killy-killy-killy' cry, and dives repeatedly at the intruder, at times coming as close as six or eight feet. The female usually flies off to a perch nearby, but takes no active part in defense, although some individuals may 'killy-killy-killy' a bit.

On May 25, 1945 a pair of sparrow hawks near Charlottesville, Virginia were loudly proclaiming their defiance of the writer as he inspected their nest. After a
few minutes they were joined by another female, probably one from another nest nearby. No other such case has ever been noted.

After the young have hatched, the male is frequently absent from the nesting area, apparently in quest of food. The female is usually 'at home', and makes a slight effort at defense by killying and flying around, but does not usually threaten the intruder by active diving, as would the male. This attitude of what may best be described as 'concerned timidity' continues until the time when the young are leaving the nest, when the female becomes much less timid, and her defense is correspondingly active.

On only one occasion was an exception to the above noted, at one of the nests near Bend. At this nest the female was comparatively bold, and made short half-dives at the writer until she saw one of her downy young in his hands. Then she made full dives as close as a male would have come, and killed briefly, her cry having a harsh grating quality not typical of the normal call.

In the post-hatching period the male is usually absent, as previously mentioned, but when present he still performs his function as nest protector. On no occasion was the male ever observed alone at the nest, leading to the assumption that he is the principal food-getter of the pair. The female's occasional absence's are rela-
tively short and do not take her far from the nest. Many times when a nest was investigated the female would not be present at first, but would soon make an appearance.

Feeding is done almost exclusively by the female. Only once, at the nest in the football stadium at Corvallis, was a male observed to bring food to the young, entering the nest to do so.

The young are still cared for by the adults for a short time after they are on the wing. At this time a complete family group, adults and four or five juveniles, may be seen cruising together over the fields. The adults are still concerned with feeding the young, but as the latter acquire proficiency in flight and observe their parents capturing prey, they soon try it themselves. Within a few days they are adept enough to capture young, inexperienced mice or large insects, both common at this time of year - June in Oregon - and are no longer dependent on the adults. When this stage is reached they drift away from the group. By the middle of July all young birds hatched in the spring are living independently. Throughout the summer the entire population of sparrow hawks feeds on the mice, insects, and other small animal life that is abundantly available at this time of the year.

The young resemble the adults very much during their
first summer, but close inspection reveals several points of difference. Young females show somewhat heavier streaking on the breast than do the adults. Most juvenile males lack the cinnamon breast of the adult, have more and larger spots over the abdominal region, and have the back more heavily marked with black.

Migration

The summer time of relatively easy living begins to draw to a close during September in most parts of the sparrow hawk's range. There begins a gradual movement southward or to lower elevations. In the north the entire population may migrate, but in more temperate regions a few remain to spend the winter.

In Oregon the summer population begins to drift south in September, the exact date depending largely on local weather and food conditions. In the vicinity of Bend they are gone by the middle of September, but during the middle of October migrants from farther north traverse the region. After October 25, no sparrow hawks are seen except for a few stray males which wander up from lower elevations during spells of warm weather.

So far as can be determined, no such regular mass movement of migrating hawks takes place in the western United States as occurs annually in parts of the east.
At Hawk Mountain Sanctuary in Pennsylvania, a concentration point along the series of mountain ridges that the hawks follow south, riding on updrafts, Maurice Broun (15) has observed thousands of hawks each year. The vast majority are the big broad-winged soaring species, but each year an average of 130 sparrow hawks are observed passing the check point, beginning to move in late August and continuing to drift by until late October or even early November. The majority of the flight comes during September, when from ten to thirty individuals may be seen in one day (maximum 38, Sept. 26, 1943).

An impressive flock of what were probably migrating sparrow hawks was described by Law (59), who observed "thousands" sailing by in a continuous stream on September 13, 1914, in New Mexico. Often a hundred or more were in sight at one time, and all seemed in search of food. A more recent and less impressive report is that of George Marshall (letter to author dated Jan. 28, 1954) who noted a group of twelve or fourteen sparrow hawks together in the Fort Klamath area in late September, 1953. There are no other records of migrating sparrow hawks.

An idea of the general movement of migrating sparrow hawks can be gained from a study of the banding records, although these are somewhat scanty. Birds from New England and the central Atlantic coast move southward to
winter in the Carolinas and Georgia. Farther west, the birds from Kentucky, Ohio, Michigan, Minnesota, Saskatchewan and Alberta concentrate in Texas, Arkansas, and Louisiana. No records are available for the West except for two birds, banded in Arizona, that were picked up in Sonora, Mexico.

The sparrow hawks from farthest north appear to migrate farther south than those in more temperate areas. Birds from Pennsylvania and Maryland are most often recovered in North Carolina, while New England birds are picked up in South Carolina. A bird from Nova Scotia turned up in Florida, while two from near Edmonton, in Alberta, were recovered in southern Texas, distances of over 1600 miles in each case. The record is held by a sparrow hawk banded at Peers, Alberta, and later killed near Kauki, Campeche, Mexico - an airline distance of over 2600 miles!

There is a slight indication that juveniles may move northward during late summer after leaving the nest. The following records indicate this movement: Massachusetts - Maine; Ohio - Michigan; Oregon - Washington. All these birds were recovered before October, and were banded in June or July.

In some parts of their range sparrow hawks may remain to spend the winter, western Oregon being one of these
areas. In addition, birds from farther north may come down to winter there, resulting in a population which is almost as large as the summer population. The winter visitors congregate in more open country, such as the grain growing parts of the Willamette Valley, where food is easily captured, and this concentration leads to surprisingly large numbers of sparrow hawks in some localities (see Population, p. 69).

In eastern Oregon only a few scattered areas support a small number of wintering birds, among them the grain country around Madras, the Malheur bird refuge, and the region about Klamath Lake. During periods of warmer weather these birds stray up to higher elevations. At Bend such individuals, all males, have been noted on Nov. 16, Dec. 13, Jan. 29, Feb. 15, and Mar. 3, during 1952 and 1953.

The same situation, of a few birds remaining in relatively northern areas, holds true throughout the range, at least one sparrow hawk being reported to have spent the winter as far north as Toronto, Canada (89).

Molting

The annual molt takes place from August to October, and may extend into November, apparently taking place during the migration. In two juvenile captives
at Corvallis in 1952, the molt during the first fall commenced on August 3, when one cinnamon feather appeared on the chest of a male. By August 6 a female showed ruffled, partially featherless areas about a centimeter across on each shoulder, apparently the result of losing three or four feathers from each of these spots. The male still had only two cinnamon breast feathers on August 17, and the female appeared little changed. Both birds really commenced to molt heavily about the first of September, and by September 10 looked rather patchy. The male had the entire chest area outlined in cinnamon at this time, and this area was almost completely refeathered on the fifteenth. Up to this point most feathers lost were relatively small contour feathers, but on the seventeenth a number of larger ones were lost, from the back and the wing coverts. In the male the reddish crown was also being lost, and was later replaced by gray feathers except for a small crescent shaped area. A year later, in the next fall molt, this same male lost all trace of a rufous crown. By October 5 the molt was nearly complete, but a few feathers continued to drop out until October 19.

The first fall molt of the juvenile birds affects only body feathers, leaving the flight feathers of wings and tail unchanged. A year later however, during their
second fall, the birds undergo a complete molt of both body and flight feathers. In a captive male this second molt commenced on July 3, when two primaries and three secondaries, plus some body feathers, were dropped. One or two flight feathers were dropped every two or three days until July 15, when the rate slowed to one every week or ten days. The first primaries to be lost came from the proximal portion of the primary region of the wing, the molt working out distally. Bastard quills were dropped July 4 to 10, and the first tail quill (the first feather to the left of the center) on July 14. Between August 22 and October 11 no wing feathers were shed but on the latter date two secondaries were dropped, and on November 5 two more, at which time the molt was over. The old tail feathers were all out by August 28, having been shed from the center outward. The new ones in this individual had gray tips instead of cream colored ones, but it is doubtful whether this is a valid age characteristic in such a variably plumaged species. During this period the body feathers were also molted, with little apparent change.

At present no information is at hand concerning later molts, but presumably these are similar to those of other raptors, in which body feathers are molted each year, but flight feathers only every other year. With each
successive molt males develop richer colors, with fewer black markings, while in females the amount of streaking on the breast is reduced.

Abnormal Plumages

Although there is a great amount of individual variation of pattern details among sparrow hawks, especially the males, actual abnormal plumages appear to be rare. Questionnaires were sent to museums and zoos throughout the country (see p. 77) and out of a total of 1994 specimens, only two albino specimens were reported. One, at the Chicago Museum of Natural History, is only partially albinistic, having the crown, back of the neck, and wing's smudged with black, the back tinged with reddish, and the tail patterned, although much paler than normal. It is a male, collected February 15, 1928, at Roswell, Georgia, and included in the collection made by L. M. Taylor. The other is completely albinistic - a male, mounted and on display at the Museum of Natural History at the University of Oregon, Eugene. It was collected at Scio, Oregon, November 8, 1900, by George Brock, and prepared by Dr. A. G. Prill of Scio. None have been reported in the literature, nor is there any evidence to show that melanistic individuals ever occur.
Other Aspects

In discussing the annual cycle of the sparrow hawk a number of important features of its natural history were passed over completely or mentioned only briefly. These topics, concerning the food of the sparrow hawk and how it is obtained, its voice, the differences in behavior between the sexes, and its relations with other animals, will be discussed in the following pages.

Hunting and Flight

Much time is spent by adult wild sparrow hawks sitting quietly in a tree, or on telephone poles or wires along a road, especially during the middle of the day. Hunting is done primarily during the morning and late afternoon hours.

In hunting, the sparrow hawk shows excellent mastery of the art of flying; there is nothing clumsy or uncontrolled in any of its actions. Characteristically the hunt occurs over open fields. The entire area is covered methodically by a combination of actual flying, soaring, and hovering. If there is little wind, flying is frequent, with a quick wing beat that seems effortless. In still air there may be from two and one half to three wingbeats per second, which is increased to nearly five per second.
when the wind is moderate (8). On January 16, 1951, near Corvallis, a male easily maintained a position directly in front of a car travelling at twenty miles an hour. Broun and Goodwin (16) found that migrating birds at Hawk Mountain Sanctuary averaged 26.2 miles per hour.

If something attracts the hawk's interest, it hovers over the spot, a type of flight so characteristic that one of the many common names given to this species is 'wing-hover'. In hovering, the tail is usually spread fully, and the distal portions of the wings are winnowed rapidly through an arc of four or five inches (two inches above horizontal and two inches below). The head is nearly always pointed into the wind, and the tail is often lower than the body, giving an uptilted impression to the whole bird. In this fashion the sparrow hawk may hang motionless over a spot on the ground, head turned down to carefully detect anything worth closer attention, for periods up to a full minute, rarely longer. Then with a slight flip of its wings it will glide or fly over to a new location and repeat the performance. This stage of the hunting process usually takes place about fifty or sixty feet above the ground, but may be much higher.

If some small prey item is detected from this height, the sparrow hawk partially folds its wings and drops head-first to a lower elevation to hover again. After a moment
another drop is made to an even lower level, and the final
distance to the ground is made with a pouncing swoop dur-
ing which the feet are brought forward to grab the prey.

In hunting insects, the same general sequence of hov-
er and drop is followed, except that the final swoop is
changed to a slow, feet first descent, with wings flutter-
ing gently above the hawk's back, and ends with a quick
drop.

A third type of hunting frequently observed is con-
ducted from look-out perches in trees or along telephone
lines. From such a vantage point the hawk keeps the imme-
diate vicinity under close observation. If some form of
suitable prey presents itself, the hawk flies directly to
the spot and makes its capture. This hunting style is
often used for mammals, but seems to be more effective
when insects are the quarry. Frequently tadpoles or water
beetles in a roadside ditch may be located in this manner.

Soaring is not as frequent as in some other raptors,
but does occur. In soaring, the hawk spreads its wings to
their fullest extent, so that they appear less pointed
than usual. The tail is also spread, but not to the same
degree as in hovering. Circles and figure 8's are the
most frequent patterns followed, and most of the control
for these figures is accomplished by adjusting the spread
or twisting the angle of the tail.
On June 12, 1952, during a rain and wind storm, two sparrow hawks were observed having what appeared to be a wonderful time on the Oregon State campus. To quote from notes made at the time, they were "flying exuberantly — flashing down, dashing around", and seemed to relish the opportunity of testing their powers of flight on the strong winds which eddied and circled between the buildings.

The capture of prey items is made by the feet alone and, if a mammal, bird, or relatively large reptile or amphibian, the prey is immediately killed by biting at the base of the head. Insects are rendered helpless by the grip of the feet. In most cases, a few seconds are spent on the ground while the quarry is dispatched.

Wetmore (90) reports that sparrow hawks in Porto Rico plucked lizards from tree trunks while in full flight, but this was not observed among the birds studied. Bond (9) notes that the sparrow hawk can outmaneuver the pigeon hawk, but is not so fast.

Feeding

After capture, the prey is taken to a suitable perch and consumed. The perch may be only two feet above the ground, on a post or in a bush, or may be the top of a tree or telephone pole. Upon landing, the tail is almost
invariably pumped up and down two or three times in a rather deliberate manner. This action is very characteristic and serves to identify the sparrow hawk even when it is too far off to discern any other distinguishing features.

In feeding, the head is almost always the first part of the prey to be worked on. In mammals this is perhaps because the skin is too tough or smooth to give the beak a good purchase. Captives, for example, bite around the head, crushing the skull, while holding a mouse or young rat in the lumbar region with one or two claws on each foot. No tearing is attempted until the beak encounters a good grip on an eyelid, ear, or lip, and then tugging at such a point quickly exposes the meaty portions by skinning the animal in small strips. The strips are frequently swallowed, but may be discarded with a toss of the head. Mice or young rats are consumed entirely, but with birds or larger mammals the bigger bones are merely picked clean. Insects are swallowed whole if small, after one or two bites break the chitinous wing-shields, etc. If large, such as a grasshopper, the insect is held by the abdomen in one foot while successive bites work down from the head, very much as a human would eat a hot dog.

Young captive birds show a definitely possessive attitude when given food, especially if hungry. This takes
the form of crouching low over the food, with back to the observer. Wings and tail are partially spread to cover and shield the food, while a sharp watch is kept over the shoulder for any attempt at taking it away. This behavior is very likely a carryover from days in the nest, when two or three equally hungry nestlings might contest a single scrap of meat. In captives it probably remains much longer than it does in the wild, and has been noted occasionally in birds two years old, if they are very hungry.

None of the captives under observation was ever noted to drink, with one exception. A bird taken on a three day trip through northwestern California, Nevada, and the Mojave Desert took several beakfuls of water when it was provided at the end of the trip.

The food habits of the sparrow hawk have been quite thoroughly studied in the past, and a complete discussion here would seem superfluous. To give some idea of the frequency with which various food items are taken, Table V is presented. Each figure represents the number of times that particular type of prey was recorded from different sparrow hawk stomachs.

In general, the insects which form such a large portion (42.5%) of the food of the sparrow hawk are taken in the warmer months, while mammals (37.6%) are captured more frequently during the winter and early spring.
Table V - Food of the Sparrow Hawk

<table>
<thead>
<tr>
<th>Authority</th>
<th>Mammals</th>
<th>Birds</th>
<th>Other Vert.</th>
<th>Invert.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Couch (21)</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Errington (30)</td>
<td>21</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May (62)</td>
<td>427</td>
<td>147</td>
<td>69</td>
<td>282</td>
</tr>
<tr>
<td>Palmer (68)</td>
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<td>4</td>
<td>73</td>
</tr>
<tr>
<td>Pearson (69)</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Pearson (70)</td>
<td>13</td>
<td>1</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Taverner (87)</td>
<td>102</td>
<td>54</td>
<td>12</td>
<td>244</td>
</tr>
<tr>
<td>Total</td>
<td>570</td>
<td>210</td>
<td>92</td>
<td>643</td>
</tr>
<tr>
<td>Percent</td>
<td>37.6</td>
<td>13.9</td>
<td>6.0</td>
<td>42.5</td>
</tr>
</tbody>
</table>

The variety of food types is indicated by the following breakdown:

- **Mammals:** mice shrews, young ground squirrels, bats
- **Birds:** house sparrows, young robins, cliff swallows, tree swallows, domestic chicks, hermit warbler, sanderling
- **Other vertebrates:** lizards, horned lizard, garter snakes, frogs
- **Invertebrates:** grasshoppers, black beetles, long horned wood beetles, ground beetles, crickets, mormon crickets, ants, moths, cutworms, hairy caterpillars, cicadas

Items which might be considered somewhat unusual as food for this species are the bats (Stoner, 80; Wright, 94) and the sanderling (Hawbecker, 43). Both forms are excellent fliers and in most cases could probably escape from a pursuing sparrow hawk. Warburton (89) mentions a sparrow hawk eating bread in Toronto, Canada, during the winter. It had previously been in relatively close contact with a flock of feral pigeons.

Captive birds in my care have been fed primarily on stewing beef, eating from 30 to 45 grams per day. When available, whole mice or young rats are given, or
occasionally a bird. In the latter case a single bird the size of a cedar waxwing is split between two hawks. In various zoos the staple diet is horsemeat, plus mice or other small animals when these are available. An exception is the Philadelphia Zoological Park, which has developed an excellent general diet that seems acceptable to most of their hawks. (see Appendix B).

Wild sparrow hawks take in a certain amount of indigestible material, in the form of hair, feathers, or chitin, with every meal, as do all birds of prey. This material is formed into a pellet which is regurgitated a few hours later when the bird is quiescent - usually during the night. In the case of owls these pellets contain bones as well as fur and feathers, but hawks seem to be able to digest bones, which therefore do not usually appear in hawk pellets. Sparrow hawk pellets vary in size depending on the amount of indigestible material present, but average about one inch long by one half inch in diameter, and are rounded at both ends. These pellets have frequently been studied in determining the food habits of owls, but the absence of bones in hawk pellets renders them much more difficult to analyze. Errington (28)(29) has discussed the technique in detail, and Brooks (14) has pointed out some of the inaccuracies which may lead from such studies alone.
Captive sparrow hawks fed primarily on beef or horse-meat form no pellets. Falconers feel that all hawks in training for the hunt must have a casting once every other day for proper health, and provide roughage for this purpose. Examination of the pellet produced during the night provides an indication of the hawk's condition, normal pellets being firm, moist, well formed, and almost sweet smelling. After eight months without a casting, one of the captives observed in this study produced a black, slimy, odorous pellet, coated with mucous. However, all other evidence (appearance of droppings, general behavior, appetite) indicated this hawk to be perfectly healthy. It would seem that captive birds of prey, at least those not kept in hunting condition, do not absolutely require a casting four or five times a week for health, as falconers recommend. The evidence from longevity records at various zoological parks supports this hypothesis.

Normal defecation produces a white dropping with a black center. In cases of improper feeding, not enough exercise, or a bird which is too fat, these 'mutes', as they are termed, will show a green or brownish center, and will appear oily.
Voice

The typical cry of the sparrow hawk may be written as 'killy-killy-killy', 'keyee-keyee-keyee', or 'klee-klee-klee'. This is uttered in a rapid sequence of from five to thirty or more 'killies', depending on the stimulus which has evoked it, but averages about five to eight. It resembles somewhat the call of a flicker, but is delivered in a lighter manner, not hammered out as in that species, and is uttered with the beak wide open. Another call frequently noted in captives is a soft, almost conversational 'kree-kree', best described as a churr. The voices of young birds have been mentioned earlier, except for a 'cheep' uttered by some captive birds as yet unable to fly.

Sexual Differences

The general difference in behavior between males and females which has been mentioned earlier is marked enough to warrant further mention. It is observed in both wild and captive birds. Several examples will serve to illustrate the differences, but it should be mentioned that there is considerable variation between individuals. As a general rule, no captive female has ever become as tame as the tamest captive male, and conversely, no captive male has ever been as hard to manage as the most difficult
female.

As an indication of this behavior difference in wild birds, a pair which nested in the football stadium at Corvallis may be described. In 1952 this nest was visited at regular intervals to record the development of the young, and on each visit the behavior of male and female adults was in marked contrast. When the nest was first approached the female would fly out, yell for a moment, and then take a perch nearby, where she sat quietly for the remainder of the visit. She seemed completely oblivious to any possible danger to her young. The male, however, although usually absent at first, would appear on the scene very quickly and immediately initiate an attack on the observer, yelling loudly, gyrating and diving, at times coming within arm's length in a particularly daring pass. When the visit was over, the male quickly disappeared, while the female returned to the nest in about five minutes. This general pattern of behavior was noted at all nests visited, the male always taking the initiative in defense.

A young male and female were taken from this nest and showed similar differences in behavior. The male quickly became adjusted to the routine of being approached, handled, and fed, and after three or four days submitted to such treatment with little protest. The female, however, yelled, reared back defensively, and tried to escape for
nearly ten days, becoming tame much more slowly. When a dead mouse was presented to each bird, the male pecked at it a few times, then stood on it and started pulling at an ear, typical feeding behavior. The female pecked at her mouse also, but then lost interest and looked around for food. The mouse apparently meant nothing to her, although she was a day older than the male. On all occasions, whether being handled, fed, weighed, or carried about, the female was much more vocal in her protests at being disturbed, sometimes piercingly so.

Some weeks later, with both birds fully grown and accustomed to captive life, the female showed her wilder nature by being much more aggressive, especially at feeding time. She would jump about the cage so violently that the male was forced to stand back out of the way. After both birds received their food, the female would sometimes steal the male's portion before even touching her own. When feeding she would crouch low over her food, wings and tail spread protectively, to defend it from all possible intruders. The male ate openly, at ease and apparently unconcerned about the presence of the female or of watching humans.

The above example is not an isolated one. Of the eight sparrow hawks studied as captives during this investigation, the four males were all tamer and easier to
handle. The females always retained a trace of wildness, the amount varying in different birds, although treated the same as the males so far as handling, feeding, quarters and so on were concerned. Various people who have kept sparrow hawks of both sexes have told the writer of observing similar differences in behavior, and the literature contains several references to it. Sherman (77) reports that when young hawks in the nest were disturbed, the males retreated to the far side of the nest, with mouths open. The females sprang to the center of the nest, with "every feather on their heads standing out seemingly at right angles, wings spread, mouths open and squawking, ... ready to claw and bite." Holland (50), discussing two females and a male taken from the nest, describes the male as being "the most tractable". May (61) reports the same difference in two birds, a male and a female. The latter was much wilder and more vocal, whereas "the male was very docile and would have made a delightful pet." These reports bring out the point that this sexual behavior difference is not local in occurrence.

In trying to work out the reasons for this difference by careful observation of both captives and wild birds, the writer has come to the conclusion that it stems from a greater ability for adjustment to different situations in the male. The female not only adjusts more slowly, but
also does not achieve the degree of adjustment attained by the male. The male accepts and can adjust to a new experience or environment with as little disruption of his normal life as possible under the circumstances. The female resists any attempt to change the status quo, and the greater the change, the more violent the resistance.

It is of interest to note that several falconers to whom this point was mentioned reported that no such behavior difference can be noted in the larger falcons, such as the duck hawk, or peregrine, or the prairie falcon. No information is available regarding the situation in the pigeon hawk, a form approximately the same size as the sparrow hawk.

**Interspecific Relations**

In keeping with the seemingly adaptable behavior of the sparrow hawk, evidenced by its ready acceptance even of urban environments, it is interesting to note several cases of apparent tolerance of other species while nesting. Bellrose and Low (4) have reported a sparrow hawk incubating wood duck eggs, while Hanna (39, 40) and Sumner (83) report three cases of sparrow hawks nesting with screech owls. Hall (38) mentions an addled egg of a sparrow hawk in a saw-whet owl nest, and Johnson, Bryant, and Miller (55) cite a case where four sparrow hawk eggs were found
in the same cavity with three added flicker eggs. Another type of neutral relationship is cited by Dixon and Krutzsch (26), where a sparrow hawk and a California jay roosted together in the same deserted cabin.

Being a hawk, although a small one, the sparrow hawk is subjected to a certain amount of bullying or harassing, from other species of birds. Brewer's blackbirds have frequently been seen chasing sparrow hawks in flight, but do not seem to be so bold when the sparrow hawk is perched. In flight the blackbirds follow closely, and on occasion have been seen to peck a male on the back. Near Bend, on June 7, 1953, a male sparrow hawk was seen feeding unconcernedly with blackbirds hopping all about him, not more than six inches away. They made no real attack however, until the hawk finished feeding and flew off, upon which eight or ten followed to harry and peck him.

Other birds also show no fear of the sparrow hawk. Robins will spend hours heckling young hawks, yelling and diving at them, but are not as aggressive as the blackbirds. Cross (25) reported seeing a flock of 40-50 chimney swifts chasing a sparrow hawk. A shrike has been observed robbing a sparrow hawk of its prey (Hill, 48) and magpies may drive sparrow hawks away from their nests (Linsdale, 60).

Aggressive behavior is also evidenced. During the
present study sparrow hawks have been observed to chase and harry robins, band-tailed pigeons, and red-tailed hawks, especially when the latter are carrying prey to their nests. Reports from the literature indicate it may also chase meadowlarks, pigeon hawks, and road-runners (Dyer, 27), golden eagles (Broun, 15), and has been observed fighting with a starling (Hartshorn, 42) and a sharp-shinned hawk (Cram, 23). Such birds as young robins or starlings may occasionally be taken as food, but in the above cases of band-tailed pigeon, meadowlark, and pigeon hawk, the sparrow hawk was apparently chasing in a playful manner. The birds concerned showed no signs of fear, merely flying far enough to get out of the way.

Behavior of Captives

Most of the captive birds studied were taken from the nest before they could fly, and hence their reactions to various conditions cannot be considered as identical with those of wild birds. In many cases, the behavior shown is largely instinctive, with modifications due to captivity. Captives frequently showed behavior almost certainly not found in wild birds, but the basic behavior patterns remained the same, being produced from the same basic instincts.

When first taken from the nest young birds are so
defiant they must be hand fed for two or three days. Without this hand feeding the growing feathers will show weakened areas, known as 'hunger streaks'. Males quickly adapted to new surroundings and began to feed themselves from one to two days sooner than their sisters.

The behavior of young birds during their development has been outlined previously, with one exception that was noted in captive birds, and which may not occur in the wild. At least four captives displayed this attitude, which for convenience may best be termed 'setting', and occurred at the age of five or six weeks. It consists of lying flat on the ground, the entire ventral surface being in contact. The wings sag limply, resting on the ground, and the feet may be either tucked up under the body or extended posteriorly. The head is usually held up, but is tucked down on the shoulders. The entire attitude resembles that of a bird sitting on eggs. In this position the young hawks would often lie in the early morning sun, picking at ants crawling through the grass. Later in the day they would 'set' on their block perches, so relaxed that wings and tail would droop downward. At this time they kept their feet under them, and rose to standing position at any disturbance.

This 'setting' attitude may be associated with the fact that the young birds' muscles and bones have not yet
become accustomed to sitting for long hours on a hard perch, as they do in captivity. In the wild, the strain on feet and legs is relieved by considerable time spent on the wing.

When well fed and otherwise content captives will often 'rouse', using the falconer's term. This involves ruffling and shaking the feathers to place them in order, and is an excellent indication of the condition of the bird.

If the day is hot captives sit with smoothed down feathers, partly opened wings, and open bill, giving the impression of panting. On such days most individuals relish a shower from the hose, with the nozzle adjusted to a fine spray. When hosed down in this manner they crouch down and ruffle their feathers, dipping and bobbing their heads as if bathing in a pan or pool. (This bathing activity was once noted during a mild summer rain as the hawk, a male, sat on a perch in its cage, four feet above the ground.) If water is provided in a container, most birds will bathe every day that the sun shines and there is little wind, even in midwinter.

When cold, the feathers are ruffled out, the neck sinks into the shoulders, and one foot may be tucked up under the belly feathers. Similar attitudes have been noted in wild birds.
If perched on blocks only a foot or two above the ground, captive hawks showed fear immediately at sight of a dog or cat, yelling loudly, and if approached jumped off the block in an attempt to escape. In a cage, the hawks would sit on perches five feet above the ground and quietly watch a dog come up to the cage, sniff about, and trot off. If a cat approached the cage however, the hawks would 'killy-killy', often flying wildly about the cage. This may have been due to their recognition of the cat as an animal which often visited their cages at night, prowling about and over the top in an effort to find a way to get at the birds.

On one occasion, in Corvallis on August 17, 1952, two hawks tethered to blocks suddenly began yelling excitedly. Upon investigation, an immature Cooper's hawk was seen flying away. It was surmised that the latter had made an unsuccessful attempt to capture one of the sparrow hawks. Even two years later the male of this pair (the female escaped soon after this incident) would watch carefully any flying object, and would frequently announce a red-tailed hawk at a distance that would render it a mere speck to human eyes. On one occasion this individual mistook a flying domestic pigeon for a hawk, and killed accordingly, but on all other occasions was correct in his identification. No excitement was caused
by wild ducks or other large birds.

One bird was offered a whole sparrow for the first time at the age of five months. The first action was to pluck the bird, especially on the breast, an action which he never before had observed, except possibly while in the nest. The parents moreover, usually pluck birds to be fed to the nestlings before the prey is brought to the nest.

In the spring robins seem to have an especial hatred for sparrow hawks, and males would spend hours making passes at young hawks tethered in the yard, yelling almost continuously. The hawks usually ignored the robins, although they were pecked on the back at times. If a robin happened to land near a tethered hawk, the latter would fly at it, but be brought up short by the leash. The robins seemed to learn quickly the limits of safety. Other birds, such as linnets, house sparrows, goldfinches and swallows would protest by chirping or flying about, but tired of this activity in ten or fifteen minutes, leaving on other business. Robins were troublesome however, and males seemed especially persistent in their efforts to get rid of the young hawks.

A young barn owl kept near the hawks was ignored after the first day, when what might be termed 'polite interest' was displayed by the hawks. Even its powerful hissing and vicious, wing-flapping attacks on the writer
at feeding time were completely ignored, although the hawks were less than ten feet away. A wing-clipped seagull produced a similar lack of interest.

Different captives responded differently to strangers that came to see them. One male would eye the intruder carefully during the entire visit, and would fly off its perch at any sudden movement. On one occasion, when five or six small children were gathered closely around it, it regurgitated four or five scraps of meat from its meal an hour before. Another male would allow anyone to walk right up and extend their hand, making no fuss about being picked up. The first male mentioned above is one which has been captive for nearly two years. He recognizes both my wife and myself, and has always permitted us to handle him as freely as we wish. He shows what may best be described as pleasure when we are near him, rousing or jumping to our hand even after having been fed, and hence not looking for food. He churrs gently when spoken to softly. He tolerates my two year old daughter, permitting her a much closer approach than he allows other children without becoming excited, but seems to realize that her rather abrupt movements at times are a possible source of injury. The second male, as mentioned above, although less than a year old, shows no particular recognition or excitement with regard to anyone, and in addition does not
become alarmed at the sight of soaring hawks or passing dogs. Cats elicit an attitude of wariness, but no more. This individual has only once been heard to utter any type of vocalization, although he frequently hears the other bird yell, churr, etc.

Captive females also show considerable variation in behavior, some becoming definitely tame and capable of recognizing the hand that feeds them, others merely accepting their captive situation with no indication of interest or resistance. In general however, females tend to be a bit more shy and less easy to handle.

A male hawk given to the writer in Bend after being cared for by a high school student for several months showed an unusual trait. This bird had been taken from the nest before its feathers were completely grown, and had not fed sufficiently during the rest of their growth. The critical period of two or three days immediately after removal from the nest was probably not taken into account by forced feeding. Hunger streaks, weak spots known to every falconer, appeared at the bases of all the flight feathers. In preening himself after the first fall body molt this bird apparently encountered these spots and chewed at them. The result was that in the course of one month he had completely crippled himself. All primaries from the right wing had been completely trimmed
off, and only one was left on the other wing. Only two feathers were left in the tail. This bird also completely amputated the inner toe of the right foot after it was accidentally injured, although the original injury caused only a slight bleeding. Continued picking at the spot enlarged it more and more, eventually exposing the bone, and then even the bone was broken off. The wound produced would not heal due to the continued removal of the scab by this sparrow hawk. Finally a large blood vessel was exposed on March 25, 1954, and during the next two days a considerable amount of blood was lost. On the morning of March 28, following a night with a minimum temperature of 18°C, this hawk was found dead. Evidently loss of blood, plus the cold, were responsible for its death, since no signs of anything pathological were observed.

**Breeding in Captivity**

In discussing the behavior of captive birds, some mention must be made of attempts to breed the sparrow hawk in captivity. So far as can be determined, this has never been accomplished. None of the zoos which returned questionnaires reported any cases, although two (Denver, Philadelphia) had noted indications of breeding behavior. They did not report what they considered to be indications of breeding. However, the related European
species, the kestrel, was successfully bred in England, according to Prestwich (73, p. 9). His review of the literature reveals nesting records among captive kestrels in 1849, 1866, and 1896. The 1866 record is the only one which gives any details, and these are of sufficient interest to be quoted:

"... On calling at the shop of Mr. Rogers, naturalist, Plymouth, I was asked into the aviary..., and on observing a female kestrel crouched in the corner of a cage not five feet long by about three feet high, and not two feet broad (with her feathers ruffled and her wings partially spread, as if pluming her prey), asked what it meant, and was told she had been sitting on five eggs, had just hatched one young one, and that the male, which was on a perch close by, had regularly taken his turn on the nest. Of course, feeling interested, I called again in about a week, and found that the whole five had been hatched, one on every alternate day; but, strange to say, directly after the second chick was produced, she killed and ate the first, and after the third she ate the second, and so on to the fourth, allowing each to live one day, when Mr. Rogers, wishing to save at least one young bird, took away the fifth, hoping to rear it by hand, but it lived only a day or so." — John Gatcombe, Plymouth. From the Field newspaper.

Upon finding the above record, it was decided to attempt breeding our native sparrow hawk, and a cage six by eight by four feet was constructed, with a nest box meeting the specifications for this species. For two years a male and female were obtained from nests, since it was suspected that young birds would accept captive conditions more readily. The first year the female escaped, and the second female died of an overdose of
carbon tetrachloride given in a futile effort to obtain external parasites. The breeding attempt will be repeated again next year, but the data will not be available until 1955, or later.

Mortality and Disease

Sparrow hawks have few natural enemies - the golden eagle (18), peregrine falcon (17), and horned owl (34) being the only ones reported in the literature. The bird Banding records mention two sparrow hawks killed by hawks, one a red-tailed hawk. From the fact that a Cooper's hawk made an attack on a pair of captive birds in Corvallis (p. 60), it may provisionally be added to the list. The banding records indicate that one band was recovered from a screech owl's nest, but in view of the occasional close association of these species (p. 55) this is not necessarily a case of predation. Probably any of the larger hawks or owls will occasionally take wild adults, and various tree-climbing mammals may at times rob nests or take sleeping birds.

At a nest near Bend two young disappeared at the age of eight or nine days. At the time, it was felt these birds had been taken as pets by some local boy, but it is also possible that they died (this being the nest where the heavily pigmented leg condition was noted) and were
removed by the adults, or perhaps even eaten by the remain-
ing nestlings. If an animal had robbed the nest it would
seem reasonable to assume that all the young would be taken,
either at once or over a period of several days.

Man is probably the most serious enemy of the sparrow
hawk. The banding records show that of 185 banded birds
for which the cause of death was listed, 45 were shot.
Two other categories, "found dead" (52) and "killed" (32),
probably include a number of birds which were shot. Other
causes of death attributable directly or indirectly to man
include being trapped (28), captured (12), dying of injur-
ies (12), falling down a chimney, electrocuted by a power
line, flying into a window, or being hit by a car or loco-
motive (one each). Cross (24) tells of a female which
entered a courtyard in the center of an 85 foot office
building. Although open to the sky, this hawk did not
seem to realize it could escape by flying up and over the
walls, and died of starvation.

Several other unusual cases may also be mentioned.
The banding records mention one bird which was "attacked
by kingbirds, protecting their nests, driven to ground
and killed by two other sparrow hawks." Another was
killed by jays, one by a cat, and a third was killed by
lightning. One died of starvation and one "died from
cold"; whether environmental or a respiratory infection
is not indicated. Little is known of the parasites of wild birds in general, and only a few species have been recorded from the sparrow hawk. In the spring of 1953, black-flies were found in great numbers at one nest, biting the young hawks through their down. Aside from local irritation around the bites, the young hawks seemed to be unaffected by the flies. Several were collected and were subsequently identified as *Simulium canonicolum* (D. & S.) by Dr. A. Stone, of the U. S. National Museum. Blowfly (Protocalliphora) larva have been found infesting the ears and nostrils of several raptorial birds, including the sparrow hawk, in California (Hill and Work, 45; Hill, 46). A single louse (Mallophaga, *Degeeriella giebeli* Hopk., det. by C. F. Muesebeck, USNM) was obtained from a sparrow hawk subjected to a carbon tetrachloride treatment. Since the hawk died as a result of the treatment, this method was not attempted again.

At the above mentioned black-fly infested nest, five young and the adult female showed excessive pigmentation of legs, cere, and region about the eye. In addition the legs were so swollen that an aluminum band of the proper size for this species could just be fitted, allowing no room for turning on the leg. Subsequently two of the young at this nest disappeared, the remaining three all being females. The adult female was shaggy and unkempt
in appearance, and her feathers appeared thin and worn. This condition was reported to Dr. Patricia O'Connor, veterinarian at the Staten Island Zoo, in New York, who is studying diseases in wild birds and mammals. She replied that a similar condition had appeared in several birds at the zoo, including a king vulture which was on exhibition for six years. Upon its death, autopsy showed a distinct nephritis, but whether this had any connection with the swelling could not be determined.

Some of the commoner diseases to which captive hawks are susceptible are mentioned by Russell (75, p. 139-141), and include head colds, "croaks" (a disease similar to a severe cold, and named for the sound made by the hawk in flying), frounce (a fungus infection of the mouth), inflammation of the crop (leading to insufficient food intake), and coccidiosis.

Population Dynamics

Very little information is available concerning the life span of wild birds, the unpublished records of the Federal Bird Banding Program being the only source. The banding program was started by a private organization, the American Bird Banding Association, in December, 1909, but was taken over by the Fish and Wildlife Service in 1920. Since that time 2,661 sparrow hawks had been banded up
to 1949, an average of 92 a year. Only 210 bands had been returned in the 30 years between 1924 and 1953—approximately 7 each year. Considering the relative abundance of the sparrow hawk, this represents a very small sample, and conclusions reached from an analysis of this sample may be far afield.

In addition to the small size of the sample, another factor must be considered. For obvious reasons, those birds which nest in relatively close association with man will be most frequently banded, and will also be those which are most frequently killed by man. The data supports this point, since of 185 birds for which the cause of death was recorded, 107 (56.7%) were killed, shot, trapped or otherwise destroyed by human agencies, a figure which seems much too high. Many were also reported as "found dead", and these very likely include a number of birds killed by man. It is apparent that birds banded and recovered represent only those which have a relatively close association with civilization, leaving a large part of the population untouched so far as records are concerned.

In spite of these drawbacks, the reports provide the only information available on wild birds. The following table presents the data on 150 birds of known age (adult and juvenile) at the time of banding.
Table VI - Mortality of Banded Sparrow Hawks (1924-1953)

Years after banding that bird died - less than:  $1\text{ yr}$ $2\text{ yr}$ $3\text{ yr}$ $4\text{ yr}$ $5\text{ yr}$ $6\text{ yr}$ Tot.

<table>
<thead>
<tr>
<th>Adults</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of total</td>
<td>60%</td>
<td>20%</td>
<td>11.1%</td>
<td>8.8%</td>
<td>-</td>
<td>100%</td>
</tr>
<tr>
<td>Mortality each year</td>
<td>60%</td>
<td>50%</td>
<td>55%</td>
<td>55%</td>
<td>(Ave. 55%)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Juveniles</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of total</td>
<td>63%</td>
<td>25.7%</td>
<td>4.8%</td>
<td>3.9%</td>
<td>1.9%</td>
<td>1% 100%</td>
</tr>
<tr>
<td>Mortality each year</td>
<td>63%</td>
<td>70%</td>
<td>43%</td>
<td>(Ave. 59%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total average yearly mortality: 57%
This represents the percent of the banded birds alive at the beginning of each year which died during that year.

On the basis of an average annual mortality of 57%, the life span of banded sparrow hawks is about one year and eight months. The oldest wild bird was a female, banded as a juvenile near Hollywood, California, which was recovered five years and eleven months later from the same locality.

The data for captive birds shows a different picture. The questionnaires returned by zoological parks afforded the information presented in Table VII.

On the basis of the scanty figures, the average age reached by captive sparrow hawks is five years and two months. Two exceptional cases may also be cited. The first was a male which was a house pet for fourteen years before strangling on a curtain cord (Jack Marks, Director, Wash. Park Zoo, Portland, Ore., in a personal letter dated
Table VII - Age of Captive Sparrow Hawks

<table>
<thead>
<tr>
<th>Institution</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Zoo, Calgary, Alberta, Canada</td>
<td>2 yr.</td>
</tr>
<tr>
<td>Chicago Zool. Park, Brookfield, Ill.</td>
<td>3 yr. 5 mo.</td>
</tr>
<tr>
<td>Lincoln Park Zoo, Chicago, Illinois</td>
<td>4 yr.</td>
</tr>
<tr>
<td>City Zoo, Buffalo, New York</td>
<td>4 yr.</td>
</tr>
<tr>
<td>Washington Park Zoo, Portland, Oregon</td>
<td>4 yr. 7 mo.</td>
</tr>
<tr>
<td>Philadelphia Zool. Park, Phila., Penn.</td>
<td>6 yr.</td>
</tr>
<tr>
<td>&quot; &quot; &quot; &quot; &quot; &quot; &quot; &quot; &quot;</td>
<td>6 yr.</td>
</tr>
<tr>
<td>City Zoo, Memphis, Tennessee</td>
<td>7 yr.</td>
</tr>
</tbody>
</table>

February 5, 1953). The other was a male seen with an animal show associated with a small carnival in 1952. It was said to have been with the show for four years, and had belonged to a preceding owner for at least five and possibly six years. This bird was the most completely adult specimen the writer has ever seen, with a very deep cinnamon chest, completely devoid of any black markings.

In view of the disadvantages associated with the data from banding returns, and the age achieved by captives, it seems reasonable to estimate the average age reached by wild sparrow hawks as about two and a half years.

The total number of sparrow hawks in an area is difficult to estimate, since only rarely does this species congregate in numbers (see Migration, p. 35). In addition to these groups, an instance of almost communal nesting has been reported from Adams County, Mississippi, where "many pairs" were found nesting in a newly cleared field only
about one mile long by one half mile wide (79).

The best and simplest method for estimating a sparrow hawk population (and it holds for most other raptors as well) is by making roadside counts. In this method the number of birds observed from a car while traversing the roads of an area is taken as an approximation of the relative abundance of the species. If mileage is recorded for each, an estimate of the density can be obtained. There are, unfortunately, at least three disadvantages to this method. First, roads do not always traverse suitable sparrow hawk habitat. In addition, sparrow hawks in open country seem to congregate along roads, since telephone lines are favored perches, and these are often located along roads. This can lead to an over-estimate, due to counting a concentration rather than a normally spread population. Finally, only certain seasons can provide a reasonably accurate picture of the normal population of an area. In the spring many birds are either at the nest or away from roads in good hunting territory. Fall brings a shifting population as birds over a wide area drift southward. Late summer seems to be the best time, after the young are on the wing. With these difficulties recognized, road census is still the most practical method available.

Hiatt (44) has used this method in Montana to obtain
an idea of the relative abundance of raptors in that state. The sparrow hawk was by far the most abundant, comprising 49.8% of all raptors seen.

Personal observations are too few to be of conclusive value, but do give some idea of relative abundance at different seasons, with results as indicated in Table VIII. The table shows counts obtained on various trips made during this study.

Table VIII - Sparrow Hawks Seen on Trips

<table>
<thead>
<tr>
<th>Route</th>
<th>Miles</th>
<th>Birds Seen</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corvallis - Eugene</td>
<td>40</td>
<td>11</td>
<td>12-22-51</td>
</tr>
<tr>
<td>Corvallis - Eugene</td>
<td>40</td>
<td>14</td>
<td>12-28-51</td>
</tr>
<tr>
<td>Corvallis - Eugene</td>
<td>40</td>
<td>1</td>
<td>4-10-52</td>
</tr>
<tr>
<td>Corvallis - Tidewater</td>
<td>56</td>
<td>3</td>
<td>12-7-51</td>
</tr>
<tr>
<td>Corvallis - Oceanlake</td>
<td>75</td>
<td>7</td>
<td>2-23-52</td>
</tr>
<tr>
<td>Eugene - Cottage Grove</td>
<td>22</td>
<td>1</td>
<td>4-10-52</td>
</tr>
<tr>
<td>Bend - Culver</td>
<td>48</td>
<td>4</td>
<td>3-3-53</td>
</tr>
<tr>
<td>Bend - Culver</td>
<td>48</td>
<td>3</td>
<td>3-31-53</td>
</tr>
<tr>
<td>Bend - Klamath Falls</td>
<td>138</td>
<td>1</td>
<td>8-24-53</td>
</tr>
<tr>
<td>Susanville-Reno-Bishop</td>
<td>281</td>
<td>9</td>
<td>8-25-53</td>
</tr>
<tr>
<td>Bend-Burns</td>
<td>132</td>
<td>4</td>
<td>6-7-49</td>
</tr>
</tbody>
</table>

As can be seen, during most of the year the birds are scattered. A somewhat different idea of concentration can be obtained by closely observing a relatively limited area during the nesting season, and determining the number of pairs present. By this method it was found that four pairs within a two by three mile area west of Corvallis each occupied one square mile or slightly less. Boundaries were determined more by available habitat than by
other territories. This estimate of approximately one nesting pair for one and two thirds square miles is probably rather high. Judging from notes made in New York, Virginia, California, and the Bend area of Oregon, in most regions one pair per five square miles would be more accurate.

A third method is for a group of observers to count the total number of sparrow hawks seen in an area, each observer working a different section. The annual Christmas bird census conducted by the National Audubon Society is an example of this method, and from published reports (2) the data presented in Table IX on wintering sparrow hawks in Oregon was obtained.

Table IX - Wintering Sparrow Hawks in Oregon

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Portland</td>
<td>28</td>
<td>20</td>
<td>18</td>
<td>14</td>
<td>24</td>
<td>13</td>
<td></td>
<td>117</td>
</tr>
<tr>
<td>Eugene</td>
<td>9</td>
<td>21</td>
<td>6</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td>65</td>
</tr>
<tr>
<td>Malheur Refuge</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Klamath</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Note the winter concentration in the Willamette Valley which is brought out by Tables VIII and IX, a topic previously discussed (pp. 37-38).

In the course of attempting to gather data on population an interesting point appeared. As the hawks were observed, the sex was recorded when it could be determined.
Very shortly it became evident that there were more males than females. Over a period of three years during which records were kept, 52 males (65%) were recorded, as against 28 females. These figures are small because no attempt was made to record sexes except on long trips, to avoid the possibility of repeats, and only positively identified individuals were counted. Although no record was kept, males were seen more frequently even during the late nesting season, when it would be expected that both birds of a pair would be out hunting for food for the young.

In order to check on the accuracy of the above observations, a question concerning the number of specimens of each sex was included on the questionnaire which was sent out. The results are recorded in Table I. Several of the zoos which returned questionnaires were unable to give figures on sexes, since records of that nature were not kept.

The totals show that only 52.8% of the specimens in collections are males. However, it must be remembered that most collections attempt to obtain roughly equal numbers of both sexes, so as to have adequate series of both. In addition, the majority of institutions have relatively few specimens, and of these, most have more males than females. Of the thirty-three institutions which answered the question on sex ratios, twenty-two had more males. Only two museums with large series indicated a majority
Table X - Institutions Where Questionnaires Were Sent.

The numbers after the name of each institution represent the number of males (M) and females (F) reported. Those without numbers did not reply. Where a college or university is named, the questionnaire was sent to the Museum of Natural History (MNH) at that college.

<table>
<thead>
<tr>
<th>Museums</th>
<th>M</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>California</td>
<td>78</td>
<td>54</td>
</tr>
<tr>
<td>Los Angeles Museum, Los Angeles</td>
<td>27</td>
<td>24</td>
</tr>
<tr>
<td>Mus. Vert. Zoology, Berkeley</td>
<td>178</td>
<td>194</td>
</tr>
<tr>
<td>San Diego MNH, San Diego</td>
<td>48</td>
<td>50</td>
</tr>
<tr>
<td>Santa Barbara MNH, Santa Barbara</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Colorado</td>
<td>36</td>
<td>19</td>
</tr>
<tr>
<td>Univ. of Colorado, Boulder</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Florida</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Univ. of Miami, Coral Gables</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Idaho</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Univ. of Idaho, Moscow</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Illinois</td>
<td>133</td>
<td>121</td>
</tr>
<tr>
<td>Iowa</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Univ. of Iowa, Iowa City</td>
<td>30</td>
<td>7</td>
</tr>
<tr>
<td>Kansas</td>
<td>38</td>
<td>29</td>
</tr>
<tr>
<td>Univ. of Kansas, Lawrence</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Louisiana</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Univ. of Louisiana, Baton Rouge</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Michigan</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Mich. St. College, East Lansing</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Univ. of Michigan, Ann Arbor</td>
<td>107</td>
<td>135</td>
</tr>
<tr>
<td>New Mexico</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Univ. of New Mexico, Albuquerque</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>New York</td>
<td>116</td>
<td>118</td>
</tr>
<tr>
<td>American MNH, New York City</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cornell University, Ithaca</td>
<td>41</td>
<td>24</td>
</tr>
<tr>
<td>Syracuse University, Syracuse</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ohio</td>
<td>36</td>
<td>21</td>
</tr>
<tr>
<td>Cleveland MNH, Cleveland</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Oregon</td>
<td>18</td>
<td>15</td>
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<tr>
<td>Ore. St. College, Corvallis</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Univ. of Oregon, Eugene</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>Penn. St. Col., State College</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Univ. of Penn., Philadelphia</td>
<td>-</td>
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<tr>
<td>Texas</td>
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<td>-</td>
</tr>
<tr>
<td>Tex. A&amp;M College, College Station</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Washington</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Wash. State College, Pullman</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Univ. of Washington, Seattle</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Univ. of Wisconsin, Madison</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Totals: 978 862

Zoological Parks:

<p>| California | - | - |
| San Diego Zoo, San Diego | - | - |
| Fleischacker Park, San Francisco | - | - |
| Griffith Park, Los Angeles | - | - |
| Colorado | - | - |
| Denver Zoo, Denver | 'scores' | - |</p>
<table>
<thead>
<tr>
<th>State</th>
<th>Zoo</th>
<th>M</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Georgia</td>
<td>Atlanta Zoo, Atlanta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illinois</td>
<td>Brookfield Zoo, Brookfield</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Lincoln Park, Chicago</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Iowa</td>
<td>Des Moines Zoo, Des Moines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kansas</td>
<td>Kansas City Zoo, Kansas City</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wichita Zoo, Wichita</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Louisiana</td>
<td>Audubon Park, New Orleans</td>
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<td></td>
</tr>
<tr>
<td>Massachusetts</td>
<td>Boston Zoo, Boston</td>
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<td>Michigan</td>
<td>Detroit Zoo, Detroit</td>
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<td>Minneapolis Zoo, Minneapolis</td>
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</tr>
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<td>New York</td>
<td>Bronx Zoo, New York City</td>
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<td>Buffalo Zoo, Buffalo</td>
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<tr>
<td></td>
<td>Staten Island Zoo, Staten Island</td>
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<td></td>
<td>Cincinnati Zoo, Cincinnati</td>
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<td></td>
<td>Cleveland Zoo, Cleveland</td>
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<tr>
<td>Ohio</td>
<td>Tulsa Zoo, Tulsa</td>
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<td>Oklahoma</td>
<td>Washington Park, Portland</td>
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<tr>
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<td>Philadelphia Zoo, Philadelphia</td>
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<td>Dallas Zoo, Dallas</td>
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</tr>
<tr>
<td>Texas</td>
<td>Fort Worth Zoo, Fort Worth (unsexed)</td>
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</tr>
<tr>
<td></td>
<td>Houston Zoo, Houston</td>
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<td></td>
</tr>
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<td>San Antonio Zoo, San Antonio</td>
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<td>Tennessee</td>
<td>Memphis Zoo, Memphis</td>
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<tr>
<td>Utah</td>
<td>Salt Lake City Zoo, Salt Lake City</td>
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<tr>
<td>Washington</td>
<td>Woodland Park, Seattle</td>
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<tr>
<td>Washington, D.C.</td>
<td>National Zoological Park (unsexed)</td>
<td>71</td>
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<tr>
<td>Canada</td>
<td>Calgary Zoo, Calgary, Alberta</td>
<td>1</td>
<td>0</td>
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<tr>
<td></td>
<td>Winnipeg Zoo, Winnipeg, Manitoba</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Toronto Zoo, Toronto, Ontario</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Totals 53 59

Total from Zoos - 186 plus Total males:1031
Total from Museums - 1340 Total females:921
Grand Total 2026 plus Males - 52.8%
Females - 47.2%
of females.

Another item dealing with sex ratios of this species is the report of Broun (15, p. 17), based on observations at Hawk Mountain Sanctuary in Pennsylvania. He states that about 65% of migrating sparrow hawks passing over the sanctuary are males. This figure is based on an average of 130 birds observed each year between August and November. Again, 65% of all banded sparrow hawks recovered are males. In addition, the group courtship activity mentioned by Childs and Mossman (19) and Dunlap (verbal communication, see p. 14) tends to support the data given above. Fast and Barnes (32) also mention a case of apparent polyandry.

In contrast to this male majority, it should be pointed out that in at least six nests where sexes were determined, the total of males and females was thirteen for each sex.

In conclusion, there appears to be sufficient evidence to state that males are more frequently encountered than females, the former comprising 60% to 65% of the population. It can be postulated from these figures that although all females in an area will probably mate, there is usually an excess of males which remain unmated.
Discussion

The preceding pages have presented the available facts on the natural history of the sparrow hawk, many of them for the first time. These facts provide much basic information, but represent only a beginning toward a complete picture of the life and habits of the sparrow hawk. Such a complete picture would require at least ten or fifteen years of intensive investigation, due to the many problems involved in studying a wild predatory bird. A brief discussion of some of these problems may be of value to future investigators.

Foremost among these problems is the relative abundance of raptorial birds. The sparrow hawk is regarded as common throughout most of its range, but common for a hawk represents a much smaller number of individuals than, for example, common for a robin or sparrow. Robins may nest every hundred yards throughout an area, to be considered common. In contrast, an area with a high concentration of sparrow hawks may produce only one pair every two or three miles. This reduces the number of individuals available for observation considerably.

The most satisfactory means of studying the various aspects of behavior, development of young, and the establishment and maintenance of territories is to observe an
adult breeding pair at the nest. Since nests are usually a cavity of some sort in a tree, rather than an easily spotted structure of sticks, they are often very difficult to locate. Near Bend, nearly 20 hours were spent over a period of several days in a futile search for a nest almost certainly within a quarter-mile square area, its presence being strongly indicated by the actions of a pair of adult sparrow hawks. It was never found. When a nest is located, the entrance hole must usually be enlarged so the young may be removed for observation and weighing. This is done with a keyhole saw in one hand, the other hand being used to cling to the tree. In tough juniper it may take an hour to open a nest - a tedious and tiring job.

Chance is an important factor in a field study of this nature. Should some important, but rarely observed, aspect of the sparrow hawk's life cycle be missed one season, an entire year must pass before that aspect again occurs, with a consequent delay in obtaining the desired information. Only once in three years, for example, was the copulation of sparrow hawks observed, yet this point is one on which more information is particularly desired, to clarify the prevalence of polyandry. Since 1890, there have been only a half dozen descriptions of copulation among sparrow hawks in the literature, including those mentioning polyandrous activities.
Such problems as those concerning breeding behavior, territories, and sex ratios could certainly be clarified by several more years of intensive observation. There remain a number of other problems, however, relating especially to the population dynamics of the sparrow hawk, which even fifteen years of work, under present conditions, could not solve. Such questions as—what is the actual mortality rate among sparrow hawks?; what is the actual life span?; how widespread is the occurrence of migration throughout the population?—can only be answered after an intensive banding program. Since 1924 less than 3000 sparrow hawks have been banded, and information on the above topics is limited to an analysis of only 210 recoveries—only seven a year! At this rate, even fifteen years might not be sufficient time for obtaining complete answers.

A study of the natural history of an animal—that is, its life and habits within its natural environment—is, of necessity, a field study. In the course of the present study, over 1000 hours were spent in the field, but due to the problems previously mentioned, this figure was reduced to less than 300 effective hours during which sparrow hawks were actually being observed. This represents a striking contrast to an equivalent laboratory study in which experiments can usually be performed at any time and can be repeated almost at will.
From the facts which are available, what conclusions may be drawn concerning the sparrow hawk as a species? The most obvious conclusion concerns the adaptability of the sparrow hawk. The species is found throughout the western hemisphere, and is not restricted to any climatic zone, but rather to a general vegetation type. It is not rigidly limited to the most favorable habitat, but also occurs in a number of others, although in reduced numbers. Open areas of any type are satisfactory, provided suitable nesting sites are available. Taverner (87) has cited evidence to illustrate the importance of nesting sites. He reports that before the construction of transcontinental telephone lines, sparrow hawks were absent from large parts of the treeless prairie country of central Canada. After the installation of such lines, flickers followed the lines out from their more normal, wooded habitat, constructing nesting cavities in the poles, and sparrow hawks followed them, utilizing the nest sites made by the flickers. They are now found quite commonly in this central part of the continent.

Although nest sites must be available, since sparrow hawks do not construct their own, the type available is not critical. As long as some sort of partially enclosed cavity is present, nesting takes place with no apparent difficulty. In some cases the sparrow hawk will even
occupy the same nest concurrently with other hole-nesting species (p. 55). When a nesting site is available, the sparrow hawk's reproductive urge is apparently strong enough to overcome any other potential obstacles. The food habits of the sparrow hawk are not restrictive; if a prey species is available, it is preyed upon, whether it be grasshoppers or bats. If a normal prey is scarce it may even turn to usually unacceptable foods, such as bread (pp. 47-49).

In many cities the sparrow hawk has adjusted to urban life successfully, and is frequently observed over large wasteland areas, such as city dumps, or at golf courses, parks, school campuses or similar areas which likewise provide sufficient open habitat. Food and nesting habits of urban sparrow hawks have changed in order to meet the new conditions. Although primarily feeding on small rodents and insects in its natural environment, English or house sparrows form a large part of the diet of sparrow hawks in cities. Since trees with cavities are scarce, ledges and crevices about buildings are used for nesting.

This adaptability is a characteristic of species which are successful in an evolutionary sense. Less tolerant, more specialized forms are eliminated when changes occur to which they cannot adjust. Adaptability is also partly a reflection of the variation which exists in a
species. The sparrow hawk shows obvious variation among individuals in behavior, in size, and in the patterning of the plumage, particularly among the males. This variation has in the past resulted in the development of at least 20 subspecies in various parts of the western hemisphere. The wide range occupied by these forms insures the continued existence of the species, even though local populations might be exterminated.

Since the species is successful in the evolutionary sense, its future as a member of the American fauna seems assured. Its only serious enemy appears to be man, judging from the causes of death listed in the records of birds banded and recovered (p. 67, p. 70). These figures are very likely biased, since only those birds in close contact with man are likely to be banded and their bands recovered, leaving a large portion of the population unanalyzed in this respect. It should be mentioned that the sparrow hawk is recognized as a beneficial hawk in most parts of its range, and nowhere is it as persecuted by farmers and hunters as are the larger birds of prey.

In conducting this study, the writer has been particularly interested in the provocative questions raised by the available information on mortality rates, sex ratios, and the differences in behavior between the sexes, and their possible evolutionary significance. The average
life span, for example, based on the mortality rate (p. 71), seems rather short for a bird of prey. The banding reports provide the only information available on the life span of a large number of individuals, and indicate an average age of only one year and eight months - less than two nesting seasons. If the average sparrow hawk is able to reproduce only once before being killed, the species must have a relatively high reproductive potential in order to survive. Does this coincide with the facts?

Although there are several gaps in the necessary information, the following analysis is presented as an interesting, though tentative answer to that question.

Since the mortality rate is approximately 57% (see p. 71), every 100 sparrow hawks must produce 57 young each year to insure the survival of the species. 63% of the juveniles die during their first year, leaving only 37 out of every 100 alive, so in order to produce 57 young which survive to nest the following year, 154 young must be produced, by every 100 adults. 65% of the population are males however, so out of every 100 birds there will be 30 unmated males and 35 pairs. These 35 pairs must raise the necessary 154 young, or 4.4 young birds from each pair. This is very close to the average number of eggs in a clutch - 4.8 - certainly a provocative correlation.

Unfortunately, not enough information is available to
substantiate the validity of these figures. The mortality rate is based on banded sparrow hawks only, not on the entire population. The ratio of males to females is based on a relatively small sample, and cannot be regarded as final. The number of young leaving the nest is by no means the same as the number of eggs produced, the difference being termed the nesting success. Information on nesting success is practically absent; of the nests observed, one contained an infertile egg, and at another two of the five young disappeared before leaving the nest. It is doubtful whether these two cases reflect the actual nesting success of the entire population. Consequently, the foregoing analysis is interesting for its correlation, but is not conclusive on the basis of available information.

The differential in the number of birds of each sex, an easily demonstrated fact, is another item which probably has an effect on the evolutionary success of the sparrow hawk, although just what this effect may be is as yet undetermined. In the sparrow hawk there is a male majority of approximately 65%. Mayr (63), discussing the accipiters, indicates that there is a surplus of females in that group, at least in Europe and in Pennsylvania during migration. He points out that little is known about the sex ratios among the other genera of raptors. In the
sparrow hawk, the surplus of males has resulted in at least a few cases of polyandry (pp. 14-16).

The differences in behavior between the sexes among sparrow hawks are also of interest, and probably have some effect on the success of this species. The apparently greater adaptability of the male may result in males being the first birds to occupy a newly opened habitat, such as the open prairies in central Canada mentioned earlier. In support of this hypothesis is the fact that all sparrow hawks seen in the Bend area during the occasional warm weather during the winter are all males.

These questions, in addition to the challenge presented by an attempt to breed the species in captivity, have been of sufficient interest to cause the writer to plan a continuation of his investigation of the sparrow hawk.

The sparrow hawk is a predator, and factual knowledge of the ecological position of predators is scanty. By its size and relative abundance, the sparrow hawk is admirably suited to be a subject for the study of this group — or at least its avian component. The clarification of its position in the fauna may afford clues to a better understanding of the entire group of predators, and the importance of predation in general.
Left: Male sparrow hawk. Note facial markings, long, pointed, gray-blue wings, and banded tail.

Right: Female sparrow hawk. Note barred back, wings, and tail, and generally browner appearance.

(White patches on the back of the female are due to the molt. This picture was taken September 15, 1951.)
Age 7 days
Male and Female (R-L)

Age 14 days
Female, Female, Male

Age 22 days
Female and Male

Juveniles
Male, Female, Male
Bibliography


53. Ingles, Lloyd C. Some observations and experiments bearing upon the predation of the sparrow hawk. Condor 42:104-105. 1940.


64. Miller, Alden H. Bird remains from Indian dwellings in Arizona. Condor 34:138-139. 1932.


Appendix A - Form of Questionnaires
(Mimeographed on double post cards)

I. Inquiry - to both museums and zoos.

I am investigating the natural history of the sparrow hawk (Falco sparverius sparverius) as part of my work at Oregon State College, and would greatly appreciate your filling out the attached card and returning it to me.

Should you have more detailed information on any of the items mentioned, I would be grateful for a letter from you.

Thank you,

(Signature)

II. Questionnaire sent to museums.

How many males in your collection? _____ Females_____
Number of albinos, with degree of albinism and collection data:
Same for melanistic birds: ____________________________
Any other unusual plumages? Please describe:

Remarks:

III. Questionnaire sent to zoos.

How many males have you kept? _____ Females?_____
How many albinos? _____ Melanistic?_____
(Please describe these as to how much albino, etc.)
What is the greatest age reached by any of your sparrow hawks? _____ Its sex? _______
What do you feed your hawks? _______________________
Have you ever noticed any indication of breeding activity? If so, please send me the details if available.
Remarks:
Appendix B - Diet of Birds of Prey at Philadelphia Zoo
(From letter by John A. Griswold, Curator of Birds, dated February 16, 1953)

"All of our birds of prey are fed once a day the following diet:

Raw ground horse meat 55.0%
Mixture #1 (see below) 31.0%
Raw ground carrots 10.0%
A-D feeding oil 2.0%
Oystershell flour 1.5%
Aureomycin - T.P. 0.5%

Mix daily as needed; will keep well for at least 48 hours under refrigeration. Allow 25 to 75 g/kg (0.5 to 2 oz/lb) of body weight.

<table>
<thead>
<tr>
<th>Mixture #1</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Ground yellow corn</td>
<td>15%</td>
</tr>
<tr>
<td>Ground whole wheat</td>
<td>15%</td>
</tr>
<tr>
<td>Ground whole barley</td>
<td>10%</td>
</tr>
<tr>
<td>Ground rolled oats</td>
<td>10%</td>
</tr>
<tr>
<td>Peanut meal</td>
<td>10%</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>10%</td>
</tr>
<tr>
<td>Alfalfa leaf meal</td>
<td>5%</td>
</tr>
<tr>
<td>Brewer's yeast</td>
<td>10%</td>
</tr>
<tr>
<td>Dried skim milk</td>
<td>10%</td>
</tr>
<tr>
<td>Oystershell flour</td>
<td>2%</td>
</tr>
<tr>
<td>Iodized salt</td>
<td>1%</td>
</tr>
<tr>
<td>A-D feeding oil</td>
<td>2%</td>
</tr>
</tbody>
</table>

Mixture #1 is prepared in bulk as needed, but never stored longer than two weeks.

Prior to 1935 our birds of prey were fed nothing but raw horse meat and they did not do at all well on it. A new diet as listed above seems to agree with the birds and we are able to keep species that we were not able to keep before."