THE BEHAVIORAL AND PHYSICAL DEVELOPMENT OF BARRED OWL (STRIX VARIA) NESTLINGS IN ILLINOIS

A THESIS

PRESENTED TO THE FACULTY OF

THE SCHOOL OF GRADUATE STUDIES OF

WESTERN ILLINOIS UNIVERSITY

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE

MASTER OF SCIENCE

BY

THOMAS EDWARD MICHAEL VARCHMIN

DR. THOMAS C. DUNSTAN, SPONSOR

1977

ACKNOWLEDGMENTS

I wish to express my deep appreciation to Dr. Thomas Dunstan for unselfishly sharing his knowledge and for constantly encouraging me throughout the study. I wish to sincerely thank Dr. Edwin Franks and Dr. Joseph Ives, the members of my examining committee. Dr. Virgil Howe deserves my gratitude for allowing me to use his ladders. Miss Sue Arnold and the Communication Arts and Sciences Department of Western Illinois University have my gratitude for use of their sonagraph and for their time on my behalf. Richard Graber of the Illinois Natural History Survey aided in the identification of several feathers. Finally, to my wife Beth, I give deep appreciation for her advice and understanding.

THIS THESIS HAS BEEN EXAMINED AND APPROVED:

Name [redacted]
Chairman, Examining Committee

Name [redacted]
Member, Examining Committee

Name [redacted]
Member, Examining Committee

Date July 20, 1977

THE BEHAVIORAL AND PHYSICAL DEVELOPMENT OF BARRED OWL (STRIX VARIA) NESTLINGS IN ILLINOIS

An Abstract of a Thesis
Presented to the Faculty of
The School of Graduate Studies of
Western Illinois University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Thomas Edward Michael Varchmin

Dr. Thomas C. Dunstan, Sponsor

1977

ABSTRACT

The behavioral and physical development of 22 Barred Owl (Strix varia Barton) nestlings in 9 nests in McDonough County, Illinois, was studied from March to May in 1973 and 1974.

Five eggs and one embryo were measured and weighed. Hatching, fledging, and mortality information was recorded. Physical development was studied by comparative measurements of culmen, claw 3, a central rectrix, primaries 9 and 10, and weight, and by noting change in egg tooth and development of body plumage. Eighteen nestlings were measured to within 3 days before fledging, and 7 owls were captured by hand up to 10 days after fledging. Weight in relation to fledging for 9 owls was analyzed. Behavioral development was observed by climbing to the nest cavity or by watching at a distance from a blind. Sonagrams of 3 nestling calls were made. Food habits were determined by analysis of collected prey remains and regurgitated pellets.

In 1973, 13 eggs hatched between 6 April and 9 April, and 12 owls fledged between 3 May and 10 May. In 1974, 9 eggs hatched between 28 March and 3 April, and 6 owls fledged between 26 April and 4 May. Twelve out of 18 owls fledged 31 days after hatching. Five owls died from

various causes.

An important behavioral development was the acquisition of fear and its gradual replacement by active hostility. The period in the nest just prior to fledging involved much exercise and activity.

A positive relationship existed between development of the juvenal feathers and weight. The correlation coefficient of the relationship was 0.82 and was significant at the 0.001 level. Seven owls captured up to 10 days after fledging had an average weight loss of 27 g.

The diet of the nestlings consisted of 47.9 percent birds, 29.3 percent mammals, 14.2 percent invertebrates, 7.9 percent fish, and 0.7 percent amphibians.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION AND REVIEW OF THE LITERATURE

The Barred Owl (Strix varia Barton) is the most common owl in Illinois, increasing in frequency from north to south within the state according to an Illinois Christmas count reported by Graber and Golden (1960). Reed (1965) gives its range as being eastern North America from the Canadian Provinces southward, and west to the Rockies. Though it is more common than its frequent neighbor, the Great Horned Owl (Bubo virginianus), the Barred Owl is only recently receiving increasing attention from researchers.

One of the earliest descriptions of the habits of the Barred Owl was an 1840 observation recently mentioned by Wilson (1970). Bendire (1892) and Fisher (1893) wrote classical life histories of the Barred Owl, and it is information from these 2 naturalists that has since been repeated. Barrows (1912), Forbush (1927), Roberts (1932), and Bent (1938) are among the authors who have merely repeated mention of the results of these early works when giving accounts of the life history of Barred Owls. Very accurate descriptions of the plumage and physical measurements of adult owls have been reported by Errington (1932), Errington and McDonald (1937), Hodges (1947), Morrissey (1968), and Hamerstrom (1972). Bolles (1890), Carter (1925),

Wilson (1938), and Craighead and Craighead (1956) have all reported on various aspects of behavior, but not in detail.

Only in recent years has greater interest in Barred Owl behavior been shown as researchers realized the lack of available accurate data for this species. Bjorklund, Miller, and Szluha (1967) reported on the important interactions between Barred Owls and 3 species of herons on an Illinois River heronry. Dunstan and Sample (1972) described the biology of Barred Owls in Minnesota, giving much new information on behavior including a life history chronology. Kilham (1972) speculated as to why Barred Owls caterwaul. Hamerstrom and Janick (1973) described the diurnal sleep rhythm of a hand-reared Barred Owl in Wisconsin. Finally, Nicholls (1973) conducted a study of the ecology of Barred Owls in Minnesota by using an automatic radio-tracking system.

An extensive review of the literature revealed that apparently no information exists concerning the development of Barred Owl nestlings. The purpose of this study was to obtain such information by studying several aspects of the biology of nestlings. These aspects were the physical and behavioral development, food habits, and calls of the nestlings.

MATERIALS AND METHODS

Location and Time of Study

A total of 9 active nests were studied in McDonough County, Illinois, during the months of March to May in 1973 and 1974. The county is located in the west-central part of the state and contains 150,740 ha with a population of 29,000. The land is mostly farmland in the northeast with sizeable broken pastureland and forest to the southwest. The major vegetation in the county conforms to the type of land. The cropland areas are farmed principally for corn (Zea), and the pastures are mainly bluegrass (Poa), timothy (Phleum), and brome (Bromus). Very little native grass remains. The forests are made up of mixed hardwoods with oak (Quercus sp.) and hickory (Carya sp.) the predominant trees. The air temperature is generally in the range of -17.8 to 32.2 C, although the extremes may be as much as 11.1 degrees colder or warmer. The average monthly temperature for March is 4.2 C, for April 10.9 C, and for May 17.0 C, according to Dunn (1968).

Five of the 9 nests (nests 1, 2, 3, 4, and 4A) were located in Argyle Lake State Park which occupies the following portions of 3 townships: Colchester Township, the northeast one-fourth of section 1, R4W, T5N and northwest one-fourth of section 6, R3W, T5N; Emmet Township,

the southwest one-third of section 31, R3W, T6N; and Hire Township, the southeast one-third of section 36, R4W, T6N. Argyle Lake State Park covers 425.7 ha of land and partly lies in Argyle Hollow, a deep ravine surrounded by a mixed oak and planted pine (Pinus sp.) forest. The East Fork of the La Moine River flows through the park. The surface area of Argyle Lake is 38.5 ha with a watershed of 1537.8 ha. The longest part of the lake is 1.9 km, and its greatest width is 0.23 km. The shoreline is nearly 9.7 km long. More than 500,000 people use the park annually, according to Dunn (1968).

Four of the 9 nests (nests 5, 6, 7, and 8) were located along the East Fork of the La Moine River in 3 different sections of Emmet Township: the southeast one-fourth of section 26, the northwest one-fourth of section 34, and the southwest one-fourth of section 25, all R3W, T6N.

Physical Measurements

In working around the nests and with the nestlings, every precaution as noted by Hamerstrom (1970) and Olendorff (1973) was observed in order to reduce the chances of desertion, human mishandling, mammalian or avian predation, missed feedings, premature fledging, and undesirable temperature effects.

A total of 22 nestlings in 9 active nests were studied. It was necessary to use pole climbers or ladders to reach the nests which were located at heights up to 10 m above the ground. Eight of the nests were located in hollow tree cavities, and one nest was located in a 55-gallon steel drum. Initially, the nestlings were placed in a large canvas bag and were lowered to the ground where they were color-coded on their feet and upper tarsi with a black waterproof marking pen. When older, owls were banded with U. S. Fish and Wildlife Service leg bands for identification.

Each nest was visited approximately every 3 days during the early post-dawn hours. At each visit the age of the birds was recorded in relation to the day of hatching. Day 0 corresponded to the day of hatching, while day 1 referred to the first day after hatching and one day of age. Days before hatching were indicated by negative numbers. For example, -2 days of age meant 2 days before the day of hatching.

During each visit, culmen, claw 3, a central rectrix, and primaries 9 and 10 were measured to the nearest 0.1 mm with a vernier calipers according to methods by Olendorff (1972). The nestlings were weighed to the nearest gram on an Ohaus triple-beam balance. Where applicable, all measurements were taken on the right side of the bird's

body. Culmen was measured as the straight-line distance from where the culmen emerges from the cere to the tip of the upper mandible. The 4 toes of each foot were assigned numbers as suggested by Pettingill (1970). The hallux or posteriorly-projecting toe was toe 1. The innermost of the 3 anteriorly-projecting toes was toe 2, the middle anteriorly-projecting toe was toe 3, and the outermost anteriorly-projecting toe was toe 4. Length for claw 3 of the corresponding toe was measured as the straight-line distance between the point where the upper surface of the claw emerges from the skin at the tip of the toe to the end of the claw. Measurements of all feather lengths were taken to the tips of the developing teleoptiles. Any neossoptile present on the tip of a teleoptile was not included in the measurement. The lengths of a central rectrix and primaries 9 and 10 were measured as the straight-line distance from the point where the shaft exits the skin dorsally to the tip of the feather, with the feather allowed to assume its natural bend. Primaries 9 and 10 correspond respectively to the second outermost and outermost primaries of the wing, as numbered from the inside to the outside of the wing.

In addition, body measurements were taken of 3 Barred Owls which were recovered as freshly-dead fledglings. A central rectrix, culmen, claws 1 and 3, primaries 9 and 10,

and weight were measured as described. Extent, length, tarsus, and wing were measured as described by Pettingill (1970). Extent was measured as the distance from tip to tip of the longest primaries of the outstretched wings. The specimen was placed flat on its back, and the wings were grasped at the wrist joints. Length was measured as the distance from the tip of the beak to the tip of the longest rectrix. The specimen was placed flat on its back and was gently stretched. The commissure of the beak was brought parallel to the ruler. The tarsus length was measured with a calipers from the point of the joint between the tibia and metatarsus to the point of the joint at the base of the middle toe in front. Wing was measured with a calipers from the bend of the wing to the tip of the longest primary. The curvature was not straightened, so the measurement was made from the bend directly to the tip.

Seven owls were captured by hand after fledging and were measured in the same manner as the nestlings.

Five fresh eggs were measured and weighed at the nest. Length and width were measured with a calipers, and the eggs were weighed to the nearest 0.1 g on an Ohaus triple-beam balance.

One embryo about 2 days from hatching was measured and weighed. Culmen and claws 1 and 3 were measured as described.

Measurements of culmen, claw 3, a central rectrix, primaries 9 and 10, and weight which were taken for each owl during visits to the nests were grouped for owls of similar age. A mean, range, and standard deviation for the composite data for each day of age were determined, and the values were plotted on graphs. To eliminate a small-sample bias, the standard deviations were calculated by use of the following formula, taken from Downie and Heath (1970):

$$s = \sqrt{\frac{\Sigma\ (x-\bar{x})^2}{n-1}}$$

To initially determine if the relationship between feather development and weight reported by Sumner (1933) might exist for Barred Owl nestlings, preliminary graphs were made of body weight and length of primary 9 for the data of each nest. Because the data for the 3 owls of nest 6 were the most complete of the 22 owls studied, only the graph of nest 6 data was included in a later section of this study.

To determine if the relationship between weight and length of primary 9, as revealed by the individual owl data, existed for the entire study sample of 22 nestlings, a graph of the means of these measurements for all owls for each day of age was constructed.

A Pearson product-moment correlation coefficient was calculated, and the degree of significance of the

coefficient was determined. The correlation coefficient (r) was calculated by use of the following formula taken from Downie and Heath (1970):

$$r = \frac{\Sigma Z_x Z_y}{n}$$

where x and y are individual deviations from the means, s_x and s_y are the standard deviations as defined previously, and $z_x = x/s_x$ and $z_y = y/s_y$.

Any interpretation of the composite data graphs for this study should include 3 important points. First, physical measurements of nestlings just after hatching were taken for only 2 owls. Young from only one nest were worked with at this early critical stage of the brooding period in order to avoid, or at least minimize, possible nesting failures.

Secondly, a schedule was followed by which each nest was visited approximately every third day, depending on weather conditions. This staggered schedule was necessary for several reasons. The visits to each nest had to be made in the early post-dawn hours in order to collect prey remains, since the pellets were usually regurgitated at this time, and to keep the weighing times consistent. Also, the early morning hours were helpful in avoiding detection by curious park visitors or other persons who might have hindered the study. Because the nest sites were

often separated by large distances and were in some cases difficult to reach by foot, time was a limiting factor in determining how many nests could be visited each morning. This schedule influenced the collection of data in several ways. As an example, if perhaps in one morning 3 nests containing a total of 6 owls were visited, it was possible for each owl to be of a different age. This was the result of asynchronous hatching within an individual nest and of variation in hatching days from nest to nest. The sample size for any one day of age could therefore be quite small since it was impossible to measure all owls for every day of age. Also, since the same group of owls was not measured on consecutive days, it was possible for the mean measurements of these different groups to vary widely enough to show a loss on the graph for such physical parameters as feather length. Obviously, this loss was artificial, having been introduced by the necessity of measuring different owls on each of 3 consecutive days.

Thirdly, it became apparent during the study that the physical measurements of owls of the same age sometimes varied widely within each nest and between nests. In explanation, it is possible that the variation was due to at least 2 factors. First, different hunting success of adult owls could have resulted in a variation in the nutritional intake of young owls in different nests.

Likewise, within a single nest, the presence of a peck order could have produced an uneven feeding of siblings and a resultant variation in nutritional intake among the siblings. Second, since there is a sexual dimorphism in size in Barred Owls, with the females usually being larger and heavier, it is possible that a size difference was already being expressed in the nestling stage.

Behavioral Observations

Behavioral observations were recorded at 5 stages: nestling, diurnal pre-fledging, nocturnal pre-fledging, diurnal fledging, and nocturnal fledging. In this study, fledging is defined as the act in which a Barred Owl nestling leaves the nest cavity without returning to it again, although the owl may remain in the nest tree for several days. Nestling behavior included behavior of the owls in the nest from one day after hatching until the day of fledging. Diurnal and nocturnal pre-fledging behavior included the 2- to 3-day period in the nest just prior to fledging. This period is actually part of nestling behavior but demands separate consideration because of the important preparation needed for nest departure. This pre-fledging behavior is considered to be anticipatory of the act of fledging. Diurnal fledging and nocturnal fledging behavior included the day and night of fledging and described the activities associated with departure from the nest.

For the nestling stage, observations were made of a total of 22 owls in 9 nests. Visits were made to each nest approximately every 3 days, at which time the identification number and age of bird at time of the observed behavior were indicated. Before the birds were removed from a nest, notes were taken of body posture, mode of movement, arrangement in the nest, and reaction to the climber. In nests containing more than one owl, group interaction, such as peck order, were observed. When the birds were on the ground, notes were taken of body posture, climbing ability, and reaction to the researcher. Any use of wings, talons, and beak was noted.

For the diurnal and nocturnal pre-fledging stages, observations were made of 6 owls in nests 6, 7, and 8. For the diurnal and nocturnal fledging stages, observations were made of the 2 owls in nest 7. Observations of in-cavity behavior were made possible by the structural features of nests 6, 7, and 8 which allowed viewing of nestlings from ground level. Nest 6 was a top-entrance cavity with a large side portion of the cavity wall missing. Although the missing portion of the wall was not large enough to permit the adult owls to enter the nest from the side, the opening was wide enough to permit observation of nestling activity from ground level. This was very advantageous as it was therefore possible to observe

activity of nestlings in a top-entrance nest. These observations would not have been possible had the cavity wall been completely intact. Nests 7 and 8 were side-entrance cavities in which the floor of the nest was level with the lower lip of a U-shaped entrance. The entrance was wide enough to allow viewing of nestling activity from ground level.

Detection by the owls was avoided by making all ground observations with binoculars at a distance of 15 m from a blind made from a dark green blanket. At night, to get enough light on the nest cavity, a sealed-beam 12 volt lantern was placed about 5 m from the tree. The light was aimed on the nest just before darkness and seemed to have no apparent disturbing effect on the nestlings or adult owls.

Sonagrams of Nestling Calls

Sonagrams or audiospectrograms are visual reproductions of sounds made by a sound spectrograph. Sonagrams show more details of a bird call than would be possible to detect with the human ear. By use of sonagrams, it is possible to obtain information on the pitch of notes, the loudness or amplitude of notes, and the number of notes in a series. The higher the note on the graph, the higher is its pitch. The closer the notes appear on the graph, the greater is their speed of delivery.

The fainter duplicate notes which appear at octaves above the fundamental pitch of a note are overtones or harmonics which give richness of quality to each note. A pitch which could be considered very high by humans is one over 6 kc.

The horizontal axis of a sonagram indicates time in seconds while the vertical axis indicates the number of vibrations in kilocycles per second.

During each visit to a nest, notes were made of any calls heard either while the birds were in the nest or on the ground. On 2 occasions, nestling calls were taped using a Uher reel-to-reel tape recorder. In addition, the food-begging call of one nestling near to the day of fledging was recorded at night using a parabolic sound disc and a Panasonic casette recorder. In this study, food-begging calls are defined as plaintive high-pitched whines given by young owls which stimulate the adult owl to bring food to them. The call can be easily heard by humans at a distance of 10 m.

Later, the 3 recorded calls were played into a Kay Company sonagraph, and the calls were visually reproduced on a Type B65 sonagram and were then analyzed as to frequency range and duration of call.

Food Habits

During each nest visit, all whole prey items found in the nest were identified and weighed immediately. Any

fragmentary remains, such as feathers or bones, were collected and brought to the laboratory for identification as were any whole or partial pellets which were regurgitated by the nestlings. The whole pellets were dried, weighed, measured, and dissected. The stomach contents of one dead nestling were also analyzed, and the results were included in the food habits data.

Identification of prey items was made with the aid of a stereoscopic microscope using appropriate taxonomic keys. Feathers were identified by comparison with specimens housed in the Western Illinois University Museum or sent to Richard Graber of the Illinois Natural History Survey for identification.

RESULTS AND DISCUSSION

Egg and Embryo Data

Hatching of Barred Owl eggs was asynchronous. In 8 out of 8 clutches, hatching occurred over a 2- to 3-day period. In 1973, 13 Barred Owl eggs hatched between 6 April and 9 April. In 1974, 9 eggs hatched between 28 March and 3 April. Dunstan and Sample (1972) reported that eggs are laid in March in Minnesota and that hatching occurs from late March until early April. Bent (1938) reported the following egg dates for Illinois and Iowa: 23 records, 25 February to 30 April and 12 records, 6 March to 13 April. Ford (1956) reported 4 eggs on 13 April 1919, in Lake County, Illinois.

During the study, only one egg was weighed accurately. This egg was one of 2 eggs being incubated in a nest along the La Moine River on 2 April 1974. On 5 April 1974, one egg remained in the still active nest and weighed 53.4 g and measured 54.4 x 43.5 mm. On 15 April 1974, this egg was brought to the laboratory because it was thought that the nest had been abandoned. The egg weighed 50.3 g and when candled it was found to contain a live embryo. The egg was incubated in the laboratory until 30 April 1974, when it was accidentally disturbed in the incubator, and

the embryo died. The egg was approximately 2 days from hatching and weighed 48.4 g. The embryo itself weighed 34.5 g and was almost entirely covered with down except for the spinal tract. Claw 1 measured 3.8 mm, claw 3 measured 4.3 mm, and the culmen measured 11.3 mm. The known incubation period of this egg was from 2 April 1974 until 30 April 1974, a total of 29 days. The egg was still about 2 days from hatching on 30 April so the potential incubation period could have been approximately 31 days. Bendire (1892) reported the incubation period to be 21 to 28 days while Bent (1938) gave a period of 28 days.

On 10 March 1974, 2 eggs that were being incubated in nest 4A at Argyle Lake measured 53.0 x 43.3 mm and 52.6 x 43.8 mm. On the same day, 2 other eggs were found being incubated in a nest at Argyle Lake and measured 52.8 x 43.1 mm. On 29 March 1974, these latter eggs were found destroyed in the nest.

No weight data for Barred Owl eggs could be found in the literature, but egg sizes were available. Bendire (1892) reported 49.5 x 42.5 mm as the size of an average egg. Barrows (1912) reported 49.3 x 41.9 mm. Forbush (1927) gave a size range of 50.0 to 52.8 x 37.8 to 44.4 mm, while Roberts (1932) reported 50.8 x 41.1 mm. Bent (1938) reported 49.0 x 42.0 mm. Most recently, Reed (1965) reported a size of 49.5 x 41.9 mm. The average for all these egg

measurements is 50.1 x 41.6 mm. As a comparison, the average size of the 5 eggs in this study was 52.8 x 43.4 mm.

Fledging Dates

In 1973, all 12 owls fledged between 3 May and 10 May. In 1974, all 6 owls fledged between 26 April and 4 May. All owls fledged between 30 and 32 days after hatching, and 12 of 18 nestlings fledged 31 days after hatching. According to Bent (1938), Barred Owls fledge when they are about 4 or 5 weeks old. Dunstan and Sample (1972) reported that young owls in Minnesota fledge 7 to 9 weeks after hatching and gave fledging dates of 6 June 1972, 31 May 1971, and 10 June 1967.

In 1973, 2 nestlings from nest 5 along the La Moine River fledged at 27 and 28 days of age, respectively. This was considered to be a premature fledging which was prompted by severe human disturbance to the nest tree. The nest tree was located in a housing development, was often visited by curious people with their pets, and was chopped on with an axe. It is significant that one of these owls, owl 39, fell into the river and drowned only 2 days after fledging prematurely. The occurrence of such premature fledging among raptors has been reported by Olendorff (1973).

Mortality

Of a total of 22 owls, 2 nestlings and 3 fledglings were known to have died from various causes, and 2 nestlings

were missing from their nests and were never found. These missing owls most likely fell from the nests and were scavenged or killed on the ground by other animals.

On 23 April 1973, one nestling was missing from nest 5 at 16 days of age. On 7 May 1973, fledgling owl 39 of nest 5 drowned in the La Moine River at 31 days of age. On 18 May 1973, owl 26 of nest 2 died at Western Illinois University at 41 days of age. This owl was illegally taken from Argyle Lake State Park at 31 days of age, its day of fledging. A local youth kept the owl as a pet and fed it oatmeal until the owl was too undernourished and sick to stand. He then brought the owl to the university where it died after 30 minutes. An autopsy revealed that the digestive system of the bird was clogged with oatmeal, and the gall bladder had burst. On 16 May 1973, owl 29 of nest 4 was found starved to death on the ground at 38 days of age, having fledged at 31 days of age. An autopsy revealed that the digestive system was atrophied. On 10 April 1974, the 2 nestlings of nest 4A were found dead at 13 and 14 days of age, respectively. The cause of death was determined to be predation by a raccoon (Procyon lotor), an occurrence which has been previously reported by Hamerstrom (1970) and Olendorff (1973). On 24 April 1974, owl 103 of nest 7 was missing from the nest at 28 days of age.

The measurements of freshly-dead owls 26, 29, and 39 are given in Table 1.

Table 1

Measurements of Freshly-dead Barred Owls Recovered after Fledging

	Owl Number		
	39	29	26
Days of age	31	38	41
Days after fledging	3	7	10
Central rectrix (mm)	82.0	91.0	91.0
Claw 1 (mm)	15.0	15.3	14.4
Claw 3 (mm)	17.4	17.4	16.2
Culmen (mm)	20.1	20.0	19.7
Extent (mm)	602	629	649
Length (mm)	331	342	349
Primary 9 (mm)	116.0	134.0	120.0
Primary 10 (mm)	57.0	70.0	52.0
Tarsus (mm)	66.8	72.1	78.0
Weight (g)	518	368	432
Wing (mm)	222.0	239.0	225.0

Physical Development

No measurements of juvenile Barred Owls could be found in the literature. However, measurements of adult owls are available. Craighead and Craighead (1956) reported that the weights of 9 adult female Barred Owls in Michigan averaged 625 g. Nicholls (1973) attempted to sex Barred Owls by establishing an index based on several growth parameters. He was not successful, but he did record the measurements obtained. He found that the average wing length was 356 mm for 2 adult females, 334 mm for 4 adult males, and 335 mm for a mixed group of 11 adults, including 2 females, 4 males, and 5 unsexed owls. The average wing span was 1098 mm for 2 adult females, 1070 mm for 4 adult males, and 1069 mm for the mixed group of 11 adults. The average weight was 970 g for 2 adult females, 719 g for 4 adult males, and 754 g for the mixed group of 11 adults, with a range of 628 to 1050 g for the group. The average tail length was 223 mm for 2 adult females, 203 mm for 4 adult males, and 209 mm for a mixed group of 10 adults, including 2 females, 4 males, and 4 unsexed owls.

General plumage development. Observations of general plumage appearance were made infrequently since the time spent during each visit to a nest was limited to minimize the chance of nesting failures as explained previously. Those plumage observations that were recorded are included

for completeness.

At hatching, 5 nestlings were sparsely covered with white natal down. Between days 1 and 3, the bodies of 5 owls acquired more downy cover, except for the back. No contour feathers were present. Between days 4 and 6, the down of the wings and tails of 5 owls began to be pushed out by the emerging pinfeathers. The primaries, secondaries, and rectrices were entirely enclosed by their sheaths. The sheaths for 2 nestlings averaged approximately 1 mm in length with about 3 mm of down attached at the tips. Between days 7 and 9, the scapular and spinal tract feathers of 10 owls were evident, and the bluish color of their sheaths became apparent through the white down cover. At this time, the primaries, secondaries, and rectrices were still entirely enclosed by their sheaths with downy tips attached to them. Between days 10 and 12, the retrices of 13 owls were still enclosed within their sheaths and had downy tips attached, and approximately 1 mm of actual juvenal feather was exposed from the sheaths of primaries 6 and 7. Between days 13 and 14, the scapular region of 13 owls became buffy in color. All primaries still had downy tips, but about 4 mm of actual juvenal feather was exposed from the sheaths of primaries 6 and 7. The rectrices were still entirely enclosed in sheaths and also had downy tips. At this time the wings and back region of the nestlings

acquired their first obvious juvenal coloration due to the exposed juvenal feathers. Between days 15 and 18, the downy tips of 20 owls began to drop off the outermost primaries, and only a small portion of down was still apparent on them. The retrices were still entirely enclosed by sheaths, and downy tips were present. Between days 23 and 25, the first actual juvenal feather was exposed from the sheaths of the retrices of 19 owls, but the downy tips were still present. Between days 29 and 31, there was only a small portion of down remaining on the retrices of 18 owls and almost 13 mm of actual feather was out of the sheath. By day 33 there was no down remaining on any of the primaries or secondaries of 2 owls, but the retrices still retained a small portion of down.

By the time of fledging, usually about day 31, 19 out of 19 owls had a well-developed juvenal plumage. The capital and spinal tracts of all owls were still down-tipped. The juvenal plumage of Barred Owls has already been well described by Ridgway (1914) and Roberts (1965).

Culmen and egg tooth. The composite measurements for length of culmen are presented in Figure 1. After 4 weeks of age, it was difficult to measure the culmen of all owls with repeatability as the soft tissue of the cere began to dry and flake off unevenly.

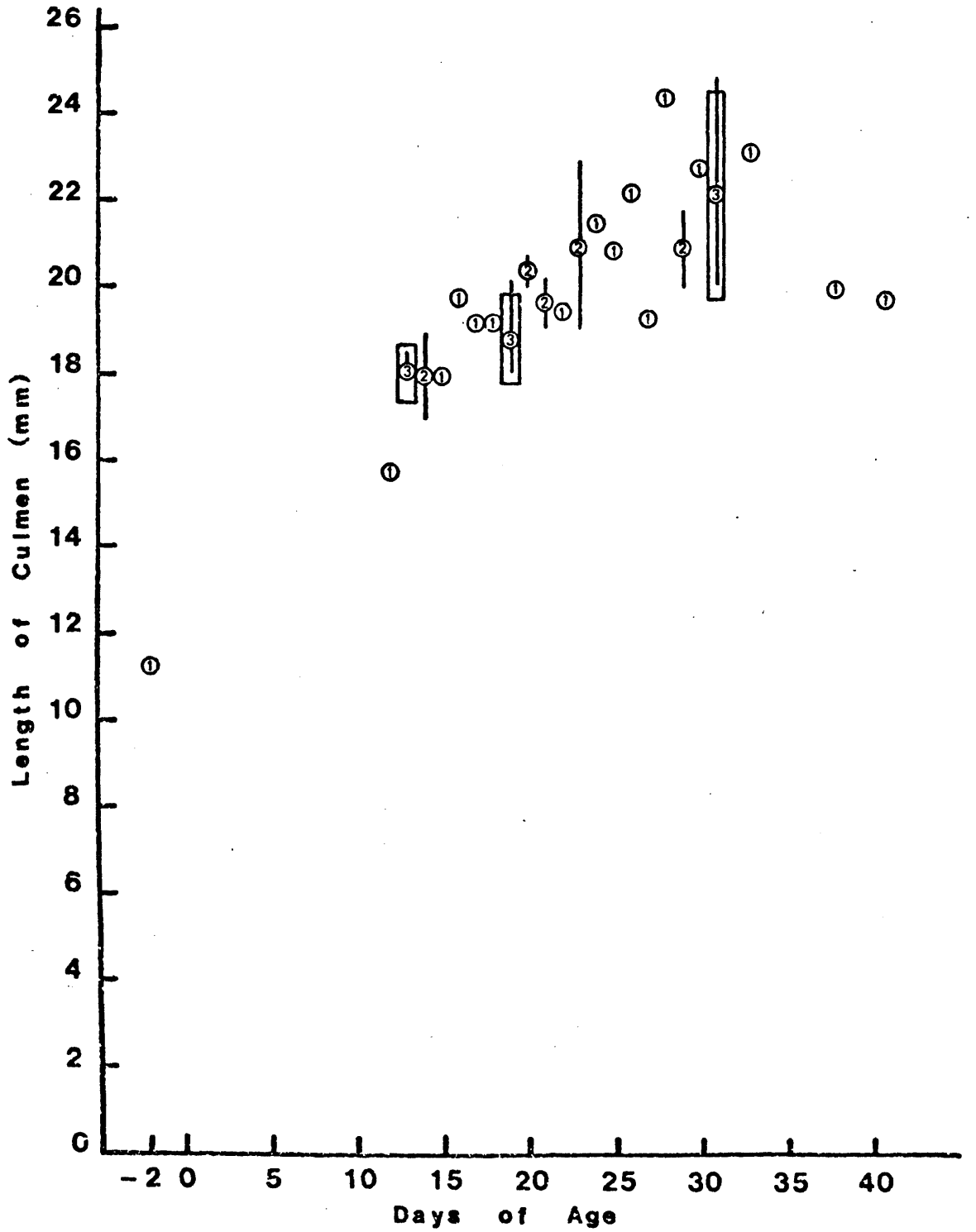

Figure 1. Composite measurements of length of culmen. Circles are means, vertical lines are ranges, rectangles are one standard deviation, and numbers are sample size.

The culmen of one embryo approximately 2 days from hatching measured 11.3 mm. The average culmen length at 13 days of age was 18.2 mm, at 19 days of age, 22.2 mm, at 38 days of age, 20.0 mm, and at 41 days of age, 19.7 mm.

Much of the egg tooth was present on the beak until about 9 days of age, flaking off completely by 12 days of age.

Claw 3. The composite measurements for length of claw 3 are presented in Figure 2. For one embryo approximately 2 days from hatching, claw 3 measured 4.3 mm. The average length of claw 3 at 13 days of age was 11.5 mm, at 19 days of age, 14.8 mm, and at 31 days of age, 17.4 mm.

Central rectrix. The composite measurements for length of a central rectrix are presented in Figure 3. As in many raptorial birds, the tail feathers of Barred Owls grew very slowly. The sheaths first emerged from the skin at about 4 days of age, and the feather itself was almost totally enclosed until 23 to 25 days of age. For all owls measured, the sheath began to flake off at approximately 25 days of age. For all owls measured at the time of fledging, almost one-half of the juvenal feather was still enclosed by sheath.

The average length of a central rectrix at 4 days of age was 1 mm, at 19 days of age, 13.0 mm, at 23 days of age, 13.7 mm, at 24 days of age, 17.9 mm, at 28 days of age,

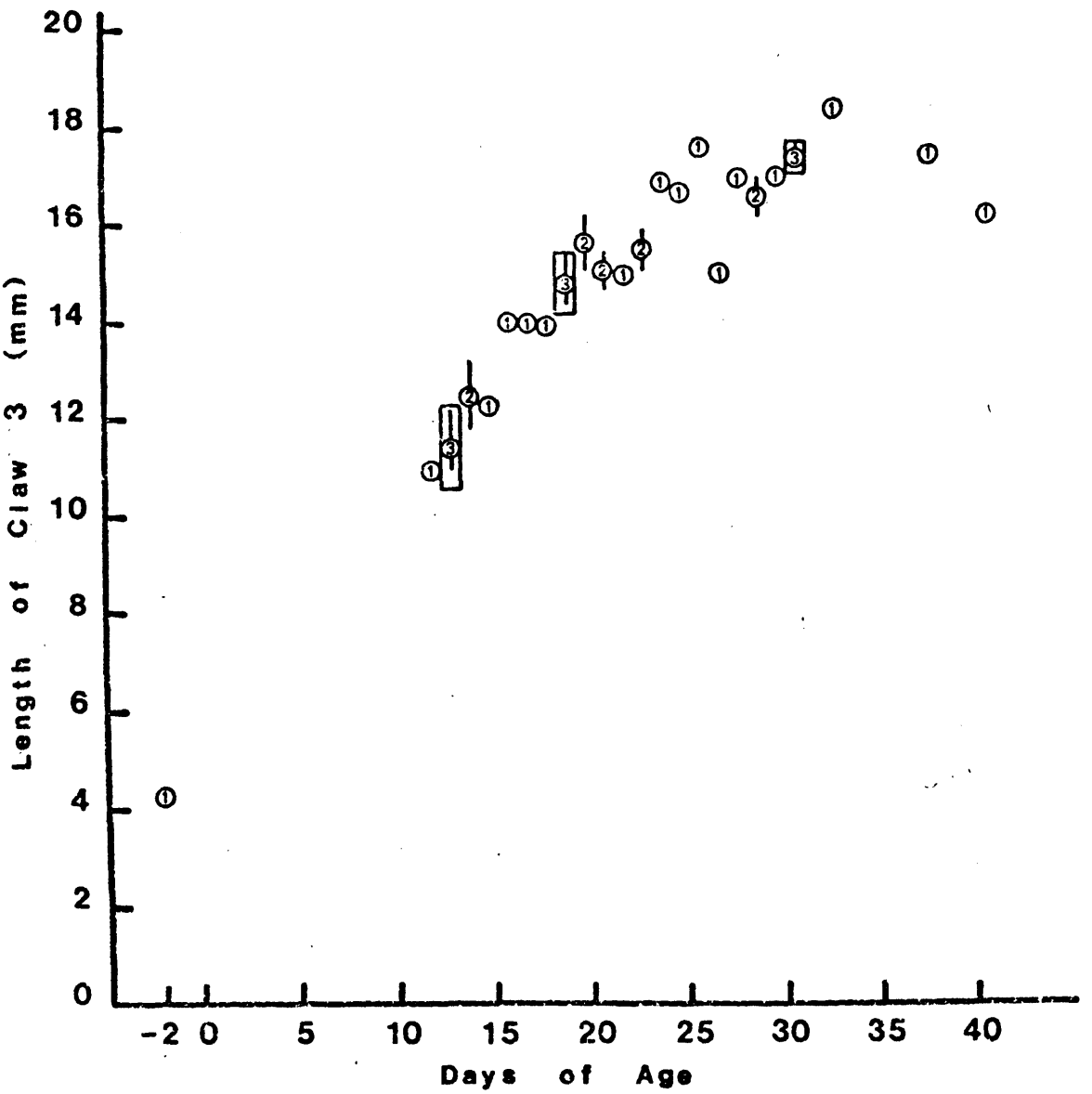

Figure 2. Composite measurements of length of claw 3. Circles are means, vertical lines are ranges, rectangles are one standard deviation, and numbers are sample size.

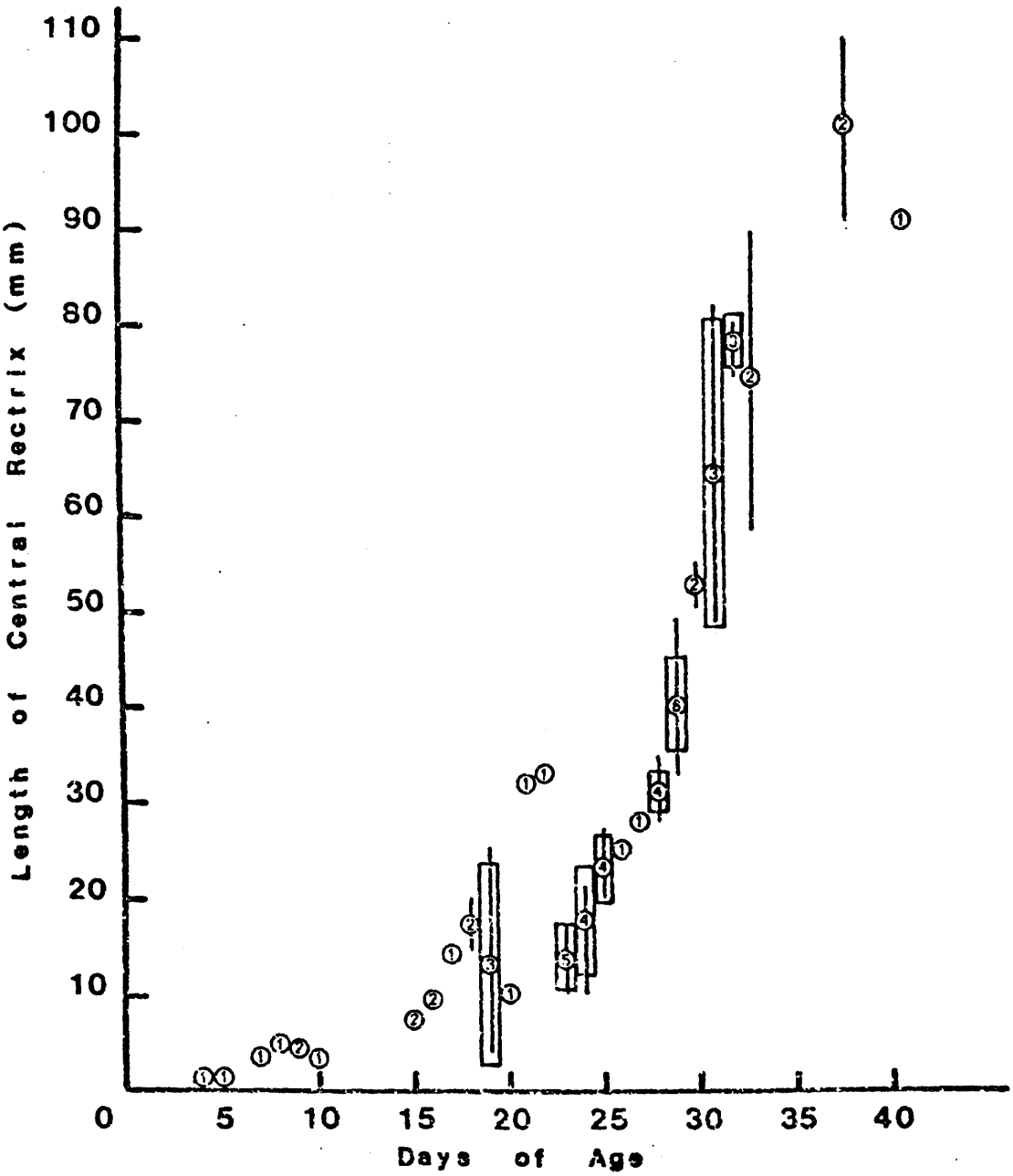

Figure 3. Composite measurements of length of central rectrix.
Circles are means, vertical lines are ranges, rectangles are one standard deviation, and numbers are sample size.

30.3 mm, at 29 days of age, 40.0 mm, and at 31 days of age, 64.3 mm.

Primary 9. The composite measurements for length of primary 9 are presented in Figure 4. At 4 to 5 days of age, the sheath emerged from the skin, but no actual juvenal feather was exposed from the sheath until 9 to 11 days of age at which time approximately 1 mm of feather was out. At the time of fledging, about one-third of the juvenal feather was still enclosed by the sheath for all owls measured.

The average length of primary 9 at 4 days of age was 1 mm, at 15 days of age, 17.3 mm, at 19 days of age, 29.1 mm, at 23 days of age, 82.7 mm, and at 41 days of age, 120.0 mm.

Primary 10. The composite measurements of primary 10 are presented in Figure 5. This feather grew slower than primary 9. Between 4 and 5 days of age, the sheath emerged from the skin. No juvenal feather was exposed from the sheath until 9 to 11 days of age, when less than 1 mm of actual feather was out. At the time of fledging, approximately one-half of the juvenal feather was still enclosed by the sheath for all owls measured.

The average length of primary 10 at 4 days of age was 1 mm, at 15 days of age, 11.4 mm, at 23 days of age,

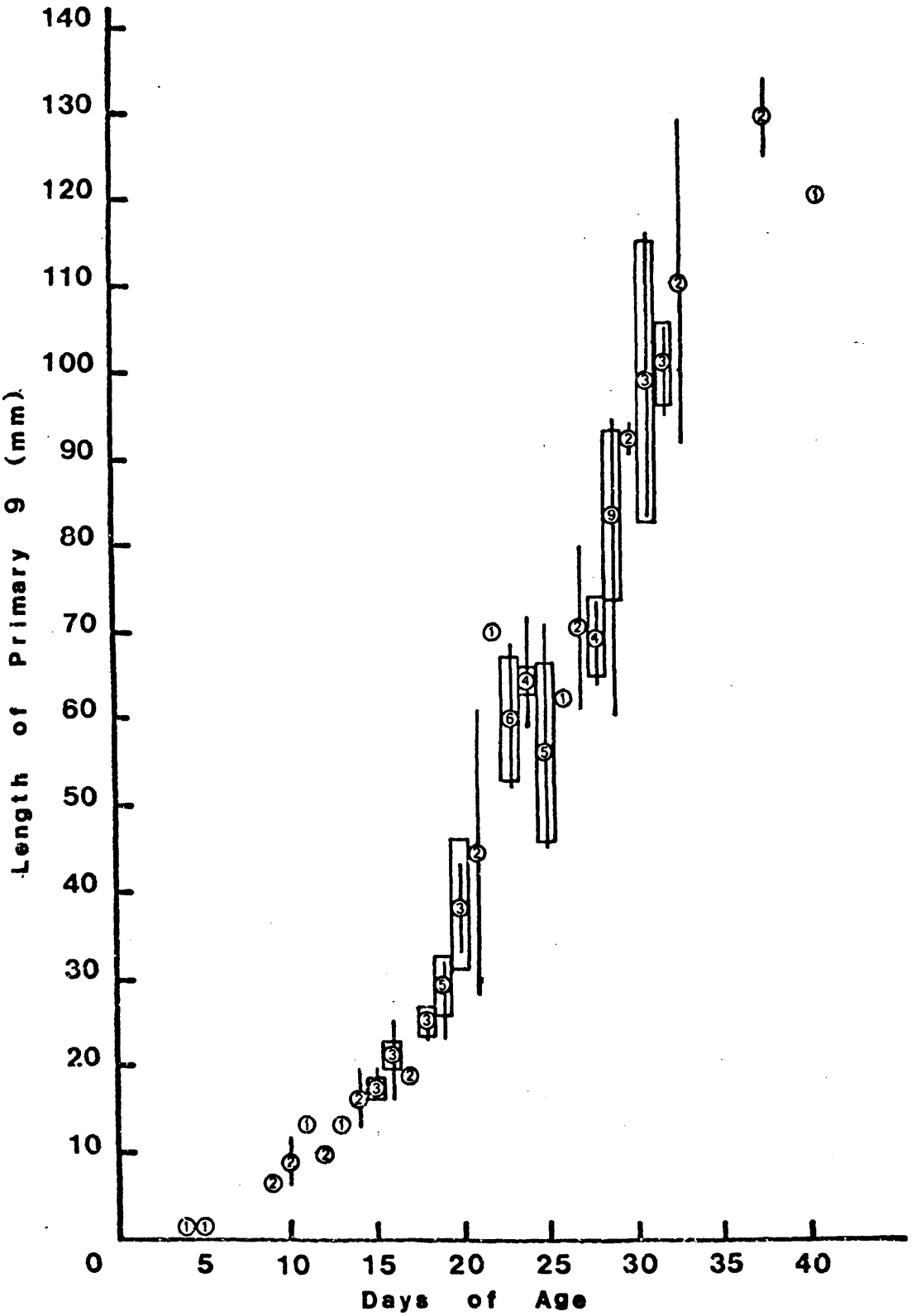

Figure 4. Composite measurements of length of primary 9. Circles are means, vertical lines are ranges, rectangles are one standard deviation, and numbers are sample size.

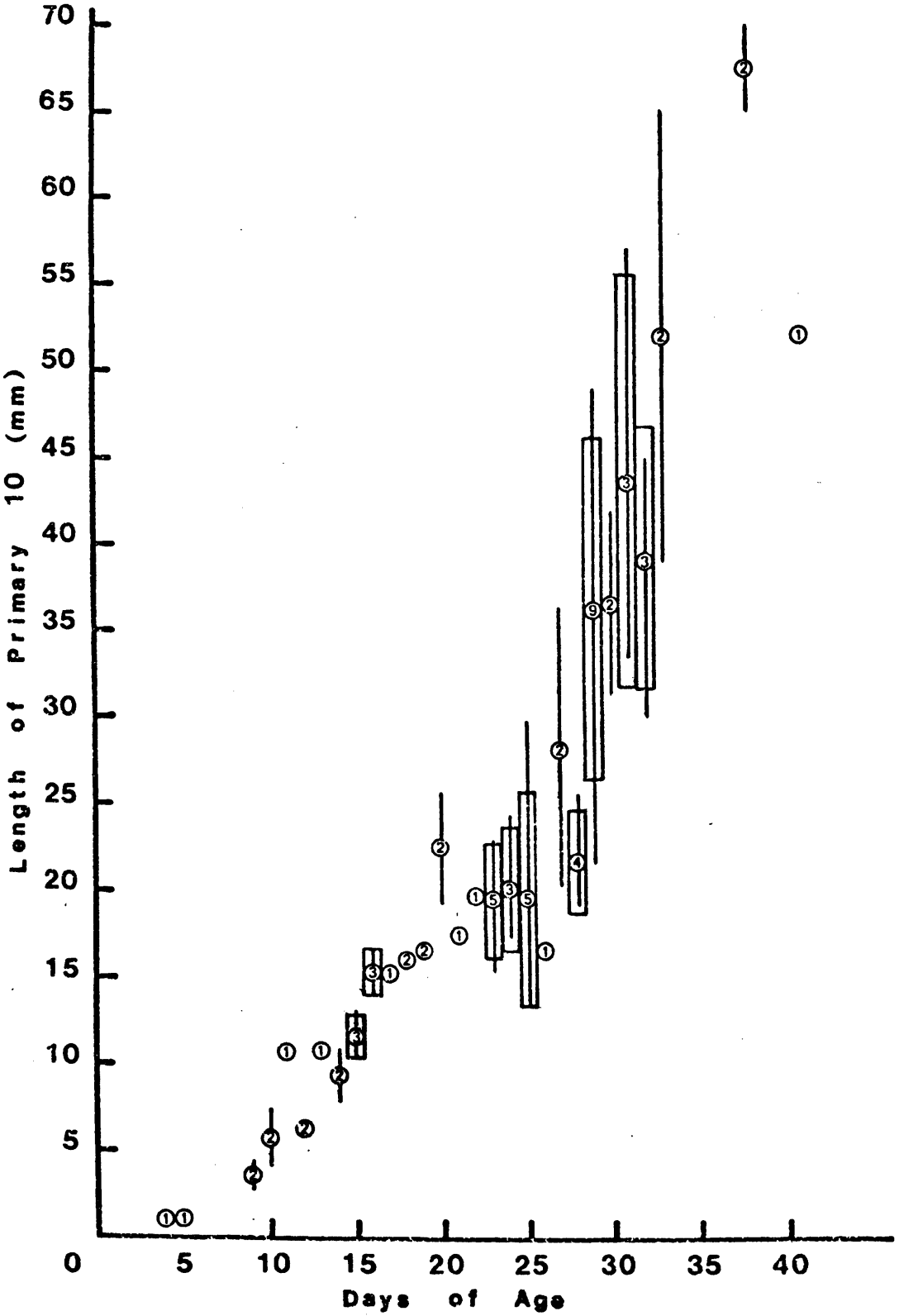

Figure 5. Composite measurements of length of primary 10. Circles are means, vertical lines are ranges, rectangles are one standard deviation, and numbers are sample size.

19.5 mm, at 25 days of age, 19.6 mm, at 29 days of age, 36.1 mm, at 31 days of age, 43.6 mm, and at 41 days of age, 52.0 mm.

Weight. The composite measurements for weight are presented in Figure 6. When considering any raptor weight data, it is necessary to consider the influence that unregurgitated pellets could have on the measurements. For this reason, all of the weighings were made in the early post-dawn hours when these castings are often regurgitated. The weights of some nestling castings are presented in a later section.

One embryo approximately 2 days from hatching weighed 34.5 g. The average weight at one day of age was 45 g, at 9 days of age, 247 g, at 15 days of age, 380 g, at 19 days of age, 487 g, at 23 days of age, 503 g, at 29 days of age, 528 g, at 31 days of age, 532 g, and at 38 days of age, 572 g.

Length of primary 9 and weight. While working with young Barn Owls (Tyto alba) and Screech Owls (Otus asio), Sumner (1929) first noted that these raptors both exhibited a marked loss of weight toward the end of their nest life. To explain this loss, he attempted to correlate body weight and development of the juvenal feathers. A short time

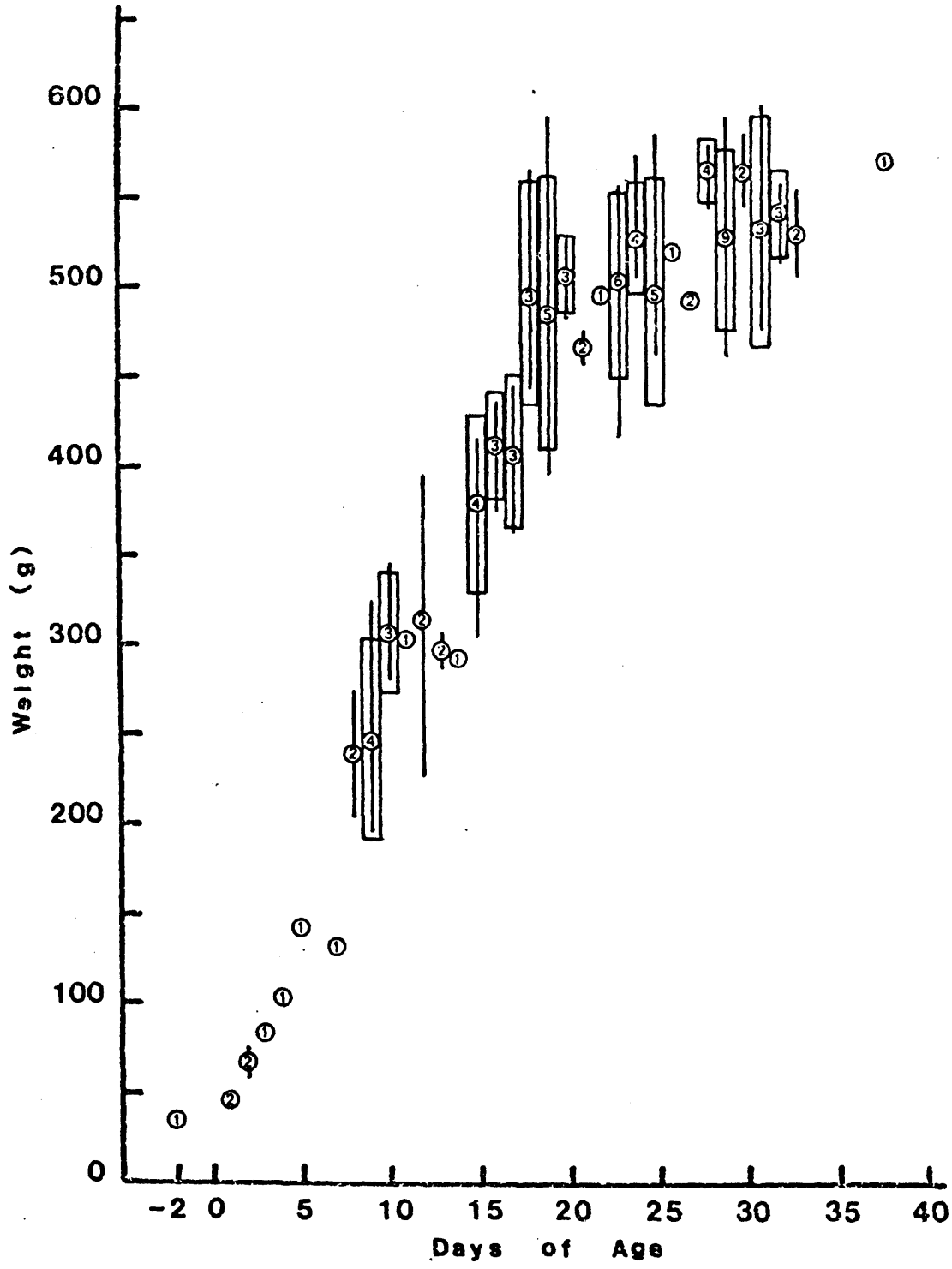

Figure 6. Composite measurements of weight. Circles are means, vertical lines are ranges, rectangles are one standard deviation, and numbers are sample size.

before the bird is ready to fly, Sumner noted, these feathers have nearly reached their full development. At this point, the blood and plasma in the quills begin to recede, the shafts become filled with air, and there is a general toughening and lightening of cellular structure in preparation for flight. The bones which until this time have been soft and filled with liquid now likewise start to strengthen and lighten. Sumner (1929) believed that this whole process might proceed at such a rapid pace that the assimilation of food cannot compensate for it, although an equilibrium is later reached.

Sumner (1933) further reported on body weight and feather development in raptors after studying Great Horned Owls and Barn Owls. He found that definite changes in body weight occurred in his nestlings according to 3 stages which he felt were probably characteristic of the growth of altricial birds as a whole: 1) an initial period of rather slow gain in weight, lasting about one week after hatching, followed by 2) a period of maximum increase in weight, which is in turn succeeded by 3) a final and protracted interval of minor fluctuations. This last period is often marked by a considerable weight loss during the first weeks of flight.

Sumner (1933) discussed the possible factors involved in determining this three stage growth which are important

to the understanding of how feather growth and body weight may be correlated. Considering the first stage, he explained that a young bird at hatching has its whole source of food supply changed. The alimentary tract with all of its appendages, previously unused, is suddenly called upon to receive and successfully deal with a miscellaneous and intermittent stream of digestibles and indigestibles. In other ways, also, the calm of embryonic life is upset as the bird's body temperature changes rapidly when the adult comes and goes during brooding. In this manner, the bird's entire metabolism is disturbed at a time when the bird's surface is greatest as compared with its volume, and its downy covering is at its thinnest. Sumner (1933) noted that a temporary condition of defective nutrition results from this metabolic disturbance and pointed out that a few hours before hatching, bone growth becomes retarded and remains so until at least 24 hours after the young bird has left the shell. Such a condition of defective nutrition would be quite sufficient to account for the slow increase in weight in the first stage of the bird's development.

The second stage is characterized by maximum growth in weight of the body and by the appearance of the juvenal plumage together with a certain measure of body temperature control. During this stage, he noted, feather development is being inhibited by rapid body growth.

The third stage is marked by: 1) a distinct flattening out of the weight curve, followed by fluctuations, 2) a maximum development of juvenal feathers, and 3) a rapid emergence of the instinctive reactions associated with play, which result in a marked increase in bodily activity.

In trying to explain this important third stage of growth, Sumner (1933) noted that other than his speculations as given in his 1929 publication, he could add little new information to help explain it. The question, he felt, is complicated by the fact that some species of raptorial nestlings weigh more than the adults when at their maximum, for example, Barn Owl nestlings which double the weight of the adults and then drop down toward the weight level of the adults before leaving the nest. Other species, however, such as Screech Owl nestlings, begin to lose weight before they ever reach the level of the adults.

Sumner (1933) suggested, in addition, that the loss of weight in young birds could result from a condition of partial starvation forced upon them by their parents to motivate them to leave the nest. Sumner (1933), however, did not believe that this factor was relevant as his birds never were starved and always had sufficient food available to them throughout the study. If there was any starving, it was on a voluntary basis and indicated a normal physiological state.

Also, Sumner (1933) suggested that perhaps the increasing amount of exercise taken during this third period may aid in keeping weight gain at a minimum. He pointed out that this factor may not be very important, though, since such hole-dwelling species as the Screech Owl and American Kestrel (Falco sparverius) exhibit as much of a weight decline as any of the others, and yet their opportunities for exercise, at least while in the nest, are limited.

To initially determine if any relationship existed between body weight and feather development for the Barred Owl nestlings of the present study, the individual data for length of primary 9 and body weight for each owl were plotted on a graph for each nest. The data for the 3 owls of nest 6 are presented in Figure 7.

Figure 7 indicates that the 3 nestlings gained weight rapidly from the day of hatching and continued to do so until approximately 19 to 21 days of age, at which time the rate of gain began to level off, with minor fluctuations in weight occurring until the end of the nestling stage. The figure also indicates that the growth rate of primary 9 increased between 19 and 21 days of age for all 3 nestlings, with the feather having grown at a slower rate between approximately 12 and 19 days of age.

Figure 8 is a graph of the means of the grouped data for all owls measured for each day of age. This figure

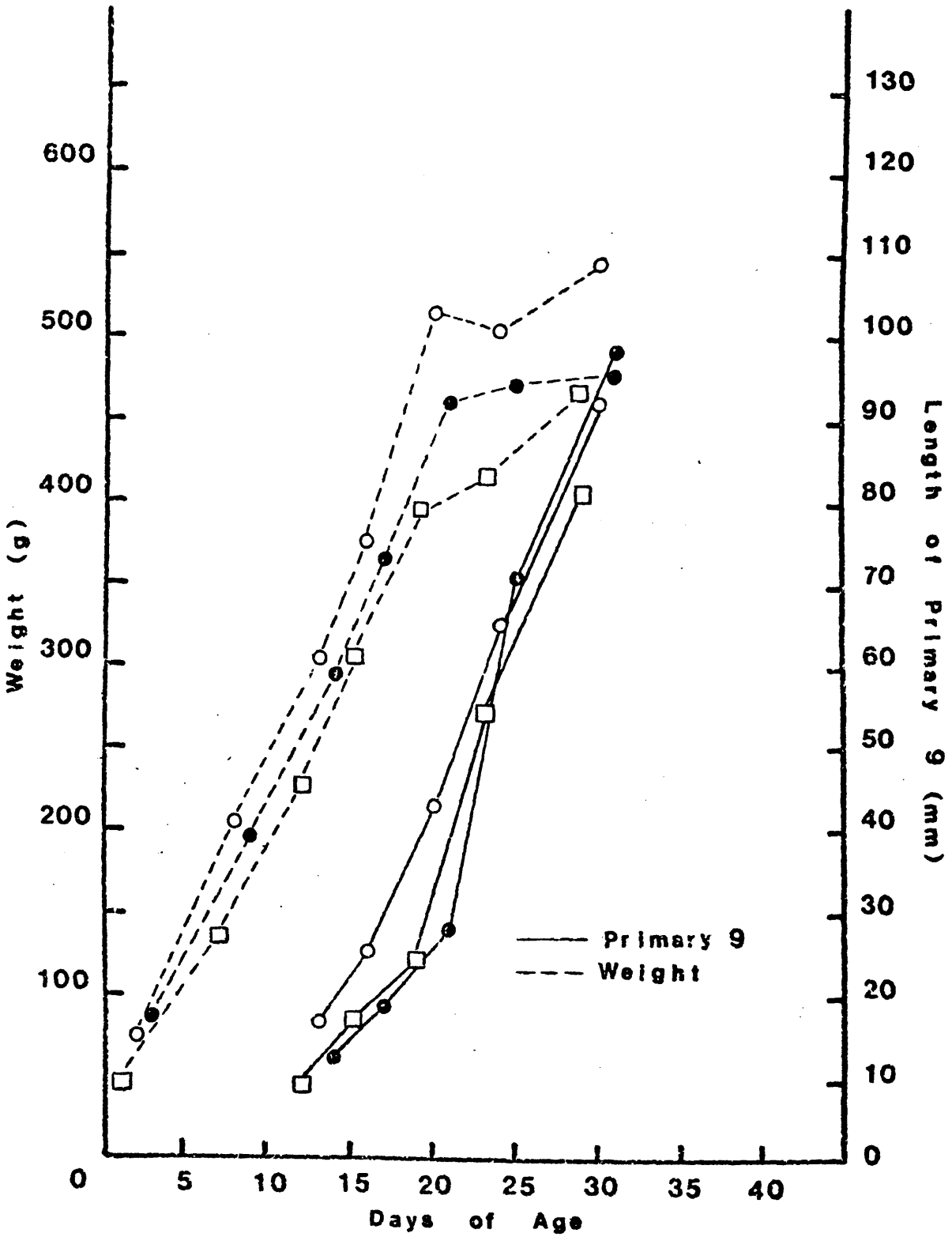

Figure 7. Individual measurements of length of primary 9 and weight for 3 owls in nest 6.

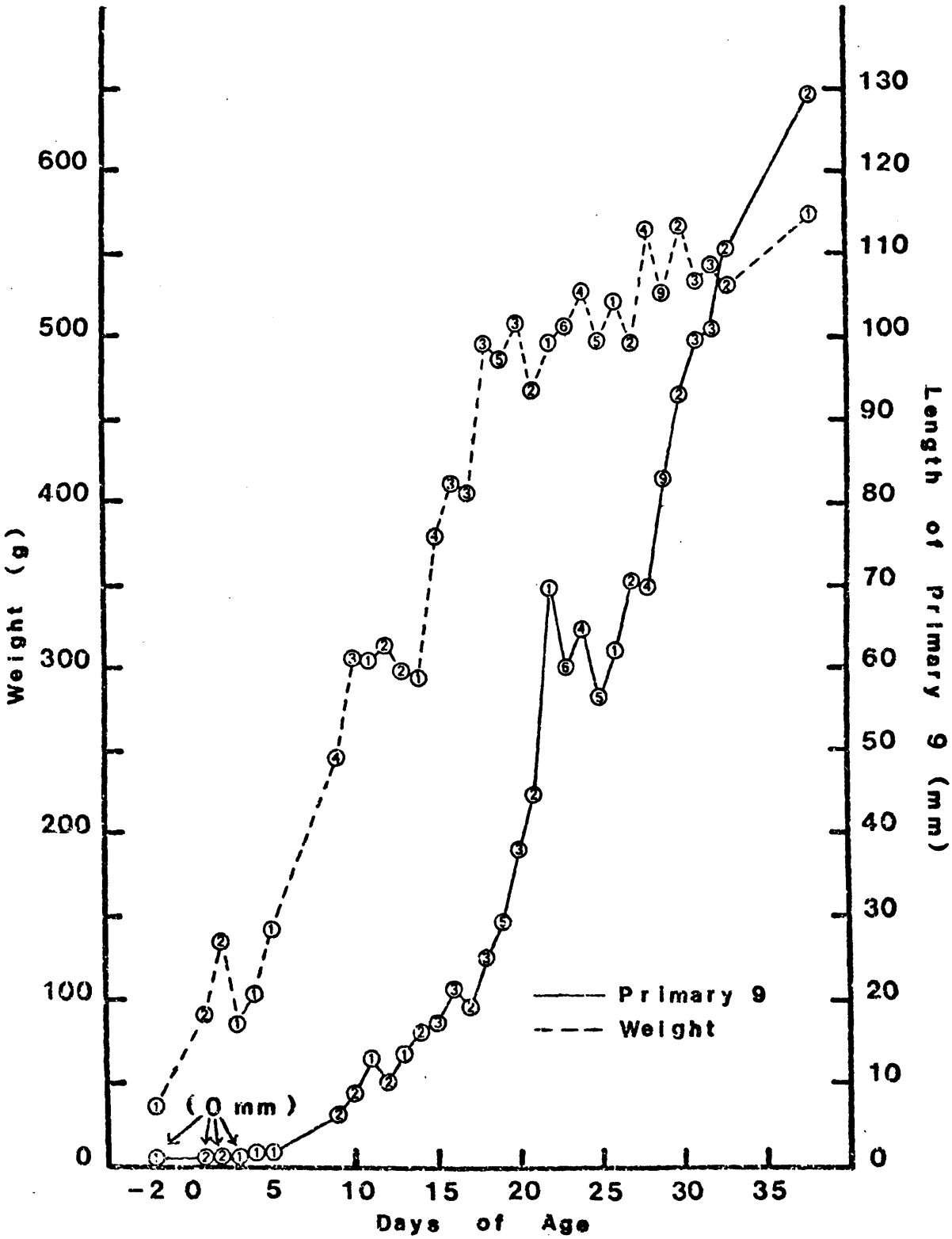

Figure 8. Mean measurements of length of primary 9 and weight.
Circles are means, and numbers are sample size.

provides more complete information than Figure 7, including data for one embryo and early feather and weight data for 2 owls just after hatching. Also, later feather data for 2 owls at 38 days of age are given.

Figure 8 indicates that the nestlings gained weight rapidly from the day of hatching until approximately 19 days of age, at which time the rate of gain began to level off, with minor fluctuations in weight occurring until 38 days of age. The growth rate of primary 9 increased at approximately 18 to 19 days of age, with the primary having grown at a slower rate between day 4, its day of emergence, and day 18.

The correlation coefficient for the means of body weight and length of primary 9 was 0.82 and was significant at the 0.001 level. This coefficient, together with analysis of Figures 7 and 8, indicates that a significant positive relationship exists between body weight and primary 9, and that Barred Owls follow the growth stages as described for Barn Owls, Great Horned Owls, and Golden Eagles (Aquila chrysaetos) by Sumner (1933), except for the first stage. There is a rapid period of increase in body weight coupled with the appearance of primary 9, and there is a period of leveling off in body weight with minor fluctuations and rapid development of primary 9. There does not appear to be, however, a first stage of early, slow weight gain as described by Sumner (1929; 1933), although, as pointed out, the

data for owls at the time of hatching and near to hatching were available only for 2 nests.

Starvation had little or nothing to do with weight loss, since during this study the adult Barred Owls continued to bring food to the young owls up to the day of fledging. Since Figure 7 shows that the weights of all 3 owls in the same nest leveled off and fluctuated somewhat together, the importance of a peck order seems questionable. It can probably be assumed that at least one owl could be expected to continue to gain weight or at least maintain its weight if it obtained most of the food brought to the nest because of its dominance over its siblings, if intake was the only factor involved. Two factors could partially account for the leveling off and subsequent fluctuations in weight. One is the development of the juvenal feathers as described by Sumner (1929), and as reported in the present study. A second factor could be the initiation of play and exercise by nestlings as reported by Sumner (1933). Observations of the activity of the nestlings near the time of fledging would seem to point to a necessarily greater expenditure of energy by the young.

Measurements taken near time of fledging. Because no information on the physical measurements of Barred Owls at the time of fledging could be found in the literature, these data were collected and organized in tabular form.

Table 2 contains the final individual measurements of 18 nestlings taken within 3 days before fledging. In Table 3 these measurements are averaged and grouped according to days before fledging.

A total of 7 Barred Owls were captured by hand after fledging. Table 4 contains the individual measurements of these fledglings, while in Table 5 these measurements are averaged and grouped according to days after fledging.

Weight in relation to fledging. The body weights of 9 owls taken just prior to and after fledging are presented in Table 6.

Owls 26, 29, and 39 were recovered and weighed freshly-dead. Their weights are included in the table for completeness, but were not used to compute the average weight loss. However, owl 29 was captured alive 2 days before it died, and so this live measurement is included in the computation of the average weight loss. Thus, 2 weight losses are recorded for owl 29 since it was weighed once when captured and once when recovered.

All but one owl showed a weight loss after fledging. The average weight loss for 7 captured owls was 27 g, with a range of 15 to 46 g. Owl 39 showed a weight gain of 27 g, but it should be noted that this owl was considered to have fledged prematurely from nest 5. Owl 24 was captured 7 days after fledging and showed a weight loss of 23 g.

Table 2

Individual Measurements of Barred Owls Taken within 3 Days before Fledging

	Owl Number								
	23	25	27	101	102	22	24	26	28
Days of age	28	28	28	27	29	29	29	29	29
Days before fledging	3	3	3	3	3	2	2	2	2
Central rectrix (mm)	28.0	29.0	30.0	---	---	34.0	49.0	42.0	37.0
Claw 1 (mm)	---	---	---	13.6	14.8	---	---	---	---
Claw 3 (mm)	---	---	---	14.9	16.9	---	---	---	---
Culmen (mm)	---	---	---	19.3	21.9	---	---	---	---
Primary 9 (mm)	70.1	73.0	64.0	80.2	94.2	81.4	89.0	93.0	91.0
Primary 10 (mm)	19.1	23.0	25.4	36.3	43.2	41.6	48.0	22.0	33.0
Weight (g)	543	575	580	496	574	497	595	501	544

Table 2 (continued)

Individual Measurements of Barred Owls Taken within 3 Days before Fledging

	Owl Number								
	29	36	40	30	30	104	105	107	108
Days of age	29	29	25	30	27	30	29	31	31
Days before fledging	2	2	2	1	1	1	1	1	0
Central rectrix (mm)	41.0	33.0	27.0	51.0	28.0	54.2	44.0	62.0	49.2
Claw 1 (mm)	---	---	---	---	---	16.4	14.9	15.9	15.4
Claw 3 (mm)	---	---	---	---	---	17.0	16.3	17.2	17.7
Culmen (mm)	---	---	---	---	---	22.8	20.0	21.8	24.9
Primary 9 (mm)	80.0	75.2	55.0	93.0	60.0	91.5	80.8	98.0	83.6
Primary 10 (mm)	49.0	32.1	30.0	42.0	20.0	31.3	21.6	40.7	33.2
Weight (g)	521	594	495	586	491	546	469	478	601

--- No measurements taken.

Table 3

Average Measurements of Barred Owls Taken within 3 Days before Fledging

	Days Before Fledging			
	3	2	1	0
Number of owls measured	5	7	5	1
Central rectrix (mm)	29.0*	37.5	47.8	49.2
Claw 1 (mm)	14.2**	---	15.7*	15.4
Claw 3 (mm)	15.9**	---	16.8*	17.7
Culmen (mm)	20.6**	---	21.5*	24.9
Primary 9 (mm)	76.3	80.6	84.6	83.6
Primary 10 (mm)	29.4	36.5	31.1	33.2
Weight (g)	554	535	514	601

--- No measurements taken.

* 3 owls measured.

** 2 owls measured.

Table 4

Individual Measurements of Fledgling Barred Owls

	Owl Number						
	23	25	27	29	40	108	24
Days of age	32	32	32	33	29	33	38
Days after fledging	1	1	1	2	2	2	7
Central rectrix (mm)	80.0	75.0	80.0	90.0	40.0	59.5	110.0
Claw 1 (mm)	---	---	---	---	---	15.5	---
Claw 3 (mm)	---	---	---	---	---	18.4	---
Culmen (mm)	---	---	---	---	---	23.2	---
Primary 9 (mm)	105.0	102.0	95.0	129.0	60.0	91.2	125.0
Primary 10 (mm)	45.0	42.0	30.0	65.0	35.0	39.0	65.0
Weight (g)	514	560	552	505	462	555	572

--- No measurements taken.

Table 5

Average Measurements of Fledgling Barred Owls

	Days After Fledgling		
	1	2	7
Number of owls measured	3	3	1
Central rectrix (mm)	78.3	63.1	110.0
Claw 1 (mm)	---	15.5*	---
Claw 3 (mm)	---	18.4*	---
Culmen (mm)	---	23.2*	---
Primary 9 (mm)	100.6	93.4	125.0
Primary 10 (mm)	39.0	46.3	65.0
Weight (g)	542	507	572

--- No measurements taken.

* One owl measured.

Table 6

Weight in Grams of 9 Barred Owls Taken within 3 Days before and 10 Days after Fledging

Owl Number	Days before (-) or after (+) fledging									Weight loss (-) or gain (+) in grams
	-3	-2	-1	0	+1	+2	+3	+7	+10	
23	543				514					-29
24		595						572		-23
25	575				560					-15
26		501							432*	-69
27	580				552					-28
29		521				505		368*		-16, -153
39			491				518*			+27
40		495				462				-33
108				601		555				-46

* Freshly-dead weight.

Behavioral Development

Behavioral development was divided into 5 stages, as previously described. Certain physical characteristics of the owls are included in the discussion of behavior, since physical and behavioral development are closely related.

Nestling Behavior

Although the behavior of Barred Owl nestlings has not yet been described in the literature, comparative studies of several other young raptorial birds have been reported by Sumner (1929; 1934). According to Sumner (1934), raptorial birds display a limited number of instinctive reflexes at hatching. These reflexes closely parallel the initial instincts, such as the gaping response, shown by the altricial young of other bird groups such as the passerine birds. These instincts gradually become modified by subsequent development and learning, so that certain responses become associated with certain stimuli.

Sumner (1934) further pointed out that perhaps one of the most important of all these developments is the acquisition of fear by the nestlings. With sight comes fear; and in the early stages of nest life, this fear manifests itself by a passive cowering in which the bird lies on its abdomen, neck tucked in, with eyes shut completely. Gradually, the nestlings display an active hostility in place of fear.

According to Kuhlmann (1909), instinctive fear develops gradually in young passerine birds and follows a definite pattern. Sumner (1934) feels that raptors follow this same pattern but in a more gradual fashion. Kuhlmann (1909) presents a sequence that is: a) the cessation of the food reaction to random stimuli that at first aroused it, b) a momentary shrinking from the stimulus, c) crouching in the nest (passive cowering), d) an attitude of alertness and attentive watching of moving objects, and e) escape from the nest when approached.

In this study, Barred Owls closely followed a similar sequence of behavioral development.

Days 1 to 3. During this period, one visit was made to 2 nests containing 2 and 3 owls. This 3-day period corresponds to the "mechanical toy" stage as described by Sumner (1934). It is a period in which a limited number of instinctive reactions or reflexes are performed by young raptors.

At this time, the eyes of all 5 nestlings were completely closed. When turned on their backs, 5 out of 5 nestlings grasped at the air with their feet and opened and closed their toes. All 5 nestlings were able to walk weakly. This walk was described by Gerrard, et al. (1973) as waddling and was the first mode of locomotion around the nest. In waddling, the entire tarsus was in contact with the nest

surface, and the young often used their wings as an aid in movement and balance. When being weighed on the balance, all 5 nestlings would lie on their abdomens, necks stretched, and beaks resting on the pan of the balance. This early inactivity was noted by Sumner (1929) to occur in some juvenile Strigidae.

In both nests, the nestlings were found huddled together with their beaks touching in a circle at the center of the cavity. At this age, all 5 owls were in a lying posture as described by Gerrard, et al. (1973). In a lying posture, the young had their heads and abdomens in contact with the nest surface. A peep call was given softly and continually by all 5 nestlings, both on the ground and in the nest. The call can be paraphrased as "peep - peep - peep - peep - peep." According to Sumner (1929), a similar sound is made by young Barn Owls, Long-eared Owls (Asio otus), Screech Owls, and Great Horned Owls. He refers to it as whimpering. The peeping was performed in unison by all 5 owls and could offer 2 advantages to them. First, this call may serve as the first means of communication for the young owls whose eyes are not yet open, allowing them to orientate to one another. For example, in the case of the one nest containing 3 owls, it was noted on one occasion that when one sibling was returned to the nest alone while the other siblings remained outside in the bag, this first returnee was

completely disoriented, not moving toward the center or the periphery of the nest and appeared to be frightened. However, when the second owl was returned to the nest, both owls immediately responded to each other's peeping and moved toward each other, meeting at the center of the nest. This movement was accomplished by use of the wings and feet and without vision. When the third sibling was returned to the nest, it also waddled to the center and joined the other 2 owls. Within one minute of meeting at the center, all 3 siblings were touching beaks at the center of the nest and peeping continually. Secondly, the continuous peeping of the young owls at this early stage may serve as a stronger stimulus to the brooding adult, demonstrating that the owls were all alive at this time, thus helping to assure that the brooding activity of the adults would continue and more food would be brought.

Days 4 to 7. Five owls from 2 nests containing 2 and 3 owls were observed once at this age. The eyes of all 5 owls were barely open, appeared to bulge, and the pupil and iris were clouded. Touching the sides of the owls' beaks with a finger elicited a gaping response from all 5 nestlings. The method of movement for all owls was waddling as previously described.

The call in the nest for all 5 owls observed was not a peeping call. Instead, it was a series of "chitters" sounding

like "chitter - chitter - chitter - chitter - chitter," with the series repeated usually 7 or 8 times and not given continuously. The number of chitters in any series varied. This call was given only when the 5 owls were disturbed, such as when they were removed from or returned to the nest. The orientation in both nests was at the center. However, in both nests the siblings overlapped each other by placing their heads on each other's backs. All 5 young were on their abdomens, but their heads were off the nest surface, being supported by the backs of the other owls.

On the ground, all 5 owls chittered when being placed on the balance or when separated from their siblings. All owls could only weakly hold their heads up and wobble from side to side when placed on the balance. When placed in the bag, all owls huddled together with their siblings with heads touching and remained very still in the darkness of the bag.

When returned to the center of the nest, all 5 owls immediately overlapped each other by placing their heads on each other's backs.

Days 8 to 11. A total of 11 nestlings from 3 nests containing 3 owls each and one nest containing 2 owls were observed at this age during one visit to each nest. The eyes of all 11 nestlings were only slightly opened, and the entire eye appeared cloudy. All owls were able to squat in the nest and on the balance. Squatting was described by

Gerrard, et al. (1973). In a squatting posture, the young sat with their weight on the whole length of the tarsi, but with the breast and abdomen anterior to the legs off the nest. All 11 owls used waddling, as previously described, as the mode of movement, but there was almost no use of the wings for balance. Audible bill-clacking was performed both in the nest and on the ground by 10 out of 11 nestlings. This sound can be simulated by quickly snapping together the upper and lower teeth. It was not definitely determined how the owls made the clacking sound, but it is possible that the sound was created by the snapping together of the upper and lower mandibles, since this action was observed for all 11 owls. One of the 11 owls attempted to bill-clack, but the clack was not audible. If 11 nestlings observed at this age were continually harassed by moving a hand in front of their faces, they would eventually revert to the chitter call during which no bill-clacking was given.

For all 4 nests, a definite peck order was developing. In the 3 nests with 3 siblings each, the smallest owl was found away from the larger owls which squatted close together at another location in the nest. In the nest with 2 siblings, both owls were also separated from each other. Eleven out of 11 owls faced outward in the nest in a squatting posture and used the walls of the cavity to support their heads. Six owls had their beaks hooked onto the wood of the

cavity wall, and 5 owls had their heads resting against the wall so that their beaks were pointed up toward the top of the nest.

On the ground, all 11 owls were able to grasp well with their talons, and their wings were held in almost adult position. When placed on their backs, 11 out of 11 owls used their feet as a righting mechanism, rapidly opening and closing their toes. When the sides of the beak were stroked with a finger, a response was elicited from 8 of the 11 owls which appeared to be more of a defense mechanism than a feeding response in that the beak was used to strongly grasp the finger in an aggressive, biting manner. However, the relatively mild grasping response elicited from 3 out of the 11 owls appeared to be more of a feeding response. Sumner (1934) observed a similar waning of this "grasping reflex" in Great Horned Owls and Screech Owls, noting that this reflex becomes a defense mechanism with the development of fear in these raptors.

Although a peck order seemed to be developing at this age, when the 11 owls were placed in a bag on the ground at each nest, they huddled together with their siblings as previously described for days 4 to 7. Also, when returned to the nest, all 11 owls initially squatted together at the center of the nest with their eyes almost closed and their wings in almost adult position. Eight out of the 11 owls

squatted with their heads held skyward. Three out of 11 owls grasped the back feathers of other siblings with their beaks. However, within an average of 5 minutes after being returned to the nest, all 11 siblings moved away from one another, perhaps due to the developing peck order. It was not determined if the owls eventually arranged themselves in the nest as before with the smallest owl away from the larger owls. This may have occurred some time after I had descended from the nest opening.

Days 12 to 14. A total of 12 owls from 3 nests containing 3 owls each, one nest containing 2 owls, and one nest containing one owl, were observed once at this age. The eyes of all 12 nestlings were almost three-fourths open, and the iris appeared dark brown while the pupil was pale blue. When I arrived at the opening of each of the 5 nests, 9 out of the 12 owls were already leaning back on their rectrices looking up toward the top of the cavity. The breast and abdomen anterior to the legs were lifted even higher off the nest surface than in the squatting posture which was described for days 8 to 11. The weight of the 9 owls in this posture was placed on both the entire length of the tarsi and on the rectrices, unlike the squatting posture in which the weight was only on the tarsi. The 9 owls performed much bill-clacking while looking directly at me, and the wings were not spread in this posture. Three of the

12 owls remained very still in the squatting posture, facing outward in the cavity with their heads resting on the wall as previously described. Since the owls were disturbed by my approach, it was not possible to determine how they were arranged in the nest before being disturbed.

When placed in the bag on the ground at each of 4 different nests, none of the 11 siblings huddled together, and all 12 owls tried to escape from the bag. Once out on the ground, each of the 12 owls actively hopped around on their tarsi in an attempt to avoid me. When approached, each of the 12 owls struck out at my hands with their beaks while bill-clacking. All bill-clacking was audible. When continuously harassed by my moving hand, all 12 owls reverted to the chitter call during which no bill-clacking occurred. This call was recorded for one nestling and was analyzed with a sonagraph. Discussion of this call is included in a later section.

When returned to the nest, 8 out of 11 siblings, and the one single nestling, assumed the squatting posture with heads held skyward. Three of the 11 siblings overlapped other owls by placing their heads on the backs of other siblings.

Days 15 to 17. A total of 19 owls from 4 nests containing 3 owls each, 3 nests containing 2 owls each, and one nest containing one owl, were observed once at this age.

Nineteen out of 19 owls were in a standing posture in the nest. The young were considered to be standing when the whole length of the tarsus was off the nest, and their weight was entirely on their toes. The mode of movement around the nest for all 19 owls was walking. All 19 owls showed signs of feather settling as described by Pettingill (1970). The owls would raise their feathers, shake their bodies, flap their wings, and then depress their feathers into proper position.

In the nest, all 19 owls were very aggressive. Upon my appearance at the nest entrance, all 19 owls hissed and actively struck at my fingers with their beaks while giving audible bill-clacks. When continuously harassed by my moving hand, 12 out of the 19 owls stopped hissing and bill-clacking and reverted to the chitter call as described previously. No bill-clacking or hissing occurred during this chitter call. Seven out of 19 owls continued to hiss and bill-clack while striking out with their beaks and did not give a chitter call.

Days 18 to 21. A total of 19 owls from 4 nests containing 3 owls each, 3 nests containing 2 owls each, and one nest containing one owl, were observed once at this age. At this time, the eyes of all 19 owls were completely open. Upon my arrival at the nest opening, 16 out of the 19 owls showed the partial defensive posture. Owls were considered to be in the

complete defensive posture when they gave a full wing display with wings fully extended forward, leading edge down, and feathers spread. The 16 owls assumed only the partial defensive posture in which the wings were extended only slightly out from the body. All 16 owls bill-clacked and hissed while in the partial defensive posture, and all 16 owls actively struck at my hands with their beaks. When continuously harassed by my moving hand, all 16 of the owls reverted to the chitter call previously described. However, they continued to bill-clack and hiss throughout the call. This call was recorded for one nestling, analyzed on a sonagraph, and is discussed in a later section. Three out of 19 owls were in a standing posture and continued to bill-clack and hiss, without assuming a defensive posture or reverting to the chitter call.

On the ground, all 19 owls attempted to escape when held in my hands and performed much wing-flapping when lifted onto the balance.

All 19 owls were very difficult to return to the nest. When being returned, they performed much wing-flapping making it difficult to fit them through the opening of the nest. All owls repeatedly attempted to hook their talons onto the nest tree.

Days 22 to 24. A total of 19 owls from 4 nests containing 3 owls each, 3 nests containing 2 owls each, and one nest

containing one owl, were observed once during this period. All 19 owls used their talons to grab at my hands from a standing position when an attempt was made to remove them from the nest and vigorously bit my hands with their beaks. With continued harassment from my hands, 5 of the 19 owls fell completely onto their backs and from this position threatened with their beaks and talons. Fourteen out of 19 owls, after continued harassment, assumed the partial defensive posture with much bill-clacking and hissing.

On the ground, all 19 owls were difficult to handle, as they performed much wing-flapping and hopped around the ground in an attempt to escape. When pursued, all owls bill-clacked, hissed, and assumed the complete defensive posture as described previously.

At this age, none of the 19 owls gave the chitter call, even after prolonged harassment.

Days 25 to 28. A total of 18 owls from 3 nests containing 3 owls each, 4 nests containing 2 owls each, and one nest containing one owl, were observed once at this age. To test their climbing ability, all owls were placed on the sides of trees. All 18 owls could climb extremely well. The climbing was accomplished by a coordinated use of wings, talons, and upper mandible. The 3 anteriorly-facing talons of each foot were hooked into the bark and maintained the owl's position on the tree. The owls also used their upper

mandibles to maintain position on the tree by hooking their mandibles onto the bark. While maintaining a position on the tree, the owls held their wings close to the body. To climb, the owls would stretch their necks and hook their upper mandibles onto the bark at a new, higher position up the tree. Then, while extending and flapping their wings, the owls would use the upper mandible to pull themselves up the tree while alternately moving their feet to higher positions on the tree. With each step, the 3 anteriorly-facing talons were hooked into the bark. The owls would then repeat the process after securing themselves at the new position. When the beaks of all 18 owls were unhooked from the tree by me, no change in foot position occurred for any of the owls. When the feet of the owls were removed from the tree, all 18 owls remained supported by only their upper mandibles. Dunstan and Sample (1972) reported that 6 different Barred Owls were observed climbing various species of trees in Minnesota and that the owls were not able to climb smooth trees as well as those with rough bark. Contrary to Dunstan and Sample (1972) who reported that Barred Owls use their beaks in climbing by grasping the bark with them, all 18 owls were observed to use the upper mandible by hooking it onto the bark. Sumner (1934) noted that young Barn Owls could climb smooth oak trees moving 5 m in a few seconds. Sumner (1934) further pointed out that this climbing ability

could be useful to young raptorial birds which leave their nests prematurely. This could explain why raptors are seldom found on the ground.

In the nest, all 18 owls gave a very strong hiss with much bill-clacking. The partial defensive posture was assumed by all 18 owls but the wings were spread out more from the body than they were during days 22 to 24. Seven out of 18 owls backed up against the wall of the nest after continued harassment with a moving hand. From this position, the owls gave a defensive posture in which one wing was raised up against the wall while the other wing was fully displayed as described for the complete defensive posture. During this wing display, all 7 owls hissed and bill-clacked while striking out at my hands with their beaks. At this age, all 18 owls tried to climb out of the nest to avoid being placed in the bag.

On the ground, all 18 owls tried to hop away with much wing-flapping. All owls performed much bill-clacking and hissing. When pursued, 14 out of 18 owls assumed the partial defensive posture. Four out of 18 owls backed up against trees and fully displayed one wing as up against the wall in the nest.

Days 29 to 32. A total of 18 owls in 3 nests containing 3 owls each, 4 nests containing 2 owls each, and one nest

containing one owl, were observed once at this age. As soon as I appeared at the nest opening, all 18 owls attempted complete defensive postures in the nest by displaying their wings as much as the confining dimensions of the cavities would allow. At this age, all 18 owls were so vicious they were difficult to handle without binding their feet with a leather strap. All owls were difficult to remove from the nest without suffering deep hand and arm wounds from their talons and beaks. All owls struck out viciously with their talons from the defensive posture.

On the ground, 5 out of 18 owls actively hopped at me and attempted to strike with their beaks and talons. None of the owls would remain in the bag, and when allowed, all 18 owls attempted to escape into the underbrush. None of the 18 owls stayed on the balance unless they were bound with a strap about their feet.

One out of 18 owls handled at this time punctured the floor of its mouth with its talon but this healed over with no apparent harm resulting. Sumner (1929) noted that Barn Owls viciously grabbed at and struck siblings with their talons.

Diurnal Pre-fledging Behavior

An average of one daylight hour per nest per day was spent observing the 5 owls in nests 6 and 7 for 3 days immediately prior to the day of fledging of the owls. An

average of one daylight hour per day was spent observing the one owl of nest 8 for 2 days immediately prior to the day of fledging of the owl. A total of 6 owls in 3 nests were therefore observed for 8 daylight hours over a 2- to 3-day period just prior to the day of fledging.

Exercise was perhaps the most important of the pre-fledging behaviors observed. It physically prepared the nestlings for fledging. Depending on the type of nest, whether side-entrance or top-entrance, this exercise was performed in differing manners and degrees during the observed daylight hours.

During all observed daylight hours, all 6 owls performed much wing-flapping in the nest. During each of 3 daily observation periods for nest 7, and 2 observation periods for nest 8, 3 out of 3 owls in these side-entrance nests were observed sporadically extending one wing sideways out of the nest to obtain more space for a full wing-flap. During each of 3 daily observation periods, all 3 owls in nest 6, a top-entrance cavity, were observed sporadically performing an abbreviated wing-flap in which the wings were flapped as much as the sides of the cavity would allow. Because of the small, confined area of the elliptically-shaped nest bottom, the 3 owls in the top-entrance cavity had to abbreviate their wing-flap, whereas the 3 owls in the side-entrance nest could extend one wing out of the cavity and perform a

fuller wing-flap. For all owls, the periods of wing-flapping averaged one minute. Between the sporadic wing-flapping periods, all 6 owls were observed preening their feathers. Preening is defined as care of the plumage in which the beak is used to clean the feathers, interlock the barbs that have become separated, and smooth down the plumage. During preening, the nestlings gave primary attention to the breast feathers and wing feathers, particularly those along the frontal border of the wing. In addition, allo-preening, the preening of one bird's plumage by another bird, was observed being performed on 2 occasions by 2 out of 5 siblings. In both observed cases, only the breast feathers were allo-preened. No allo-preening of the wing feathers was observed.

The 2 owls in the top-entrance cavity were observed performing possibly another exercise sporadically during all 3 daily observation periods. In this exercise, the owls' heads were extended as high up as possible while the wings were stretched downward with the primaries perpendicular to the nest floor. The motion of this exercise gave the owls the appearance of bobbing up and down. Because this exercise could be practiced in a very confined space, it could especially benefit birds in top-entrance nests who could not extend their wings out of the cavity as birds in side-entrance nests could. This exercise differed from head-bobbing which is a common behavior for some adult owls.

The movement of the wings and body during the exercise was much greater than is usually observed in head-bobbing.

The daylight hours were found to be a time of surveillance by all 6 owls of the area around the nest trees. The 3 owls in side-entrance nests were observed sporadically extending their heads out of the 2 nests during each observation period. The owls did not climb out onto the edge of the nest but remained hidden in the cavity except for their extended heads. When peering out of the nest with necks extended, the 3 owls were extremely cautious and diligently surveyed the nearby ground and trees. No head-bobbing occurred during the surveillance periods. The young were acutely aware of the flight of even small flies that chanced to pass the nest entrance. The owls reacted to the flies by ducking down into the nests to conceal themselves. On one occasion, when a Blue Jay (Cyanocitta cristata) passed one nest at a distance of 30 m, the 2 owls in the nest knocked each other down in attempting to scramble back into the recesses of the cavity. The 3 owls in the top-entrance nest were observed sporadically looking out the hole in the cavity wall during each observation period. On 3 occasions, one owl climbed partly up to the top of the cavity and extended its head to eye level out of the nest.

A possible advantage of the surveillance activity is that it afforded the owls an opportunity to partially view

the immediate area around the nest and to orient themselves in regard to fledging.

Nocturnal Pre-fledging Behavior

A total of 12 hours was spent observing the 6 owls of nests 6, 7, and 8. The 3 owls of nest 6 were observed for 4 hours on the third night prior to their day of fledging. The one owl of nest 8 was observed for 4 hours on the second night prior to its day of fledging. The 2 owls of nest 7 were observed for 4 hours on the last night prior to the day of fledging.

After darkness, additional activities were initiated by all 6 nestlings. Approximately 10 minutes after sunset, all 6 nestlings began to give food-begging calls from inside the nests. The food-begging call of one nestling was recorded, analyzed with a sonagraph, and is discussed in a later section.

All 6 owls remained in the nests and continued to give food-begging calls from inside the cavities for approximately 2 hours after sunset. During this time, the 3 owls in the side-entrance nests extended their heads high up and out of the nests. Their beaks were pointed skyward at this time, and in this position the young gave their plaintive food-begging calls. The 3 owls in the top-entrance nest remained in the nest and gave their food-begging calls from there.

Approximately 2 hours after sunset, in response to the calling of the adults, 5 of 6 owls climbed out onto the edge of the nests and continued to give food-begging calls with their beaks pointed skyward. The 3 owls in the top-entrance nest climbed up out of the cavity and perched on top of the cavity wall, while 2 out of the 3 owls in the side-entrance nests climbed out on the edge of the entrance. On one occasion, one nestling in a side-entrance nest remained inside the nest giving food-begging calls while the other nestling climbed out onto the entrance edge.

Besides giving food-begging calls, 5 out of 5 owls which perched on the nest edge performed much wing-flapping with sufficient room to give a full, rigorous wing-flap. This wing-flapping was a type of exercise in that the owls grasped the edge of the nest strongly with their talons to keep from lifting off. This allowed the owls to apply a maximum stress to the wings and to strengthen them.

During the periods between sporadic wing-flapping, 5 out of 5 owls voided over the side of the nest. Also between wing-flappings, preening of the breast feathers, and particularly the feathers along the frontal border of the wings, was observed for all 5 owls. Allo-preening of the breast feathers was observed for 2 out of 5 owls.

On one occasion, on the morning of the last day prior to the day of fledging, I returned to nest 6 about one hour

before dawn. All 3 owls were still out on the nest edge and were not giving food-begging calls. Approximately one-half hour before dawn all 3 owls retreated into the nest by jumping down into it.

For all 6 owls, the daylight hours brought a renewal of the diurnal pre-fledging activities described previously.

Diurnal Fledging Behavior

The 2 owls of nest 7 were observed during the daylight hours on the day of fledging for approximately 2 hours. On this day, both owls performed all of the activities described for them under diurnal pre-fledging behavior. However, both nestlings appeared to be more active in the nest than during the previous diurnal and nocturnal observation periods. The rate of all exercising was greatly increased for both owls. Preening of the breast feathers by both owls seemed to occur more often than on the previous day, and even more attention was shown to the feathers along the frontal border of the wings than on the previous day. Allo-preening of the breast feathers was observed to occur 7 times during this 2-hour observation period. One nestling allo-preened its sibling 5 times, while the other allo-preened 2 times.

The great increase in nestling activity on this day led me to believe that these owls were very near to fledging. I therefore returned 2 hours before sunset and erected a

blind. I remained in the blind until one hour after dawn.

Nocturnal Fledging Behavior

Approximately 2 hours after darkness, the 2 nestlings of nest 7 climbed out onto the edge of the nest as on the previous evening. Both adults at this time were judged to be within 40 m of the nest tree. At intervals of 5 minutes, an adult call was heard which can best be described as a mournful "wool-l-l-l-l." This call resulted in an increase in the volume of the food-begging calls being given by both young. An adult owl then made a visit, landing on the edge of the nest and holding on with its talons. The adult owl positioned itself on the edge so that it was near to the young. No prey was observed being carried to the nest at this time. During this visit of about 2 minutes duration, the adult owl brushed up against the breasts of both young in a prodding manner while touching the beaks of the young as in a food exchange. However, no food was brought to the nest or given to the young on this visit.

Within 15 minutes of the adult's visit to the nest, one of the 2 nestlings made a series of intention squats on the nest's edge, and after approximately 5 minutes of squatting the owl jumped to an adjacent branch in the nest tree while flapping its wings. Having reached the adjacent branch, the owl was restless and continuously looked around at the surrounding trees. After about 5 minutes, the owl

moved to a branch higher up in the nest tree by climbing as previously described under nestling behavior, days 25 to 28.

The departure of the first sibling seemingly had the effect of coaxing the remaining nestling from the edge of the nest. The nestling was giving a series of intention squats when the sound of human voices frightened it and the owl returned into the nest. Within 5 minutes, the owl climbed out onto the edge of the nest. It then gave a series of intention squats and jumped to an adjacent branch in the tree as did the other owl. Both owls remained out of the nest all night, and did not return to it when dawn came. During the night, both owls were fed once by an adult owl in response to their food-begging calls.

During the entire fledging process, both adults were present and gave a variety of calls, particularly the call described as "wool-l-l-l-l."

Sonagrams of Nestling Calls

The sonagrams of the calls of a nestling Barred Owl at 2 different ages are presented in Figures 9 and 10. Figure 9 is a call given by a nestling at 12 to 14 days of age. This call was given when the owl was disturbed or harassed either in the nest or on the ground. The call consisted of a series of raspy chitters, varying in number, but usually consisting of about 5 chitters per series. The call in the sonagram consists of one series of 2 chitters

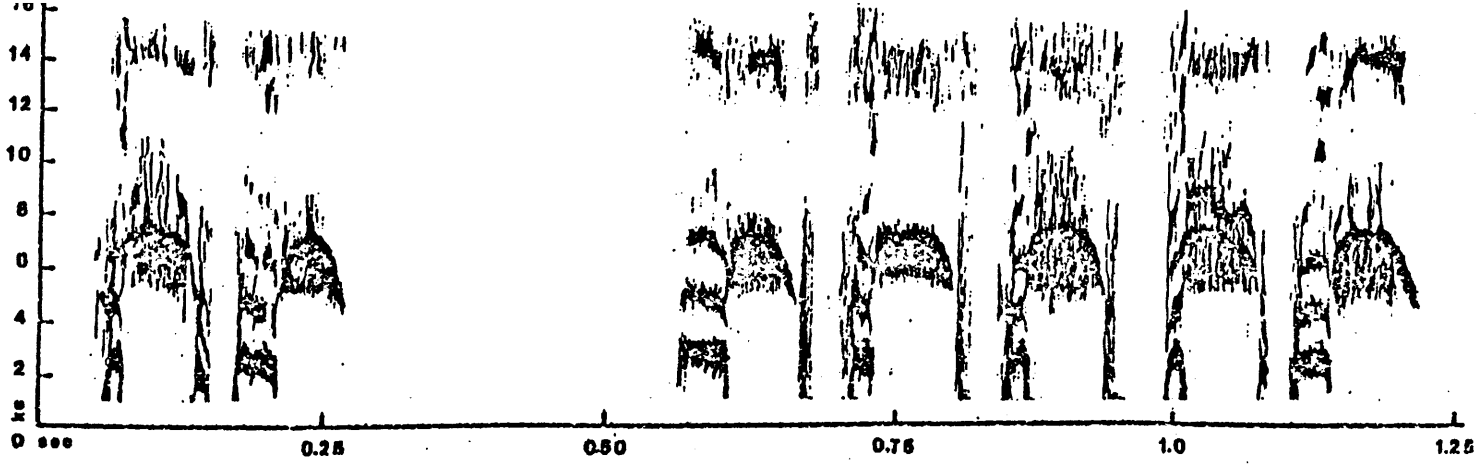

Figure 9. Sonagram of the chitter call of a nestling at 12 to 14 days of age.

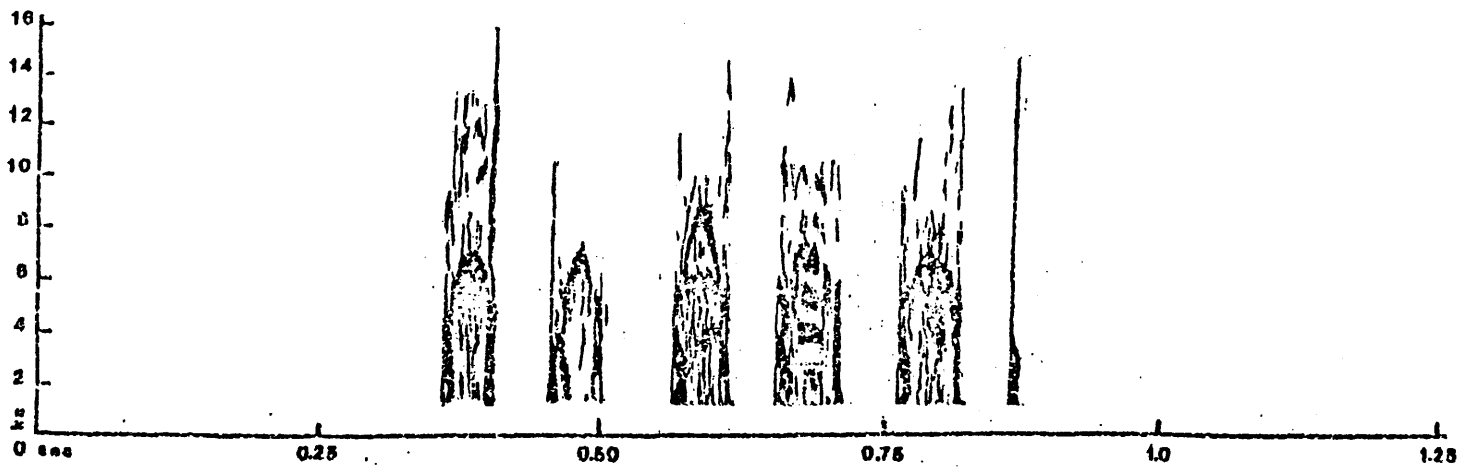

Figure 10. Sonagram of the chitter call of a nestling at 19 days of age.

followed by another series of 5 chitters and is described as "chitter - chitter . . . chitter - chitter - chitter - chitter - chitter." The average duration of one chitter was 116 milliseconds. The average time between individual chitters in a series was 37 milliseconds. The loudest part of each chitter had its peak at approximately 8 kc. Harmonics appear as faint lines above this peak.

Figure 10 is a sonagram of a nestling call at 19 days of age. The call consisted of a series of chitters in which bill-clacking and hissing were interspersed at random times. The call on the sonagram is described as "chitter - chitter - chitter - chitter - chitter - clack." The average duration of a single chitter was 46 milliseconds, approximately one-half the duration time of the chitter recorded at 12 to 14 days of age. The average time between chitters in a series was 50 milliseconds. Because bill-clacking is a type of mechanical sound, like the tick of a clock, the clack has a wide range of frequencies. The clack therefore appears on the sonagram as the dark vertical line at the end of the series of 5 chitters. The loudest part of each chitter had its peak at approximately 7 kc.

The food-begging call of a nestling at 31 days of age was recorded. This call appears in Figure 11.

The call begins with a fast rise in frequency, then gradually increases in pitch until ending with a quick

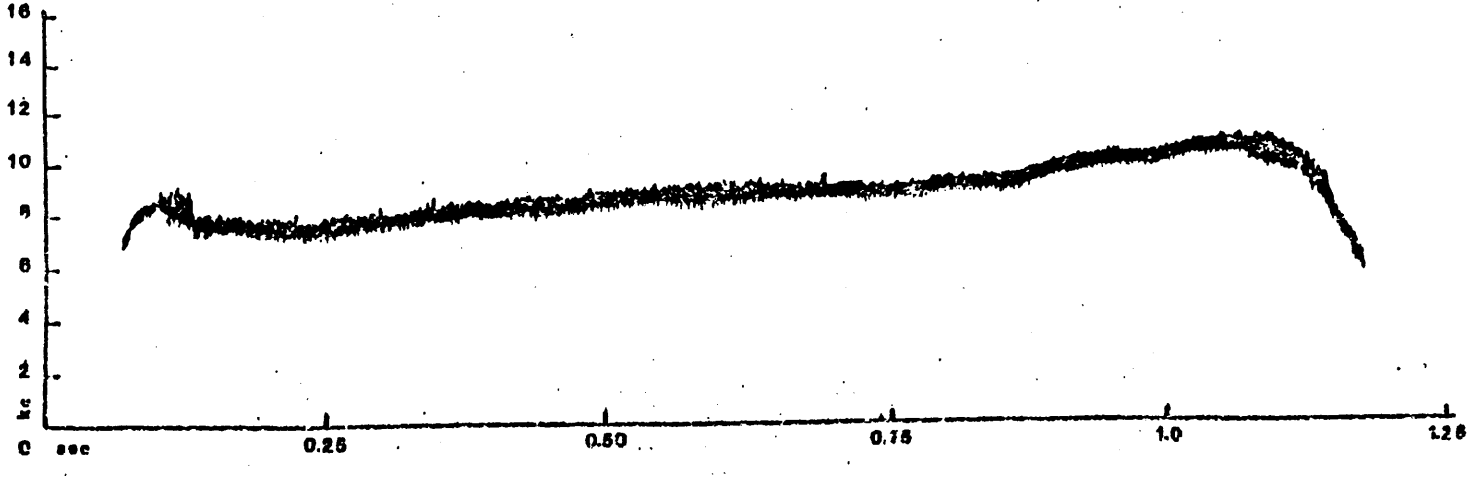

Figure 11. Sonagram of the food-begging call of a nestling at 31 days of age.

drop-off in frequency. The call was continuous without any interruptions.

The call in Figure 11 has a duration of 1,096 milliseconds. It starts at 6.5 kc, gradually rises to 11 kc, and falls off at the end to 6 kc.

Pellets and Feces

Undigested prey remains are expelled by owls in the form of compacted pellets. These pellets can often be found whole or broken up in the nest during early morning visits. The pellets increase in size with advancing age of the young owls. For 2 owls at 7 and 9 days of age, 2 pellets had respective dry weights of 0.7 and 0.8 g, wet weights of 1.5 and 1.6 g, and dimensions of 25.8 x 14.6 mm and 26.0 x 15.1 mm, respectively. For one owl at 26 days of age, the dry weight of one pellet was 2.6 g, the wet weight was 4.8 g, and the dimensions were 46.3 x 20.0 mm. One owl at 36 days of age expelled one pellet with a dry weight of 2.8 g and a wet weight of 6.6 g.

In addition to these castings, an autopsy of one nestling at age 14 days revealed stomach contents which had a wet weight of 23.3 g and a dry weight of 8.5 g. These stomach contents consisted of indigestible prey remains and had the same texture as regurgitated castings or pellets.

Fecal material accumulated in the bottom of the nests throughout the nestling period. The fecal material in the

nests was in the form of semi-solid droppings which had a yellow-white center of urate surrounded by a ring of dark brown intestinal excreta. The fecal dropping of one owl at 9 days of age weighed 1.4 g wet.

When the nestlings were handled on the ground, the feces was often voided as a liquid. This liquid was dark brown excreta with yellow-white strands of urate running through it. Apparently this feces was liquid because re-absorption of water from the urine in the cloaca and the excreta in the intestines had not progressed very far before the owl voided. Sumner (1929) reported a similar occurrence in Screech Owls and attributed their prodigious defecation on the ground to their nervousness.

By the time the owls fledged, all of the nests were well-fouled by the fecal material, and the smell of nitrogenous wastes was offensive to me.

Food Habits

Errington (1932) stated that the food of Barred Owls in southern Wisconsin was dependent upon what was available. Errington and McDonald (1937) stated that what a Barred Owl eats is mainly conditioned by where it is and by what prey it has a chance to feed upon with greatest convenience. They also stated that, season by season, the diet reflects adaptations and apparent opportunities. Preferences for certain kinds of prey do not seem to govern the natural

feeding of Barred Owls. Habit causes the owls to favor hunting grounds where prey may be of characteristic types.

Other than availability, size seems to be another factor in determining the food habits. Errington (1932) stated that the food of Barred Owls was determined by what was within the power of their feet to kill. He reported that the ordinary size limit for avian prey was a Common Flicker (Colaptes auratus) while for mammalian prey, moles and eastern cottontail rabbits (Sylvilagus floridanus) were the limit. Errington described Barred Owls as being endowed with as mild a disposition as any raptor could have and yet maintain a predaceous existence. He noted that in some cases these owls have subsisted for considerable periods on large invertebrates such as insects and crayfish, or fish and amphibians. Errington and McDonald (1937) reported that any animal living in a Barred Owl's habitat, from insects to the largest vertebrates within its power to kill, may fall victim to the owl's talons. Wing (1956), for example, stated that a Barred Owl with a body weight between 600 and 900 g and a corresponding skeletal weight of 61 g may have a total lifting power of 1360 g which would allow the bird to lift a Norway rat (Rattus norvegicus) off the ground. Kilham (1972) reported a Barred Owl eating a large eastern gray squirrel (Sciurus carolinensis) but stated that it was barely able to carry it away in its talons.

In reporting the specific food habits of Barred Owls, Hausman (1948) stated that more than one-half of their food consisted of mammals such as rabbits, chipmunks, squirrels, rats, shrews, moles, and some weasels. Among the insects eaten are large beetles, crickets, and grasshoppers. Also included are crayfish, frogs, spiders, and small fish. Among the birds reported were Fox Sparrows (Passerella iliaca), Vesper Sparrows (Pooecetes gramineus), Ruffed Grouse (Bonasa umbellus), and Bobwhite Quail (Colinus virginianus). Hamerstrom (1972) stated that Barred Owls in Wisconsin eat primarily crayfish, insects, small mammals, fish, and some birds. Earhart and Johnson (1970) reported the diet to consist mainly of mammals such as mice, squirrels, hares, and shrews with smaller numbers of fish, amphibians, reptiles, and birds. Insects were eaten only rarely. Morrissey (1968) analyzed 6 pellets of Iowa Barred Owls and found the remains of one white-footed mouse (Peromyscus leucopus) in each. In 43 pellets, he found 6 fish, 23 white-footed mice, 5 Norway rats, 4 meadow voles (Microtus pennsylvanicus), one short-tailed shrew (Blarina brevicauda), one rabbit, and one crayfish. Wilson (1938), working in Michigan, analyzed 249 Barred Owl pellets and found 777 skulls in them. Of these, one was a house mouse (Mus musculus), 5 were amphibians, 7 were southern bog lemmings (Synaptomys cooperii), 8 were meadow jumping mice (Zapus hudsonius), 8 were least shrews

(Cryptotis parva), 8 were birds, 9 were insects, 29 were deer mice (Peromyscus maniculatus), 53 were short-tailed shrews, and 648 were meadow voles. He stated that Barred Owls are mousers the year around except during and after the nesting season when one-fifth of their diet consists of song-birds. The time of the nesting season was not reported. The examination of pellets from a pair of nesting Barred Owls with a family showed that 23 percent of their food at this time consisted of birds, mostly woodpeckers.

Hodges (1947) stated that the winter diet of Barred Owls in Iowa consisted of small rodents with a few birds when rodents were scarce. He reported seeing a Barred Owl eating a small fish it had just taken from the Mississippi River and considered this a rare occurrence. However, Bolles (1890) reported that his hand-reared Barred Owls would readily jump into a water tank to grab perch with their talons. Dunstan and Sample (1972) reported that Barred Owls in Minnesota were observed sitting along trout streams on rocks, waiting for trout to dimple the surface and then catching them with their talons.

Southern (1969) in working with Tawny Owls (Strix aluco) in England reported that the food brought to the young may differ from that which the adults eat themselves. He found that adult Tawny Owls preferred small rodents and birds in their own diet but fed larger prey to their young as these

became available. He further reported that prey does not always show up in pellets, but instead it may pass on to the intestines. Southern (1969) further stated that beetle remains are hard to find in pellets and, along with small rodents, may pass into the intestines and are lost. Also, the young owls may swallow the beetles whole so that no beetle prey is found in the nests during visits. Errington and McDonald (1937) reported that nestling Barred Owls in Iowa seem to be fed the same sort of food that is eaten by the adults except for very small prey, like insects, which the adults eat upon capture.

Table 7 is a compilation of the food items from 9 Barred Owl nests. One hundred and forty items were indentified from whole or partial prey items in the nest, from prey remains found in regurgitated nestling pellets, and from analysis of the stomach contents of one dead nestling of 14 days of age.

As a taxonomic group, birds were the most frequently occurring prey items, comprising 47.9 percent of the total food items. Among the birds, the Common Grackle (Quiscalus quiscula) constituted 19.4 percent of all birds, Red-winged Blackbirds (Agelaius phoeniceus) 17.9 percent, Common Flickers 11.9 percent, Common Crows (Corvus brachyrhynchos) and American Robins (Turdus migratorius) 9.0 percent each, and Downy Woodpeckers (Dendrocopos pubescens) 7.5 percent.

Table 7

Barred Owl Food Items Collected from Nests during 1973 and 1974 Nesting Periods

Taxon Group	Species	Number of Items	Percent of Taxon Group	Percent of Total Items
Birds	Common Grackle (*Quiscalus quiscula*)	13	19.4	9.3
	Red-winged Blackbird (*Agelaius phoeniceus*)	12	17.9	8.6
	Common Flicker (*Colaptes auratus*)	8	11.9	5.7
	Common Crow (*Corvus brachyrhynchos*)	6	9.0	4.3
	American Robin (*Turdus migratorius*)	6	9.0	3.6
	Downy Woodpecker (*Dendrocopos pubescens*)	5	7.5	0.7
	Brown-headed Cowbird (*Molothrus ater*)	1	1.5	0.7
	Northern Oriole (*Icterus galbula*)	1	1.5	0.7

Table 7 (continued)

Barred Owl Food Items Collected from Nests During

1973 and 1974 Nesting Periods

Taxon Group	Species	Number of Items	Percent of Taxon Group	Percent of Total Items
Birds (cont.)	Red-headed Woodpecker (*Melanerpes erythrocephalus*)	1	1.5	0.7
	House Sparrow (*Passer domesticus*)	1	1.5	0.7
	Starling (*Sturnus vulgaris*)	1	1.5	0.7
	Pied-billed Grebe (*Podilymbus podiceps*)	1	1.5	0.7
	Unidentified Birds	11	16.4	7.9
	Totals for Birds	67	100.0	47.9
Mammals	Prairie Vole (*Microtus ochrogaster*)	12	29.3	8.6
	Southern Bog Lemming (*Synaptomys cooperii*)	6	14.6	4.3

Table 7 (continued)

Barred Owl Food Items Collected from Nests during

1973 and 1974 Nesting Periods

Taxon Group	Species	Number of Items	Percent of Taxon Group	Percent of Total Items
Mammals (cont.)	Meadow Vole (*Microtus pennsylvanicus*)	5	12.2	3.6
	Eastern Cottontail Rabbit (*Sylvilagus floridanus*)	4	9.8	2.9
	Short-tailed Shrew (*Blarina brevicauda*)	2	4.9	1.4
	Eastern Mole (*Scalopus aquaticus*)	1	2.4	0.7
	Norway Rat (*Rattus norvegicus*)	1	2.4	0.7
	Unidentified Mammals	10	24.4	7.1
	Totals for Mammals	41	100.0	29.3
Invertebrates	Crayfish (*Cambarus* sp.)	17	85.0	12.1
	Unidentified Beetles	3	15.0	2.1
	Totals for Invertebrates	20	100.0	14.2

Table 7 (continued)

Barred Owl Food Items Collected From Nests during

1973 and 1974 Nesting Periods

Taxon Group	Species	Number of Items	Percent of Taxon Group	Percent of Total Items
Fish	Bluegill (*Lepomis macrochirus*)	3	27.3	2.1
	Black Bullhead (*Ictalurus melas*)	2	18.2	1.4
	Unidentified Fish	6	54.5	4.3
	Totals for Fish	11	100.0	7.9
Amphibians	Leopard Frog (*Rana pipiens*)	1	100.0	0.7
	Totals for Amphibians	1	100.0	0.7
Totals for all taxon groups		140		100.0

As a taxonomic group, mammals were the second most frequently occurring prey items, comprising 29.3 percent of the total food items. Among the most commonly occurring mammals were prairie voles (Microtus ochrogaster) at 29.3 percent of the total mammals collected, southern bog lemmings at 14.6 percent, meadow voles at 12.2 percent, eastern cottontail rabbits at 9.8 percent, and short-tailed shrews at 4.9 percent.

The third most frequently occurring group of prey items, at 14.2 percent of the total items, were invertebrates. Crayfish (Cambarus sp.) comprised 85 percent of the invertebrates.

As a taxonomic group, fish were the fourth most frequently occurring prey items, and made up 7.9 percent of the total prey items collected. Bluegills (Lepomis macrochirus) represented 27.3 percent of the total fish, with black bullheads (Ictalurus melas) comprising 18.2 percent of the total fish collected.

One leopard frog (Rana pipiens) was identified as the only amphibian collected.

The heaviest prey items collected were 4 young eastern cottontail rabbits, with heads and front legs missing, which ranged from 200 to 325 g. One Common Crow without a head weighed 257 g, and one Norway rat without a head weighed 108.7 g.

The prey data were arranged chronologically by nest visit and studied to determine if any significant trends were apparent. Most obvious was the repeated occurrence of crayfish throughout the nesting period in the nests along the La Moine River. Crayfish were never found in nests at Argyle Lake. Beetles did not occur among the prey remains until early April, both in 1973 and 1974. Southern bog lemmings were collected only from the last week of March 1974 until the second week of April 1974, and were only in La Moine River nests and not in Argyle Lake nests. Fish occurred both in nests at Argyle Lake and along the La Moine River, but bluegills occurred only at Argyle Lake while black bullheads were found only along the La Moine River. According to Dunn (1968), there are no bluegills in the La Moine River nor any black bullheads in Argyle Lake. Eight out of 12 Red-winged Blackbirds were taken between the last week of March and the first week of April 1974. This time corresponds to a period of massive flocking of arriving Red-winged Blackbirds along the La Moine River. Significantly, the 4 nests along the La Moine River all showed a large utilization of Red-winged Blackbirds at this time. Six out of 8 Red-winged Blackbirds collected at this time were found in the 4 nests along the La Moine River. Likewise, Common Flickers were absent in prey remains until the second week of April 1973 and 1974, corresponding to the first sightings

of significant numbers of these migrating birds in the study area. One Pied-billed Grebe (Podilymbus podiceps) was taken on 10 April 1974, at Argyle Lake, at a time when large numbers of these birds were sighted along the shoreline.

Analysis of all collected data leads to the conclusion that Barred Owls are opportunistic predators. They do not hunt any one particular prey item exclusively but take whatever prey is available at the time, at least during the nesting season. These data represent only a part of the entire annual diet of Barred Owls and may actually be more representative of the diet of the nestlings than of the adults. Also, at other times of the year when adult territories may not be as strongly established and when migratory or hibernating species are not available as food items, the diet may change appreciably.

SUMMARY

The average size of a Barred Owl egg was 52.8 x 43.4 mm, and the incubation period was approximately 31 days. In 1973, 13 eggs hatched between 6 April and 9 April, and 12 owls fledged between 3 May and 10 May. In 1974, 9 eggs hatched between 28 March and 3 April, and 6 owls fledged between 26 April and 4 May. Twelve out of 18 owls fledged 31 days after hatching.

A positive relationship existed between development of the juvenal feathers and weight. The correlation coefficient of the relationship was 0.82 and was significant at the 0.001 level. Seven out of 7 owls showed a weight loss after fledging. The average weight loss was 27 g, with a range of 15 to 46 g.

An important behavioral development was the aquisition of fear and its gradual replacement by active hostility. The period in the nest just prior to fledging involved much exercise and activity.

The diet of the nestlings consisted of 47.9 percent birds, 29.3 percent mammals, 14.2 percent invertebrates, 7.9 percent fish, and 0.7 percent amphibians. Analysis of the food data indicated that Barred Owls are opportunistic predators. They do not hunt any one particular prey item

exclusively but take whatever prey is available at the time, at least during the nesting season.

The Barred Owl should be considered to be an important indicator of the quality of our environment because of its role as a secondary consumer in the food web. The varied diet of the Barred Owl makes it vulnerable to many of the same pollutants which plague mankind. Unfortunately as mankind "progresses" through modernization and increased land development, at the expense of our environment, the Barred Owl may someday be added to the endangered species list.

LITERATURE CITED

Barrows, Walter B. 1912. Michigan bird life. Wynkoop Hallenbeck Crawford Company, Lansing, Michigan. 822 p.

Bendire, Charles. 1892. Life histories of North American birds. Smithson. Contrib. Knowl. 28:335-338.

Bent, A. C. 1938. Life histories of North American birds of prey. U. S. Nat. Mus. Bull. 170(2):182-196.

Bjorklund, Richard G., James P. Miller and Adam Szluha. 1967. Great Horned Owl, Bubo virginianus, and Barred Owl, Strix varia, on an Illinois river heronry. Trans. Illinois State Acad. Sci. 60:107-108.

Bolles, Frank. 1890. Barred Owls in captivity. Auk 7:101-114.

Carter, J. D. 1925. Behavior of the Barred Owl. Auk 42: 443-444.

Craighead, J. J. and F. C. Craighead, Jr. 1956. Hawks, owls, and wildlife. Stackpole Company, Harrisburg, Penn. 443 p.

Downie, N. M. and R. W. Heath. 1970. Basic statistical methods. Harper and Row, New York. 356 p.

Dunn, Robert. 1968. McDonough county surface water resources. Illinois Dep. Conserv., Div. Fish. 47 p.

Dunstan, Thomas C. and Steve D. Sample. 1972. Biology of Barred Owls in Minnesota. Loon 44:111-115.

Earhart, Caroline M. and Ned K. Johnson. 1970. Size dimorphism and food habits of North American owls. Condor 72:251-264.

Errington, Paul L. 1932. Food habits of southern Wisconsin raptors. Condor 34:176-186.

Errington, Paul L. and Malcolm McDonald. 1937. Conclusions as to the food habits of the Barred Owl in Iowa. Iowa Bird Life 7:47-49.

Fisher, A. K. 1893. The hawks and owls of the United States in relation to agriculture. U. S. Dep. Agric., Div. Ornithol. Mammal. Bull. 3:1-210.

Forbush, Edward H. 1927. Birds of Massachusetts and other New England states. Norwood Press, Norwood, Mass. 461 p.

Ford, Edward R. 1956. Birds of the Chicago region. Chicago Acad. Sci. Spec. Publ. 12:1-117.

Gerrard, J. M., P. N. Gerrard, D. W. Whitfield, and W. J. Maher. 1973. Bald Eagle behavior study. Can. Wildl. Serv., Contract CWS-7773-43. 90 p. (unpublished manuscript)

Graber, Richard R. and Jack S. Golden. 1960. Hawks and owls: population trends from Illinois Christmas counts. Illinois Natur. Hist. Surv. Biol. Notes 41:1-24.

Hamerstrom, Frances. 1970. Think with a good nose near a nest. Raptor Res. 4:79-80.

Hamerstrom, Frances. 1972. Birds of prey of Wisconsin, Wisconsin Dep. Natur. Resour., Madison, Wisc. 64 p.

Hamerstrom, Frances and Keith Janick. 1973. Diurnal sleep rhythm of a young Barred Owl. Auk 90:899-900.

Hausman, Leon A. 1948. Birds of prey of northeastern North America. Rutgers Univ. Press, New Brunswick, N. J. 164 p.

Hodges, James. 1947. Barred Owl eating fish. Iowa Bird Life 17:36.

Kilham, Lawrence. 1972. Caterwauling of the Barred Owl: a speculation. New Hampshire Audubon Quart. 25:93-94.

Kuhlmann, F. 1909. A study of the development of instincts and intelligence in certain altricious birds. Psychol. Rev. Monogr. Ser. 11:49-85.

Morrissey, Thomas J. 1968. Notes of birds in the Davenport area. Iowa Bird Life 38:107-118.

Nicholls, Thomas H. 1973. Ecology of Barred Owls as determined by an automatic radio-tracking system. Ph.D. Thesis. Univ. Minnesota. 163 p. Univ. Microfilms. Ann Arbor, Mich. (Diss. Abstr. 74-732)

Olendorff, Richard R. 1972. Weighing and measuring raptors. Raptor Res. 6:53-56.

Olendorff, Richard R. 1973. The ecology of the nesting birds of prey of northeastern Colorado. U. S. Intern. Biol. Program, Colorado State Univ., Fort Collins. Tech. Rep. 211:1-233.

Pettingill, O. S., Jr. 1970. Ornithology in laboratory and field. Fourth ed. Burgess Publishing, Minneapolis. 524 p.

Reed, Chester A. 1965. North American birds eggs. Dover Publications, Inc., N. Y. 372 p.

Ridgway, Robert. 1914. Birds of North and middle America. U. S. Nat. Mus. Bull. 50(6):639-644.

Roberts, Thomas S. 1932. The birds of Minnesota. Univ. Minnesota Press, Minneapolis. 691 p.

Roberts, Thomas S. 1965. A manual for the identification of the birds of Minnesota and neighboring states. Second ed. Univ. Minnesota Press, Minneapolis. 613 p.

Southern, H. N. 1969. Prey taken by Tawny Owls during the breeding season. Ibis 111:293-299.

Sumner, E. L., Jr. 1929. Comparative studies in the growth of young raptors. Condor 31:85-111.

Sumner, E. L., Jr. 1933. The growth of some young raptorial birds. Univ. California Publ. Zool. 40:277-308.

Sumner, E. L., Jr. 1934. The behavior of some young raptorial birds. Univ. California Publ. Zool. 40:331-362.

Wilson, Kenneth A. 1938. Owl studies at Ann Arbor, Michigan. Auk 55:187-197.

Wilson, Alexander. 1970. Wilson's American ornithology. Second ed. Arno Press and New York Times, N. Y. 746 p.

Wing, Leonard W. 1956. Natural history of birds. Ronald Press, N. Y. 539 p.