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NESTING HABITS AND SOME
GENERAL NOTES ON
CLARK'S NUTCRACKER
(Nucifraga columbiana WILSON)

by

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Presented in partial fulfillment of requirements
for the degree of Master of Arts in zoology.

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1948

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INTRODUCTION*

Clark's Nutcracker (Nucifraga columbiana WILSON), a bird belonging to the family Corvidae is widely distributed over the mountainous areas of western North America. Because little of an accurate nature is known concerning the natural history of this species and because it is relatively abundant in western Montana, Dr. Philip L. Wright suggested that Clark's Nutcracker might be an excellent subject for a thesis.

This study was planned so as to secure a maximum amount of material and information. Beginning in October 1946 and extending through April 1948, intensive field work, documented with detailed field notes and with photographs, was conducted in central western Montana. This thesis is based primarily on this field work. From specimens of Clark's Nutcracker collected during every month of the study, skins, gonads, stomachs with their contents, as well as external and internal parasites were preserved. Certain data which were readily available from this specimen material, and which would contribute to a better understanding of some of the subjects here considered, have been incorporated in this thesis. Additional study will be required to completely evaluate the specimen material on hand.

*Study supported in part by the Wilson Ornithological Club Louis Agassiz Fuertes Research Grant for 1947. Financial aid was also received from the Graduate Committee of Montana State University.

During the course of this study, I have received much invaluable assistance from many persons, only a few of whom I can mention here. Foremost was Dr. Philip L. Wright, who willingly gave counsel and material assistance throughout the course of the project. Dr. Ludvig G. Browman helped much in acquainting me with the mountainous areas in which the field work was done. Dr. Royal Bruce Brunson and Mr. William B. Hebard assisted with photography. Mr. Clinton H. Conaway accompanied me on many field trips and contributed several important specimens. Mrs. Frances Lee Mewaldt prepared most of the study skins. Important Old World nutcracker reference material was provided by Dr. Donald S. Farner and by Dr. Ernst Mayr.

MATERIAL AND METHODS

Field observations and notes. More than 200 separate field trips were made between October 13, 1946 and April 30, 1948. In excess of 1,000 miles were traveled on foot while spending more than 900 hours in actual field observation. Several thousand miles travel by motor vehicle are not included in field observation miles or time. All observations were made in Montana west of the continental divide. Most data were obtained in Missoula and Ravalli Counties, though many other areas are represented, including the vicinity of the Montana State University Biological Station on Flathead Lake, Montana. Detailed notes taken on these trips comprise the basic material used to prepare this paper. Notes taken in a pocket field note book were transferred to data sheets, except that when observations were made from a blind, they were recorded directly on the data sheets. Copies of these data sheets appear as pages 4 and 5. Whenever nutcrackers were encountered, the time, elevation, whether the birds were heard and/or seen, as well as other circumstances related to each observation were recorded. A Short and Mason altimeter was used to take altitudinal readings. On longer trips, altimeter adjustments were made from U. S. Geodetic Survey bench marks or from U. S. Forest Service maps. A pair of 6 x 30 binoculars was employed.

Specimens of Clark's Nutcracker, 234 as of April 30, 1948, were collected in every month of the year, permitting

DAILY FIELD OBSERVATIONS
OF
CLARK'S NUTCRACKER

Date _____

Obsv. # _____

Time schedule
Locale & route
Sky & wind
Precipitation
Distance traveled
Snow depth
Temperature
Altitude

How located
Vegetation
Number Observed
Nature of flock
Activity
Notes and voice
Other species

Food being taken
Direction moving
Speed of travel
Recent weather
Reaction to man
Mortality
Predacity

Multiple horizontal lines for data entry.

OBSERVER: _____

CLARK'S NUTCRACKER
(Nucifraga columbiana)

Date _____

Obsv. # _____

Locale & Route _____

Hour	Alt.	Miles	No. Birds	Remarks
		0		
		1		
		2		
		3		
		4		
		5		
		6		
		7		
		8		

more accurate evaluation of observations in many instances. This material, which includes skins, stomachs and contents, reproductive organs, and internal and external parasites, will be supplemented and evaluated for inclusion in a later paper.

Four occupied nests found in March and April of 1947, two of which were visited almost daily from nest-building until the young had left the nest, supplied the basic material for the nesting portion of the study. Field work is documented with photographs taken with a 35mm Leica camera with an f 3.5 lens and with 16mm kodachrome motion pictures.

Throughout this thesis Mountain Standard Time has been employed. It is believed that the 24 hour clock system used, is superior to indications of a.m. and p.m. on the 12 hour system. So that this system may be made clear a few comparisons between the two systems are shown below:

<u>24 hour time</u>	<u>12 hour time</u>
0015	12:15 a.m.
0455	4:55 a.m.
1200	12:00 m.
1315	1:15 p.m.
2000	8:00 p.m.
2400	12:00 p.m.

When references are made to nests by number, specific nests are indicated. Nests 1, 2, and 3 were located on Mitouer Ridge. Nest 4 was located near Sweeney Creek, on the lower slopes (4,300 feet) of the Bitterroot Mountain Range.

Early in the nesting cycle a blind was constructed near nest 1 for detailed observations of nesting behavior (Figure 14). A tripod was first erected and allowed to stand for a few days about 15 feet from the nest before a platform and a dull green canvas tarpaulin were installed. Observations were begun during the incubation period with the observation aperture about 12 feet from and slightly above the level of the nest. This distance was gradually reduced until the aperture was 6 feet from the nest. At 6 feet, the nutcrackers appeared to completely ignore the blind and the observers face, as well as both the lens and the shutter noises of still and motion picture cameras.

Continuous running notes were taken during all observations from the blind. Temperatures were recorded at least hourly from a standard Fahrenheit thermometer suspended below the blind on a string such that it remained in the shade. On April 8 the thermometer was accidentally broken, preventing readings at the nest on that date.

Age classes. Nutcrackers have been placed in four age classifications. Plumage characters, gonadal development, and the bursa of Fabricius, were found useful in establishing age groupings. Descriptions of color, when capitalized, signify that they have been taken from Ridgway's (1912) Color Standards and Color Nomenclature. A brief discussion of each of these age classes and of their application in this thesis follows:

1. Nestling. Young nutcrackers from the time of hatching from the egg until their contour feathers are sufficiently developed to permit sustained flight, are classed as nestlings. The natal down is lost during the postnatal molt and replaced by juvenal plumage.

2. Juvenile. From the time that the young birds have acquired the power of sustained flight until the partial postjuvenal molt is completed, they are classified as juveniles. The body and head feathers are Light Mouse Gray, frequently tipped with Pale Ochraceous-Buff. The glossy Black of the dark areas of the wings and tail tends to turn Dusky Brown much more rapidly than in the case of adults. Preliminary findings indicate that the postjuvenal molt may be in progress from June into October. Near the end of the postjuvenal molt, the Mouse Gray rictal bristles and the forehead and chin feathers are replaced by white bristles and feathers. The bursa of Fabricius is well developed throughout this age class.

3. Yearling. From the completion of their postjuvenal molt until they can no longer be distinguished from adults, the nutcrackers are designated as yearlings. In the hand they are distinguishable as yearlings from about October until about the following July, when the last of their juvenal feathers are usually lost. Some of the characters used by Emlen (1936) in age determination of the Crow (Corvus brachyrhynchos) and by Pitelka (1945)

for Aphelocoma, were found useful in differentiating this age class of nutcrackers from adults. The bursa of Fabricius is usually persistent until late January or February. Data on gonad weights obtained during this study indicate that yearling Clark's Nutcrackers were not in physiological condition to breed in the study areas of 1947.

4. Adult. After the disappearance of the last juvenal remiges, rectrices, bastard wing feathers, and wing coverts, usually in July of their second year, the adult classification has been assigned to all nutcrackers. The bursa of Fabricius has not been found to persist beyond July of the second year.

In the field, unless nutcrackers can be banded or otherwise marked, the most accurate method of differentiation between age classes is to make observations and then collect at least one of the nutcrackers for subsequent determination of age and sex. However, with experience, some distinctions can be made under favorable observational conditions (i.e. good light, close range, and use of binoculars). Thus juveniles can be separated from yearlings and adults by the absence of white on the forehead and chin of juveniles. Yearlings and adults can be distinguished only under the most favorable conditions, and then chiefly by the brownish appearance of the dark areas

of the wings and tails of the yearlings. During the breeding and nesting seasons especially, some nutcrackers were classed as adults on the strength of their behavior pattern. This was inferred from the apparent sexual immaturity of the yearling birds.

Sex differentiation. In a nesting study the ability to differentiate between the sexes is of considerable importance. No plumage coloration differences appear to be present between male and female Clark's Nutcrackers. The mean weight of 45 adult females was found to be $123\frac{1}{2}$ 1.137 grams, whereas the mean weight of 71 adult males came to $137\frac{1}{2}$ 0.633 grams. In order to see if the difference between these means was real, Fisher's t test was used as described by Snedecor (1940). The calculated value of t was 10.219, with 2.62 being the value of t at the 1% level for 100 degrees of freedom. Thus the chance that the difference between mean male and female weights is not real is very slight, being far less than 1 in 100.

It is seen that the above males averaged about 11% larger than the females. Under certain favorable circumstances I have found this sexual size dimorphism useful when making field observations of paired nutcrackers. In instances when collection of one or both birds of such pairs was made, my previous sex differentiation just prior to collection was confirmed.

On the first day that observations at nest 1 were made from the blind, one of the adults was captured on

the nest by hand and banded on one tarsus with a U. S. Fish and Wildlife Service aluminum band and with a red celluloid band on the other tarsus. The celluloid band disappeared before the end of the third day following, but the aluminum band remained intact. The day after the young had left nest 1 the banded adult was collected and found to be a female. No difficulty was encountered in distinguishing between the individual adult birds of nest 1.

The western Montana region. Because this study of Clark's Nutcracker was conducted in western Montana, a consideration of the topography and climate of the region is deemed desirable. The main range of the Rocky Mountains crosses the western part of Montana in a northwest-southeast direction, dividing the state into two regions of unequal size. Western Montana, the smaller of the two portions, is characterized by rugged mountains and mostly narrow valleys. The highest elevation, 12,850 feet, is on the summit of Granite Peak, near the south boundary and the lowest elevation, about 1,800 feet, occurs where the Kootenai River leaves the state in the northwest part of Montana.

Although weather in the central western Montana valleys is comparatively mild, the adjacent mountain slopes and summits exhibit quite different weather conditions. These higher areas are cooler and receive greater amounts of precipitation. Annual precipitation varies from less

than 12 inches in some of the broader valleys to in excess of 40 inches in some of the higher mountain areas. Comparatively mild microclimates exist on some of the lower south exposed slopes, where even during the winter months temperatures are higher at mid-day and snow is less persistent than in areas immediately above and below. These microclimates are frequented during the winter months by many resident animals including Clark's Nutcracker.

Figure 1 shows the trend of temperatures at about 4,600 feet in the vicinity of Missoula, Montana. A correction factor was applied to U. S. Department of Commerce Weather Bureau records for Missoula, to more realistically demonstrate temperature conditions at the elevations where the major portion of the field work for this study was conducted. A comparison of hourly temperatures that I recorded on Mitouer Ridge at 4,600 feet with Weather Bureau hourly records, disclosed that the U. S. Weather Bureau correction factor of 7° F. for 1,400 feet in this particular altitudinal range is quite useful in the determination of general temperature trends on Mitouer Ridge. The minimum temperature recorded at Missoula during the past 56 years was -28° F., whereas the minimum for 1947 was -8° F. recorded on January 3. The Missoula maximum during the same 56 year period was 105° F. while the 1947 maximum was 98° on July 14.

The greater portion of western Montana mountain masses support from sparse to heavy stands of coniferous timber, from the edges of the major valleys to the summits of all but the higher mountains and those whose rocky summits do not hold sufficient soil to support trees. Although logging operations, and forest fires have affected considerable areas, actually many of these tracts support greater vertebrate populations than do adjacent virgin timber stands.

Descriptions of principal study areas. The majority of the field work for this study was done in four principal areas within reasonable driving distance of Missoula, Montana. A general description of each of these areas follows:

1. Mitouer Ridge extends in a northeasterly direction from the valley of the Clark's Fork River at a point (3,250 feet) about 5 miles east of Missoula, to the summit of Marshall Mountain (7,000 feet). Marshall Creek flowing from northeast to southwest into the Clark's Fork River is just northwest of Mitouer Ridge; whereas Mitouer Gulch, with its smaller stream, flowing roughly parallel to Marshall Creek drains the southwest facing slope of Mitouer Ridge.

The top of the ridge from 4,000 feet to 4,800 feet, which represents a linear distance of about 1,200 yards, and that portion of the southeast facing slope below this portion of the ridge, down to 4,000 feet comprised the

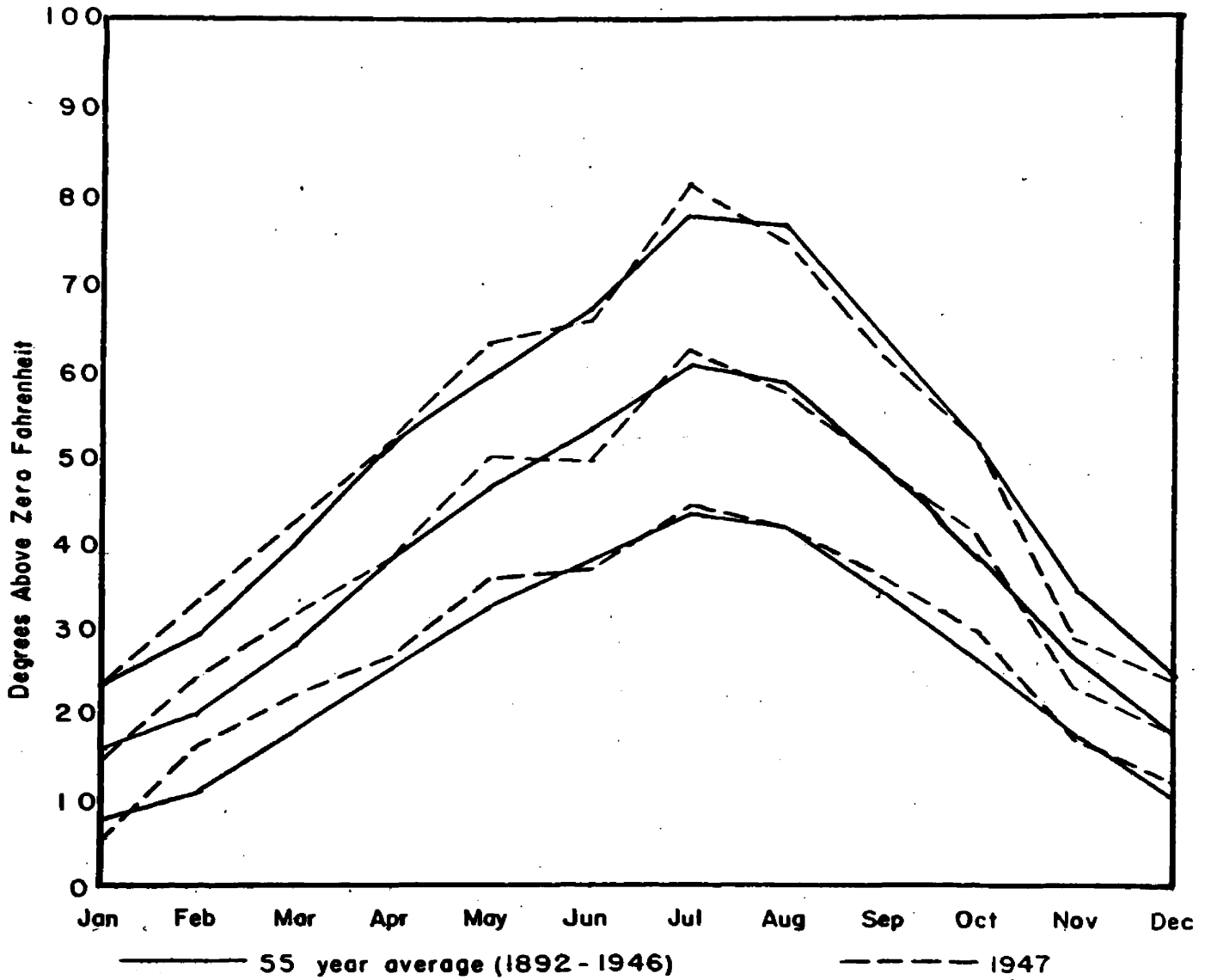


FIGURE 1. Approximate mean maximum, mean monthly, and mean minimum temperatures by months at about 4,600 feet near Missoula, Montana. Derived by application of a 7 degree correction factor to records of the U.S. Weather Bureau Station at Missoula (3,200 feet).

most important single area under observation (Figure 12). In 1910 this slope and the facing slope across Mitouer Gulch were burned in a major forest fire. In 1947 the area supported scattered clumps of two age groups of Ponderosa Pine and Douglas Fir. There were mature trees of both species which had survived the 1910 fire and clumps of predominately young Douglas Fir which had grown since 1910. The slope is approximately 30 degrees from the horizontal, and exhibits a few limestone outcroppings.

2. The Pattee Canyon area includes such landmarks as Mount Sentinel, University Mountain, and Pattee Point. The area is bounded on the north by the Clark's Fork River valley, on the west by the Bitterroot River valley, on the east by Deer and Bear Creeks, and on the south by Miller Creek. Including approximately 28 square miles, elevations range from 3,200 feet on the Montana State University campus to slightly more than 6,000 feet on the summit of Pattee Point.

Lower south and west slopes variably support grasslands and open stands of Ponderosa Pine. Areas above 4,800 feet support stands of Douglas Fir and Ponderosa Pine. North and east slopes are characteristically covered with heavy stands of Douglas Fir and Larch from the bottoms of the various drainages to the tops of the ridges.

3. The Rattlesnake Creek area lies in the foothills of the Mission Mountain Range. Elevations range from

about 4,000 feet on the lower portion of Rattlesnake Creek to about 8,000 feet on the summit of Stuart Peak. There are numerous small lakes in the upper tributary valleys, ranging from 5,500 to 7,000 feet in surface elevation. This area is not penetrated by roads and has not been subject to logging except for some of the slopes on lower Rattlesnake Creek.

Nearly all important forest tree species are represented, with Douglas Fir, Ponderosa Pine, Alpine Fir, White-Barked Pine, Engleman Spruce, and Larch among the most abundant. Their distribution appears dependent upon elevation and exposure (Figure 20).

4. The Bitterroot Mountains of Montana extend from just southwest of Missoula, south along the Montana-Idaho state boundary for more than 100 miles. That portion of the range with drainage into the Bitterroot River, and north of Hamilton, Montana, was visited on many occasions. Elevations in this area range from 3,200-3,500 feet in the Bitterroot valley to 9,540 feet at the summit of St. Joseph's Peak. Another dozen peaks in this 40 mile portion of the range rise above 9,000 feet. A substantial portion of the area, especially in toward the state line is Hudsonian and Alpine in character, with many areas well above the timber line. Vegetation types probably include nearly all important species found in central western Montana. Snow may remain in high protected spots throughout the entire year.

GENERAL HABITS

The first recorded observation of Clark's Nutcracker appears in the journals of the Lewis and Clark Expedition of 1804-06, under date of August 22, 1805 (Thwaites, 1905)*. Davis and Stevenson (1934) in making a study of the Lewis and Clark Expedition journals place this first recorded observation as on the Montana side of the Bitterroot Mountains, near the head of what is now known as the Beaverhead River. They have further determined that the type specimen collected on May 28, 1806, was obtained about two miles north of Kamiah, Idaho County, Idaho.

Habitat relations. Ecological factors limiting Clark's Nutcracker are not clear. In various parts of the Rocky Mountain area they are reported as occurring in nearly all types of mountainous conifer habitats. Bent (1946) writes: "The nutcracker is a mountain bird, ranging from 3,000 feet up to 12,000 or even 13,000 feet, according to latitude and season; its breeding range seems to be mainly between 6,000 and 8,000 feet, or from the lower limit of the coniferous forest up to timber line". Saunders (1921) writing of Clark's Nutcracker distribution in Montana states that it is: "An abundant permanent

*All references are credited to the author and are dated in the body of the thesis. An alphabetical listing of literature cited appears at the end of the thesis.

resident of the mountains throughout the western half of the state, ranging eastward to the easternmost mountain ranges."

A survey of the literature indicates that Clark's Nutcracker shows a preference for higher elevations, especially those areas supporting conifers which produce large seeds (i.e. Pinus flexilis, Pinus albicaulis, etc.). However the lower elevations forested with Pinus ponderosa and Pinus edulis are also reported to support large nutcracker populations especially during the colder months of the year. During months of insect abundance they are encountered out of otherwise normal habitats both above the timber line and below the timber belts in the more arid areas.

In western Montana, I have found Clark's Nutcracker distribution apparently closely related to the occurrence of the Ponderosa Pine (Pinus ponderosa), the White-Bark Pine (Pinus albicaulis), and the Douglas Fir (Pseudotsuga taxifolia). Saunders (1921) writes: "Since white-bark pine is a Hudsonian zone tree, yellow pine [Pinus ponderosa] a Transition species, and limber pine ranging from Hudsonian down through Canadian and into Transition, the abundance of Nutcrackers at various elevations in fall and winter, varies with the abundance of the seeds of these various species."

Probably the most important species of tree in the ecology of Clark's Nutcracker in western Montana, is the Ponderosa Pine. These trees not only provide nest sites, but also produce seeds large enough to be of some importance in the diet of the nutcracker. Forest Service Experiment Station tests show Ponderosa Pine seeds from Idaho and western Montana forests average about 10,000 to the pound (Cunningham et. al., 1926).

The White-Bark Pine, found only at higher elevations is also important as a producer of seeds readily taken by nutcrackers. The seeds of the White-Bark Pine number about 2,800 to the pound (Van Dersal, 1939).

The Douglas Fir is utilized by the nutcracker for nest sites. The fact that it produces very small seeds, about 44,000 to the pound (Cunningham et. al., 1926) may account for its apparent unimportance as a source of food.

Distribution and food supply. In western Montana, the Ponderosa Pine (Pinus ponderosa), whose seeds are probably important in the diet of nutcrackers, produces good seed crops irregularly; on an average of about once every 3 to 4 years (Cunningham et. al., 1926). In late 1946 and extending into early 1947, Ponderosa Pine seeds were in good supply in the study areas and nutcrackers were common to abundant. However, from mid-1947 into early 1948 very few seeds could be found, and nutcrackers became rare to apparently entirely absent from most areas where they had been common to abundant a year earlier.

GIFT
cop. 2

Figure 3 shows the numbers of nutcrackers observed per trail hour and per trail mile during this period of diminishing Ponderosa Pine seed availability. The lows shown for January and for May of 1947, are not necessarily indicative of lower nutcracker populations in the area as a whole, but rather due to faults in the samples taken. Even during seasons when nutcrackers may be classed as abundant in a region, their distribution is not homogeneous. More areas visited during January and May of 1947, either did not support many nutcrackers, or appeared to be entirely void of the species.

That food plays a dominant role in the varying distribution of Clark's Nutcracker, has been suggested by several writers including Rust (1915). Formosof (1933) demonstrated well a correlation between invasions into eastern and western Europe of the Siberian Nutcracker (Nucifraga caryocatactes macrorhynchus) and fluctuations in the numbers of skins taken from the Squirrel (Sciurus vulgaris), showing that both, though especially the nutcracker, were dependent upon the nuts of the "Siberian Cedar" (Pinus cembra sibirica). He cites references which indicate that this tree does not produce a good crop every year, but rather after a good crop year, follow several years with smaller crops, or with no crops at all. Similarly Kirikov (1937) points out in his English

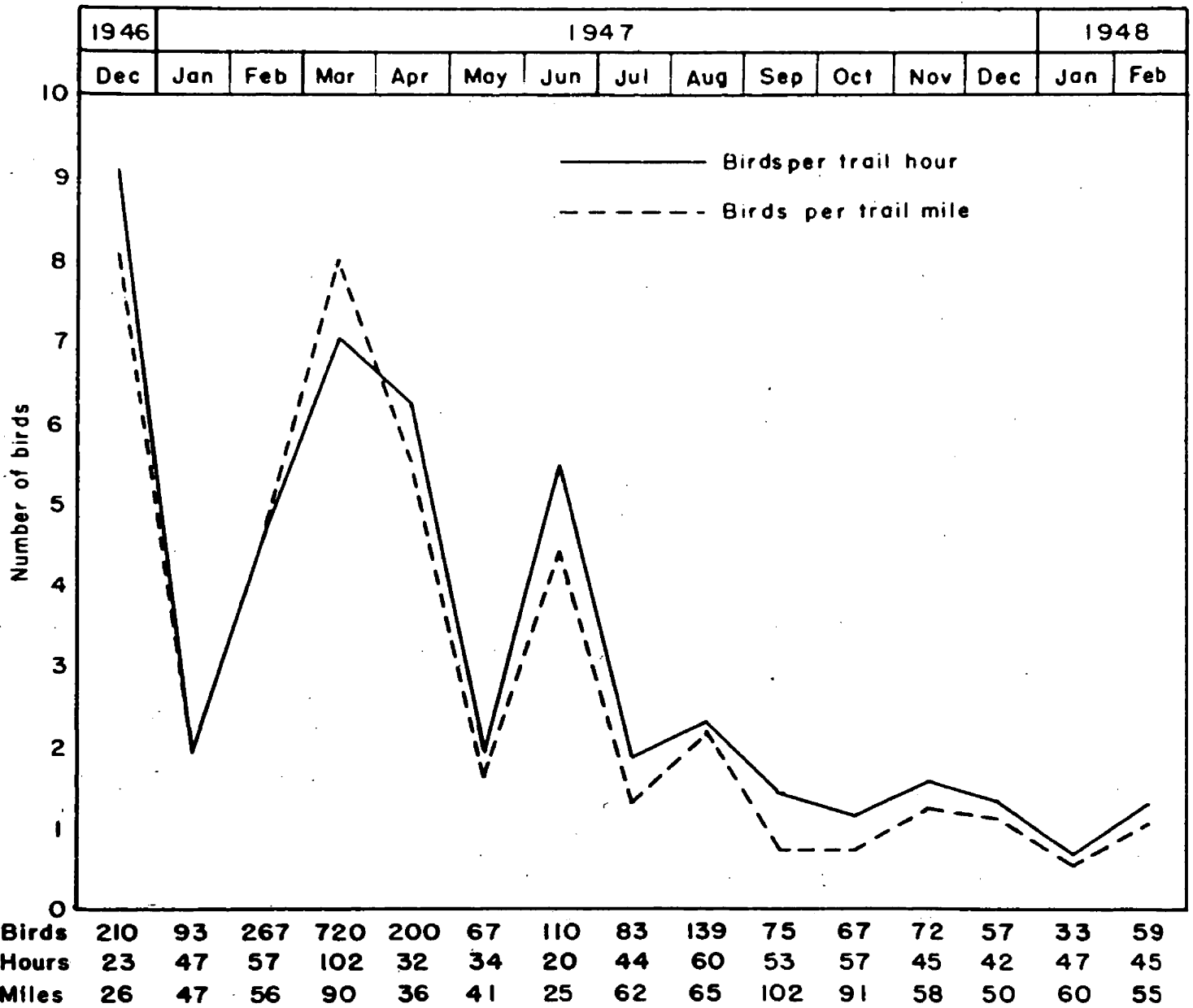


Figure 3. Numbers of Clark's Nutcrackers observed (seen and/or heard) per trail hour and per trail mile by months from December 1946 to February 1948.

summary that Nucifraga caryocatactes "in the European, Siberian and Middle Asiatic parts of its area inhabits the fir and cedar forests during the nesting period, feeding on fir seeds and cedar nuts." (i.e. several species of Pinus and Picea). He further states: "A periodicity of fruit-bearing is peculiar to these coniferous species, on the fluctuations of which the nutcrackers migrations chiefly depend, beginning with insignificant displacements from regions with either bad crops or no crops at all, to those with better crops and ending in the birds' migrations from Siberia to western Europe, which fact, attracting great attention, took place when poor crops of cedar nuts and fir seeds coincided over a vast area of western Siberia and eastern Europe."

A review of the American literature including more than 50 individual references reveals that in certain years invasions of Clark's Nutcrackers have taken place into areas outside of their usual ranges.

From the beginning of observations in October 1946, through April 1947, far more yearlings were encountered in the field than adults. These yearlings were usually found in flocks of from 15 to 80 or more birds. Of 77 nutcrackers collected during these 7 months, 56 were yearlings. Selective collecting was necessary in order to obtain the 21 adults, 17 of which were taken in February, March, and April, when breeding birds were being

sought. It is not thought that the dominance in numbers of yearlings indicated a scarcity of adults. Because the yearlings were flocked, they were more conspicuous and probably screened the more wary adults. It is thought that these adults occurred usually in pairs, or small loose flocks in some areas, and perhaps were not even present in other areas where yearlings were abundant.

On the contrary, beginning on August 19, 1947, and extending through April 30, 1948 the 101 nutcrackers collected have been adults, with the exception of 1 juvenile collected on October 4, 1947. No selective collecting was done during this later period due to the scarcity of nutcrackers in this region. It is possible that some of the 100 birds classed as adults were adults less than 2 years old, and indistinguishable from older birds by plumage characters.

From December 1946, through July 1947, about 60 percent of all nutcrackers observed were known to be in flocks numbering 11 or more birds. However, from August 1947, through February 1948, less than 4 percent (all in September 1947) of observed nutcrackers were known to be in flocks of 11 or more birds. Figure 4 shows the change which occurred in the general pattern of flock sizes.

The composition of these flocks was determined to be predominately yearling. Of 51 birds collected from flocks of 11 or more nutcrackers, only 3 were found to be adults. Two of these adults, both males, appeared to be

actual members of the flocks, whereas the third, an adult female, was collected in the midst of a flock of yearlings, but was found to be a nesting bird (see page 42) and possibly was not actually a part of the flock. The amount of land area over which individuals of flocks of yearling nutcrackers were found distributed during the period from October 1946 through June 1947 varied considerably. In most instances individuals of flocks of 25 or more birds were broadcast over an area of from about 5 acres to a square mile. These flocks moved in a given direction apparently using the regular call to maintain contact. During March and April of 1947, a few ground feeding flocks were seen in compact groups covering less than an acre. These flocks, except for a few stragglers, moved forward partly by walking and partly by short flights from the rear of the flock to the front.

By August 1947, these flocks were no longer found, except for 1 flock of 12 birds seen in September (see below). Nor were any flocks of more than 10 nutcrackers observed until after March 1, 1948.

The following account describes what was probably a migratory flight, or at least a movement of flocks over greater distances than they are commonly seen to move.

At 0935 on September 4, 1947, at about 4200 feet near the Blackfoot River in Missoula County, a compact flock of 12 nutcrackers was seen to fly over at about 500

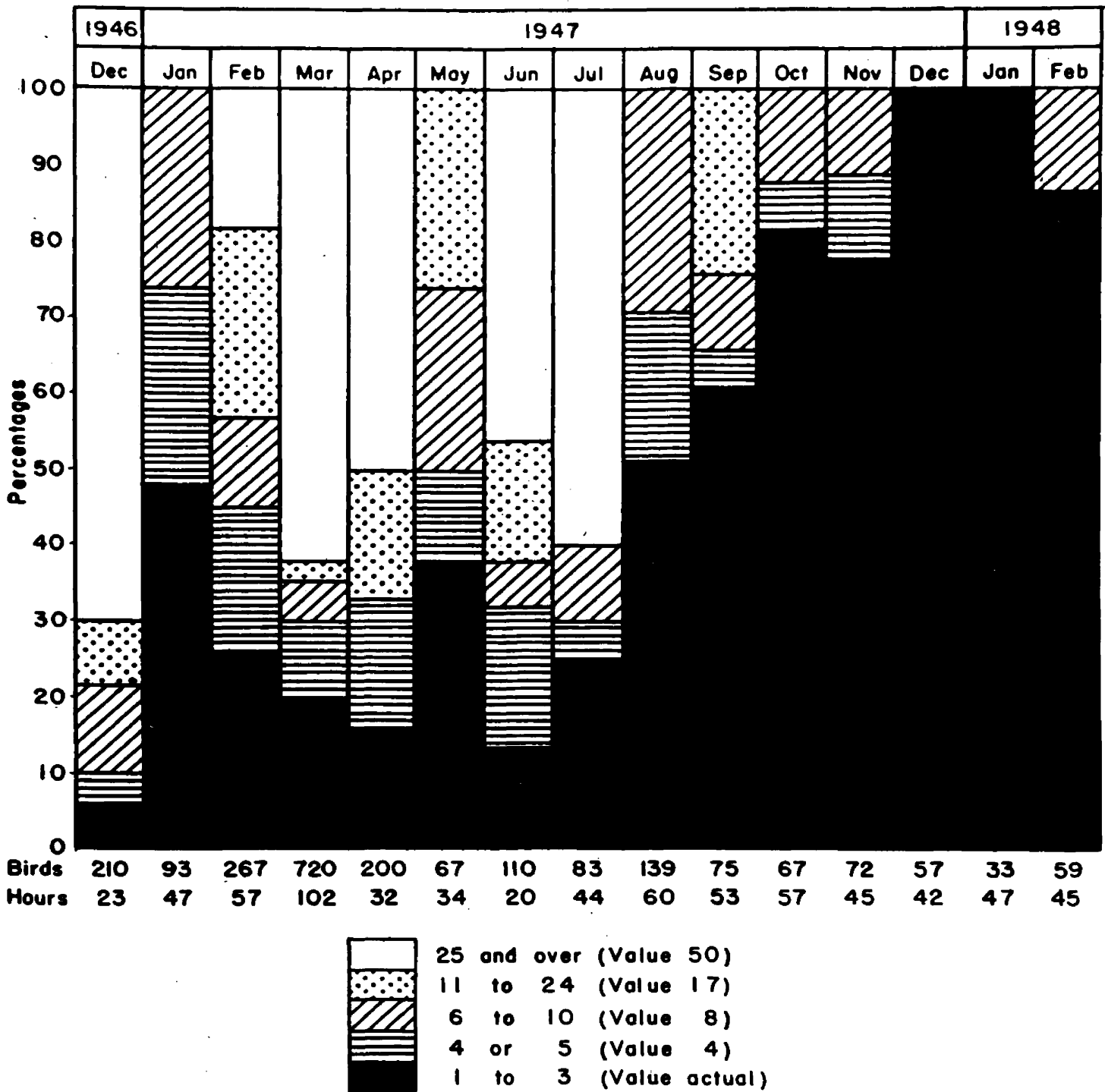


Figure ³ Percentages of total Clark's Nutcrackers observed in groups of specified sizes by months from December 1946 to February 1948.

feet. They disappeared behind a ridge more than a mile away. About 30 seconds later a similar flock numbering 8 birds appeared overhead and was watched with binoculars for more than $1\frac{1}{2}$ miles before it too disappeared beyond the same ridge. Their behavior was not characteristic of nutcrackers flying from one feeding area to another. Flight was rapid, regular, and sustained in a southeasterly direction. No calls were heard from either of the flocks. Similar though more extensive nutcracker flights were observed by Webster (1947) in September of 1945, near Ogden, Utah.

Altitudinal distribution. The habitats occupied by Clark's Nutcracker are for the most part located on the slopes of the principal mountain ranges of western North America. Nutcrackers have been reported from Death Valley (Gilman, 1936 and 1937) and from elevations in excess of 13,000 feet (Packard, 1935).

Seasonal altitudinal movements are reported by several writers including Lincoln (1939), but are not known to be based upon quantitative data. Though my data are insufficient for definite conclusions, enough information was collected to indicate a trend in altitudinal distribution in central western Montana (Table 1). A few weaknesses in the sample taken, however, must be enumerated. The bulk of the data for elevations above 7,000 feet was collected during July, August, and September of 1947.

Populations observed through the end of June 1947 consisted principally of yearlings, usually in flocks, whereas after that month most nutcrackers were adults observed in singles and pairs. Because most trips were of but one day's duration, often consisting of an ascent up slope during the morning, and a descent during the afternoon, daily vertical movements may have affected the data materially. Because of the foregoing enumerated weaknesses in the constancy of the altitudinal sample taken, it is not deemed advisable to make a statistical analysis.

TABLE 1

ALTITUDINAL DISTRIBUTION OF CLARK'S
NUTCRACKER IN CENTRAL WESTERN MONTANA
FROM DECEMBER 1946 THROUGH NOVEMBER 1947.

Range in feet above sea level	Number of hours of Observation	Nutcrackers heard and/or seen	Nutcrackers heard and/or seen per hour
3,000-3,950	92	198	2.15
4,000-4,950	248	1,063	4.29
5,000-5,950	126	340	2.70
6,000-6,950	71	115	1.62
7,000-7,950	30	96	3.20
8,000-8,950	18	52	2.97
9,000-9,950	2	2	1.00

My observations, though by no means conclusive, lead me to believe that in the study areas there is a tendency for most nutcrackers to range comparatively low during late October, November and December, and to spend considerable time in the higher mountain areas during July, August, and September.

During the winter of 1947-48 frequent trips were made to the lower east facing slopes of the Bitterroot Mountains, between Florence and Victor, in Ravalli County. These slopes rise from the valley of the Bitterroot River at 3,200 to 3,500 feet to peaks from 9,000 to 9,540 feet. The lower slopes between 4,000 and 5,000 feet, especially those with southeasterly exposures are comparatively free of snow during most of the winter (Figure 19). Sizable populations of Elk and Mule Deer winter there. It also appears to be a favored winter range for nutcrackers. All of 53 nutcrackers collected from this area from October 1947 through February 1948 were adults. From October 2 until December 26, during 43 hours of observation 129 nutcrackers were seen and/or heard; an average of 3.0 per hour. From January 4 through February 14, when 53 hours were spent in the area only 47 nutcrackers were observed; an average of 0.9 birds per hour. However, from February 28 through March 20 (1948) 84 nutcrackers were observed in 12 hours; an average of 7.0 birds per hour. Figure 2

gives a summary of numbers of nutcrackers encountered on each of these Bitterroot field trips.

During late October, November, and December there appeared to be a concentration of resident adults in pairs on this winter range, whereas during January and February there was a tendency for these adults, still in pairs, to be more dispersed and to be more often encountered at higher elevations. During January and February what few nutcrackers could be found were mostly on the south facing slopes of the principal canyons which penetrate into the highest portions of the Bitterroot range. It is possible that the dispersal may have been in part a movement of pairs back into the interior of the range to nesting areas. Although specimens were collected from this area during observations, I do not believe that numbers of nutcrackers or their distribution were materially affected by the collecting activities.

The situation was quite different on February 28. Though 5 specimens taken were all adults, most of the 22 nutcrackers seen on that date did not behave like the birds that had wintered there. Eight were seen in one scattered flock, with no observed tendency toward pairing. One male taken from a flock had gonads less than one tenth the volume of those of a paired male taken the same day in the same area while the latter was in active courtship.

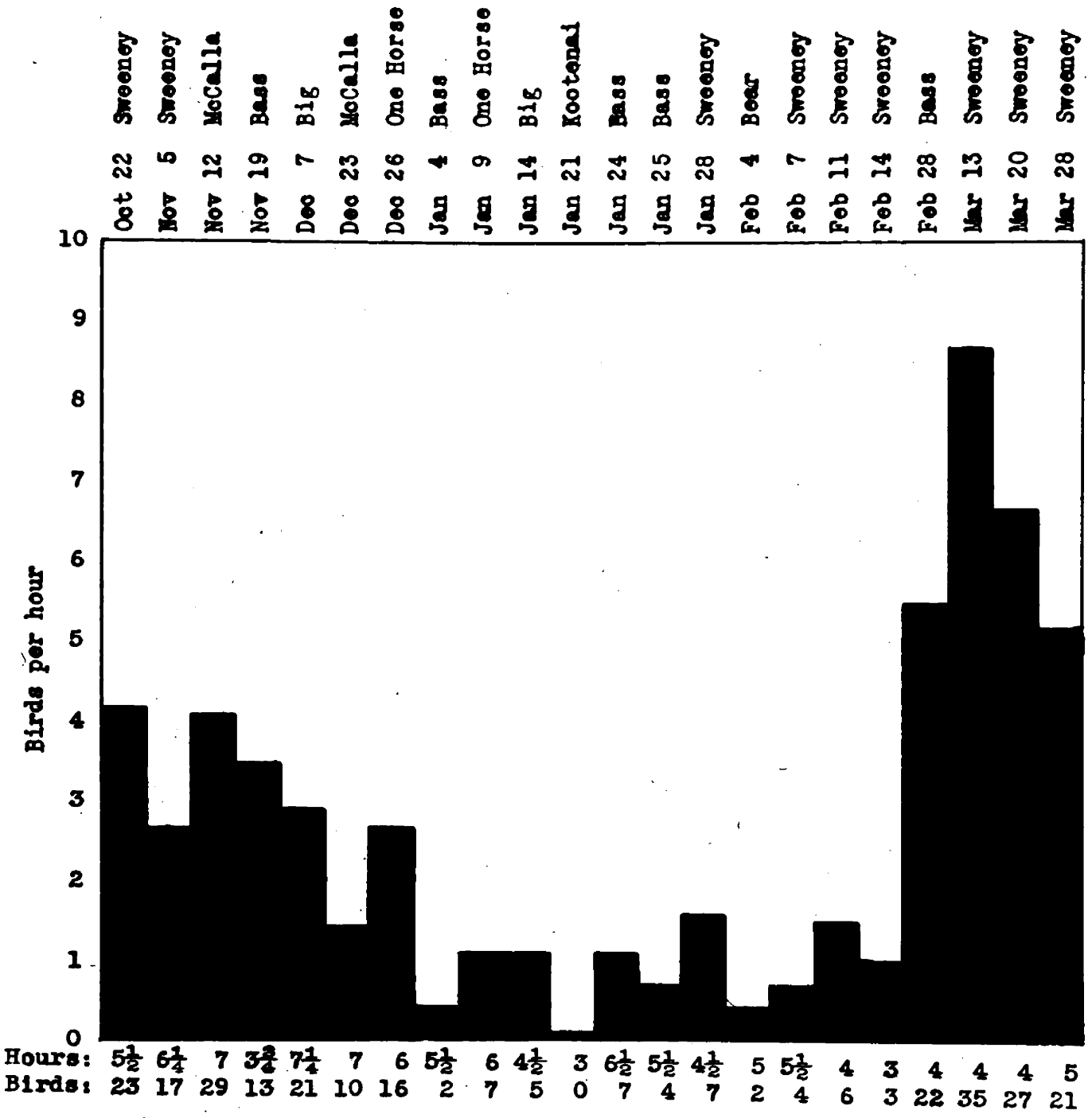


Figure 2. ⁴ Numbers of Clark's Nutcrackers seen and/or heard per hour on lower Bitterroot Mountain slopes during the winter of 1947-48.

Voice. Clark's Nutcracker has a considerable variety of calls. These appear to vary with the season of the year and with the stimulus which may provoke the call. For purposes of discussion elsewhere in this paper, descriptive names have been assigned to each call type. It is felt that one familiar with the species will be able to recognize these calls as they are here described. This listing of calls is not complete, but includes those calls most commonly heard by this observer.

1. Regular call: Described variously as khaaa or khraa (Peterson, 1941), chaar, char-r-r, chur-r-r, kra-a-a, or kar-r-r-r-ack (Bent, 1946), and kar'r'r'r (Bailey, 1918), this harsh call is the most frequently uttered by both sexes and is heard during all months of the year. Having considerable carrying quality, it may be heard from a distance of more than a mile. It is usually given in series of threes, but may be given only once, or may be given many times in succession, especially if the bird is excited. Juvenile birds use this call, though an immature quality is noticeable in its squalling character.

2. Musical call: This call, similar in many respects to the foregoing, is comparatively liquid and soft. Sounding much like a subdued regular call, its carrying quality is not great. I have heard it most often during the spring months when adults use it during the courtship and nesting periods. Both sexes of adult birds are known to use this call.

3. Shri11 call: This high pitched and penetrating screech, described by Dawson (1923) as meack, or mearrk, is given by both males and females. Generally though not always uttered during apparent excitement, this call may be heard during all months of the year.

4. Squalling call: This call uttered during periods of apparent excitement is best described as a squalling prolongation of the regular call. It may be uttered by either sex of nutcrackers of all ages during any month of the year.

5. Bullfrog call: Heard only from December to June, this peculiar call, a comparatively slow rattle, sounding much like the croaking of a frog, is given by both sexes of adults and by at least yearling females. Although no yearling males are definitely known to have used this call, it is probable that they too use it.

6. Crackle and whistle call: The alternating crackles and wheezing whistles are scarcely audible at 75 feet. The bird while uttering this call does considerable bowing and neck stretching, in contrast to the more or less conventional posture maintained when the other calls are given. These notes have not yet been attributed to a specific sex or age group. Heard on several occasions by different birds during only March and April, it would appear that this call was associated with the nesting period.

7. Hunger call: Much like the hunger calls of young crows, these squalling notes, similar in quality to "4" above, are uttered by juvenile birds of both sexes during the period of dependence after leaving the nest. Juvenile birds have been heard using this call as late as August 10, 1947. Female nutcrackers use this call during courtship.

8. Conversational squalling call: During the first few days after the young of nest 1 had hatched, the adults, when both were present, engaged in subdued musical squalling, similar in quality to 2 above. This conversation-like squalling could be heard up to only 40 to 50 feet from its source.

9. Nestling calls: Within 24 hours after hatching, the young of nest 1 began "peeping". This continued almost constantly during the daylight hours of the first week. These "peeps" uttered by the first two nestlings, hatched about 24 hours earlier, at a rate of about 35 per minute, were scarcely audible 10 feet from the nest. They continued during brooding. This "peeping" increased in tempo when feeding was in progress. When the young were about a week old, the "peeping" was gradually replaced by squealing, during feedings. The pitch of this squealing became lower and finally became the squalling characteristic of the young bird when being fed, and when enemy recognition had become established.

10. Trumpet call: During March and April, the male of nest 1 was heard to utter on several occasions a shrill "tin-horn" like call which had some qualities of the regular call. Few other nutcrackers were heard to use this particular voice.

The Clark's Nutcracker is, generally speaking, a noisy bird, and is most easily located by its calls. In areas where the birds are present in some numbers, their calls may usually be heard throughout the daylight hours. Depending upon their activity, however, individual birds may go for hours without calling.

During 584 hours of observation on 99 different days (not including nest site visits) while 714 trail miles were traveled on foot, during a twelve month period (December 1946 through November 1947), 521 first contacts were made with nutcrackers. Individual contacts varied in duration from 1 or 2 seconds to 2 or 3 hours. Table 2 gives a summary of the part played by voice in these 521 encounters. Some factors which affect such percent values as are shown in Table 2 are terrain, cover, weather conditions, presence of other animal life, and the ability and experience of the observer.

TABLE 2
 NUTCRACKER CONTACTS FROM DECEMBER 1946
 THROUGH NOVEMBER 1947

	Observations	Percent
Total	521	100
Heard	441	85
Seen	318	61
First heard	370	71
First seen	151	29
Heard only	203	39
Seen only	80	15
Heard & then seen	167	32
Seen & then heard	71	14

Nutcrackers feeding in trees use their voices in varying degrees, whereas when feeding on the ground they are almost always silent. While extracting seeds from Ponderosa Pine cones still attached to trees, the regular call may be uttered frequently. Fly-catching nutcrackers are usually silent, but occasionally give both the regular and shrill calls. On May 24, 1947, a scattered flock of about twenty nutcrackers observed fly-catching near the Blackfoot River were watched for 50 minutes. Though scattered over an area of about 80 acres, all were within easy hearing range. Only five times during this 50 minute period (1550 to 1640) were calls heard. Three birds collected from this group all proved to be yearlings. I

have not heard a ground-feeding nutcracker give any call while actually on the ground. However, at intervals they mount nearby trees, rocks, or timber snags and give any of the regular, shrill, musical, or bullfrog calls.

When calls are uttered while the bird is in flight, the regular call is usually used. When in sustained non-undulating flight this regular call, if uttered at all, is generally given only once at a time rather than in series. During undulating flights from higher to lower elevations, however, the regular call may be given in series of twos or threes near the bottom of each swoop. In hovering flight when apparently excited by an antagonistic influence, the regular, musical, shrill, squalling, and bullfrog calls may be uttered. The hunger calls of juveniles or of females during courtship may be given whether the bird is perched on some object, on the ground, or in flight.

When stimulated by antagonistic elements, nutcrackers may use the squalling call. This call is heard most frequently when they are in pursuit of hawks or owls. Usually the regular call is used while the nutcracker is 15 feet or more away from the perched hawk or owl, but as the nutcracker approaches closer it uses the squalling call. During aerial attacks against flying hawks, nutcrackers have been heard giving the regular, shrill, bullfrog, and

squalling calls. While defending the nest territory against other nutcrackers, they use the squalling call when attacking or when in close pursuit. After driving off such a trespasser, the dominant bird will usually take a prominent perch on the edge of its territory and give the regular and shrill calls several times.

There is considerable evidence that several of the calls serve as means of communication between nutcrackers. Flocks of from 10 to 60 nutcrackers scattered over areas of from 10 acres to a square mile or more in mixed coniferous timber stands have been observed on many occasions moving consistently in one direction while feeding. These flocks appear to use the regular and occasionally the shrill calls to remain in contact. Alarm is voiced and responded to by use of the squalling, shrill, and regular calls, especially, it seems, when hawks or owls are the subjects of such alarm.

Paired adults may use the musical call as a means of communication. From October 1947 through February of 1948 most nutcrackers observed were paired. These pairs were frequently discovered by their use of the musical call. On occasions when one of such a pair had been collected, the other bird would leave as the shot was fired, but would frequently return to the area 1 or 2 minutes later uttering the musical call. In each such instance when

both were collected, one was later sexed as a male and the other as a female. During the courtship activities observed in February, March, and April of 1947, the musical call was used almost constantly by some pairs, even by the bird carrying the stick.

NESTING HABITS

Courtship. Packard (1945) reports that in Rocky Mountain National Park in Colorado, Clark's Nutcrackers begin courtship in January and continue into March. Beyond this brief reference I have not found any other reference relating to courtship of any form of Nucifraga. Because there are no obvious plumage differences between male and female nutcrackers, some difficulty was encountered in the interpretation of courtship behavior. For want of a better criterion, the slight size dimorphism between sexes was found useful.

Observations of nutcrackers during October and November of 1947 indicate that some pairs may already be paired in October. In most instances during those two months birds were seen in twos. Isolated pairs of adult birds were collected on four occasions during this period and in each case one was a male and the other a female. Steinfatt (1944) says that outside of the breeding season he has often seen pairs of Nucifraga c. caryocatactes together and that it is increasingly evident that the species is a permanent resident of Rominte Hiede and that individuals remain permanently paired as for example do Magpies and Ravens. Linsdale (1937) indicates that among American Magpies, mated pairs tend to remain together as long as both birds live. Because immature birds were not present

in the study areas during the fall of 1947, these observations were more easily made than had immatures been present. These data indicate that courtship by nutcrackers as here described may be a preliminary to successful nesting by already established pairs which have been mated for five months and perhaps longer.

Though courtship was observed on several occasions, no constant pattern of behavior was evident. The descriptions which follow are fragmentary and relate to different pairs of birds in nearly every instance. These first observations indicate to me that any thorough understanding of Clark's Nutcracker courtship activity will require the amassing of considerable data from banded pairs of birds.

I observed undoubted courtship behavior in February of both 1947 and 1948. The initial observations were made early in the afternoon of February 25, 1947 on the southwest facing slope below Mitouer Ridge (see Figure 12). The afternoon was partly cloudy with the temperature at 4400 feet recorded at 27° F. At 1345 I saw one nutcracker with a stick in its beak flying from tree to tree and then to the snow-free ground below a Ponderosa Pine where another nutcracker was standing. The nutcracker with the stick had been giving the soft musical call quite regularly. The first Nutcracker seen flew to a large Douglas Fir nearby and broke off 8 or 10 dead twigs in fast succession

dropping each one in turn. It then flew down to the ground again without a stick. The second bird flew to a Ponderosa Pine about 50 yards distant and the first followed. At 1355 both birds left the pine, flew back to the ground where the second bird was first seen, and then both flew together up slope about 100 yards to a clump of 20 foot Douglas Firs. At 1400 one of the nutcrackers with a stick in its bill, and uttering the soft musical call flew to a Ponderosa Pine about 100 yards along the slope from me. Three or four minutes later the second nutcracker joined the first and they together flew to a small clump of 20 foot Ponderosa Pines about 40 yards below me. Both birds were using the soft musical note, and one bird still carried a stick. A moment later they flew together to the top of a 28 foot Douglas Fir under which I had concealed myself. From 1410 to 1415 no calls were heard, but the sound of occasional wing beats was audible overhead. At 1415 both flew off about 75 yards where one picked up a stick from the ground and returned to the tree over my head. The second bird flew to a tree 50 yards along the slope from me. The first bird followed the second calling softly still with its stick. At 1420 both birds flew behind a Douglas Fir clump where one suddenly gave the shrill call and they flew off together about 200 yards up slope.

Though this was the first instance of courtship observed in 1947, such behavior probably begins early in February or even in January. On February 25, 1947 an adult female was wounded and carried into the laboratory where she laid an egg on the morning of February 27. Placed in an incubator this egg proved to be fertile. This would indicate that egg-laying was already in progress or was about to commence. It may be postulated in this later instance that courtship must have begun at least as early as mid February to allow time for nest site selection and nest construction, before egg-laying.

On March 6th additional observations were made at 5200 feet along one of the ridges radiating from Pattee Point near the junction of the Bitterroot and Clark's Fork River valleys. The ridge running from east to west is topped by Ponderosa Pine and Douglas Fir in scattered open growth. The north facing slope of the ridge is covered with a dense growth of Douglas Fir, whereas the south facing slope holds an open stand of Ponderosa Pine. The weather was mostly clear with the temperature at the time of the observations reading 25° F. Three inches to three feet of snow covered the ground.

At 1010 I heard and then saw three nutcrackers on the open pine slope. One bird would start flying away from time to time and another would follow an instant

later. They would swing back to the same or an adjacent tree. The third bird did not enter into these activities and a few minutes later disappeared from the area. From 1020 to 1030, eight flights were made up a feeder ridge and then back. Flight was rapid and sustained in nature for about 200 yards up the ridge about 50 feet above the ground. They did not return from the ninth flight. At 1035 I found the two birds up the ridge. They saw me too and took positions on opposite sides of me and gave the regular call occasionally. At 1040 another pair of nutcrackers appeared from the direction of Pattee Point, the larger bird carrying a stick in its beak. Between 1040 and 1050, nine flights were made by this second pair. In each instance the smaller nutcracker left a perch in rapid flight and giving the regular call loudly, flew out over the Douglas Fir covered slope from the crest of the ridge. The larger, with the stick in its beak followed in equally rapid flight but without calls audible to the observer. Both birds returned each time to the same tree. Though the first pair remained silent, twice one of them (the same bird each time) joined in the last part of one of these flights. At 1050, the first pair left toward Pattee Point and the second pair proceeded on down the ridge. Upon following the second pair, I found that the larger bird continued carrying the stick nearly one-half mile from the point of the observations of 1040. Three additional flights like those described above were observed

before this pair too returned toward Pattee Point.

On a slope just below Marshall Ridge, similar in character, and about four miles from the area where the observations of February 25th were made on Mitouer Ridge, a nutcracker was seen on March 13 to carry a stick in short flights from tree to tree over a linear distance of about 300 yards, constantly calling softly. Another nutcracker traveling in a roughly parallel direction did not appear to respond. Both birds then disappeared over the ridge. This occurred at 1500 at from 4700 to 4900 feet.

About 200 yards from nest 1 on Mitouer Ridge on April 8th, at 0700 one nutcracker was observed gathering bark fibers from the ground. This bird flew into a shallow draw and proceeded to move from pine to pine without apparent destination. Two additional nutcrackers in the immediate area pursued each other, the chaser and the pursued changing several times during the following fifteen minutes. Each uttered the bullfrog note occasionally. The first bird remained in the area during these chases but did not join them. All three birds then worked out of the draw and over a feeder ridge by 0735.

On April 8 at about 4800 feet at a distance of about 400 yards from nest 1 a pair of adult nutcrackers was under observation for about thirty minutes. The smaller of the two, constantly squalling, followed the

larger from tree to tree and occasionally to the ground. Finally in the dead top of a Ponderosa Pine, the larger approached and appeared to feed the smaller crouching bird. The feeding bird stood high and placed its beak well down into the mouth of the smaller nutcracker several times. The smaller bird then stopped its squalling and the pair moved off along the ridge toward the north.

Again at 0945 on April 17th while in the blind at nest 1 a performance such as that noted on the afternoon of April 8th was observed which included five minutes of begging and then an apparent feeding. This occurred partly within the territory of the birds of nest 1. Both of these nutcrackers appeared to be adults. The male of nest 1 flew at and drove the two birds down slope just after the apparent feeding.

This begging and apparent feeding occurred after nesting was well advanced. On April 24th, five days before the two young left the nest 1, the parent birds engaged in similar behavior within their territory, though I was unable to make out the roles taken by each bird. At nest 1 both adults were seen to crouch, droop their wings, open their beaks, and occasionally squall when they had been brooding the young and the other of the pair would arrive to feed the young. These actions would take place usually on the edge of the nest. The female, was on one

occasion observed to actually feed the male at the nest. In all other instances the begging tactics were apparently ignored. This behavior was exhibited at about half of the feeding visits while continuous brooding was in effect.

The extent to which yearling nutcrackers may exhibit courtship behavior is unknown. However, due to the under-developed condition of their gonads, it is felt that such behavior would be the exception rather than the rule. During March and April of 1947, flocks of birds numbering from 20 to more than 60 nutcrackers each were sampled. Of 29 birds taken from such flocks, all were found to be yearlings with under-developed gonads.

Nesting territories and courtship areas do not appear to necessarily have the same limits. On March 6th, the second pair (page 43) continued behavior indicative of courtship nearly one-half mile from where they were first observed making circuit flights. Likewise the begging-feeding type of behavior was observed by a pair trespassing on the territory surrounding nest 1 on April 17.

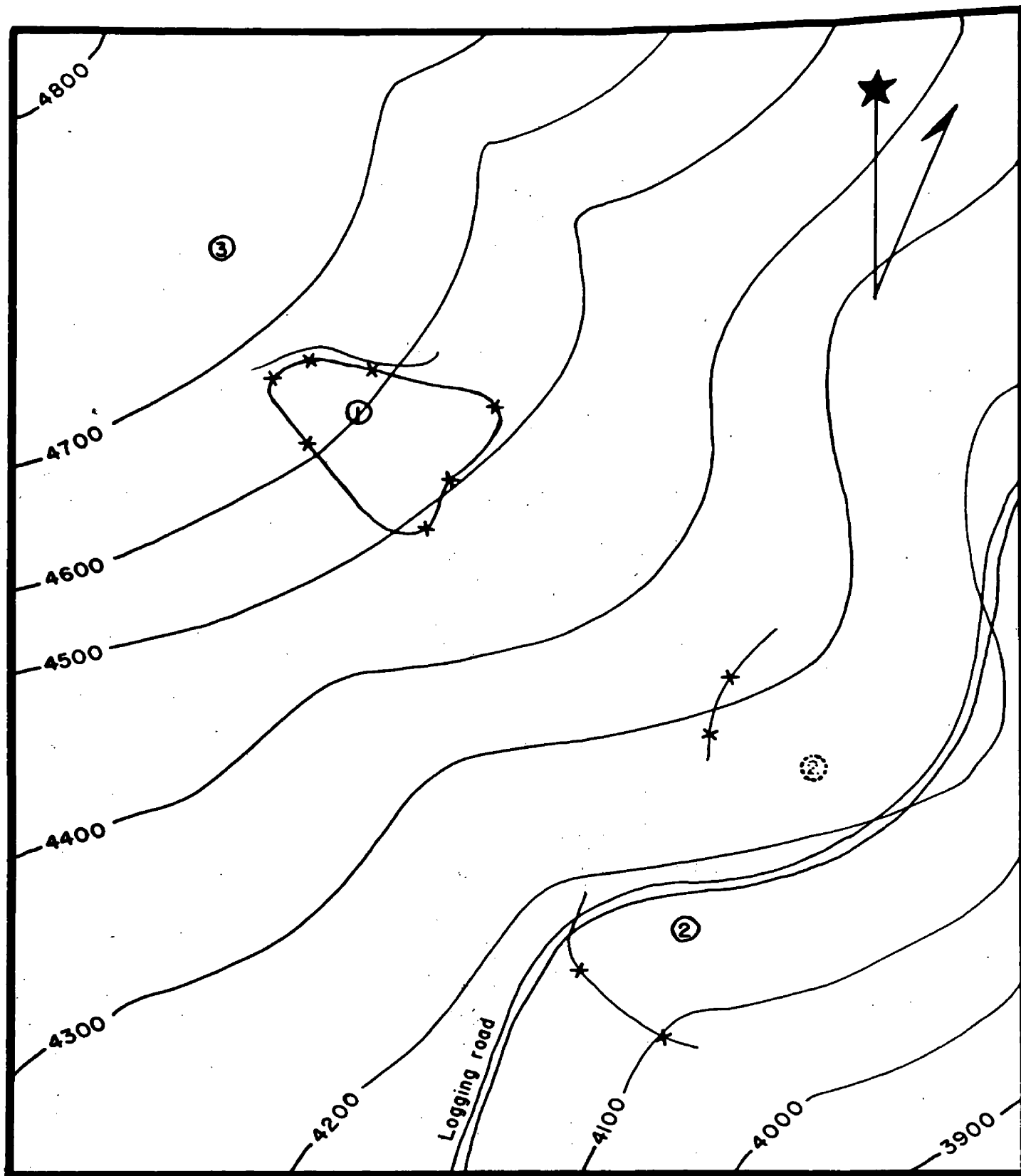
Nesting territory. Observations of nesting Clark's Nutcrackers on Mitouer Ridge indicated that defense of nesting territory was well developed in the male. I have not been able to find any reference in the literature to territorial behavior on the part of any species of Nucifraga.

The territorial behavior of these nutcrackers did not appear to conform to any of those general types suggested by Nice (1943), but rather appeared to be similar, in some respects at least, to the pattern described by Davis (1941) for the kingbird. Mate selection and courtship occur before a territory is established. Nest material may be gathered beyond the limits of the defended territory. Feeding occurs beyond territorial limits. However, defense of territory is principally intraspecific in the case of Clark's Nutcracker rather than interspecific as Davis found it for the kingbird.

Because territorial conflicts observed at nest 1 were very similar, I have selected one from the 14th day of incubation to describe in some detail. On April 1 at 0938 I had been in the blind for 98 minutes. The female had been on the nest continuously during this time. Two nutcrackers entered nest 1 territory and perched in the upper portion of a dead topped pine about 50 feet east of the nest tree. As they settled the male of nest 1 flew from one of his perches northwest of the nest to a high stump 40 feet east of the nest tree. A moment later the male flew up at one of the two trespassers. They seemed to meet at the perch and then flutter together toward the ground as they both squalled. Before reaching the ground they separated. One took a perch on a stump 20 feet east of the nest, while the other bird took a perch in the thicket about 20 feet west of nest 1. During this time

the third bird maintained its perch in the dead topped pine. The bird east of the nest, apparently the male of nest 1, uttered the shrill call and flew at the bird west of the nest. A moment later the male of nest 1 appeared below the blind chasing the intruder, half hopping and half flying to a point about thirty feet east of the nest where both birds took wing. The male followed over the edge of the slope giving the regular call. The third bird had in the meantime disappeared. About 1 minute later the male returned to one of his east boundary perches and gave the regular call about ten times. Throughout these proceedings which took about four minutes, the female on nest 1 remained alert.

In most instances at nest 1, the male was definitely known to be the defender, whereas the female was not knowingly observed to make any defense of the territory. The female was not easily excited, whereas the male was constantly alert while incubating and reacted immediately to many more outside influences than did his mate. Further observations will be necessary to determine how typical or atypical this variance in behavior may be. In the case of the pair of nest 2, both sexes were observed to pursue a trespassing nutcracker during the period before the female's (?) nest building behavior pattern was complete (page 64).



0 100 200

Scale: 1 inch = 100 yards

Contour interval
100 feet

Figure 5. Clark's Nutcracker nest locations and territories on Mitouer Divide in 1947.

On territorial boundaries each X indicates a territorial boundary perch.

The territory around nest 1 defended by the male was well defined. Seven territorial boundary perches (Figure 5) were known established beyond which he would pursue intruders and to which he would return. This male would usually return to the nearest boundary perch and give the regular call 10 or 12 times immediately after each such pursuit. He would then move to one of two perches northwest of the nest. The male nutcracker was usually silent on his territory except when he had just been involved in a dispute.

Recognition of the voice of the other member of the pair was well demonstrated on several occasions, by both the female and the male. The female, while incubating did not react to other nutcrackers in the territory unless her mate was actively in defense of territory and using his voice. On the other hand, the male became very alert, and turned in the direction of trespassing nutcrackers when they called, but did not actually leave the nest while he was incubating or brooding.

The territory surrounding nest 1 was at least 2.1 acres in area as enclosed within the seven known boundary perches observed as limits of pursuit (Figure 5). These boundary perches varied from 33 to 89 yards ground distance from the nest tree and in most cases were the only large trees between 25 and 100 yards of the nest tree in

a given direction. Toward the northwest, where there were several apparently suitable perches the ground distances to boundary perches were found to be 52 and 63 yards.

Included within the territory of nest 1 were about 15 trees more than 75 feet high. Four of these were Douglas Firs and the balance Ponderosa Pines. A clump of young Douglas Firs containing a few scattered young Ponderosa Pines, about one-quarter acre in area was situated in the north central portion of the territory. The nest was situated on the south edge of this clump in a 25 foot Douglas Fir.

Nesting materials going into the construction of both nests 1 and 2 came at least in part from areas outside of the territories known to be defended during the later nesting stages. Many of the Douglas Fir twigs of nest 1 came from two partially dead trees approximately 40 yards beyond territorial limits, while on April 1st the pair building nest 2 were seen to cross a gulch 400 feet deep to secure twigs from the opposite facing slope more than 600 yards from their nest site. Some of the material going into nest 3 was collected in that sector just north-northeast of, and less than 25 yards from, the territorial boundary of nest 1.

The adults of nest 1 secured food for themselves and later for their brood almost entirely outside of their nesting territory. This meant that during considerable periods the incubating or brooding bird was alone in the

area. No territorial defense was made during these periods. It appeared that the female was gone from the nest only long enough to feed. This left the male a considerable amount of time when he was observed to perch on the northwest edge of his territory. He would leave this perch to drive trespassing nutcrackers from the territory and then return to the same or an adjacent perch. Though definite data were not obtained, it is estimated that the male was on guard approximately one-half of the daylight hours.

Trespass by the observer onto nest 1 territory was not protested unless one of the adults was flushed from the nest. The blind placed variously from 6 to 12 feet from the nest was entered on all occasions except once without causing the incubating or brooding bird to leave. On this one occasion the male flushed while brooding. When the young were being weighed, the female was especially bold, coming within 10 feet of the observer on several occasions.

The general pattern of territorial defense as observed at nest 1 was much the same during both the incubation and brooding-feeding periods except that during the brooding-feeding period, the male made more frequent visits to the nest. Continuous observations were not made at the nest from the 6th day to the 10th day of the brooding-feeding period. However, on the 11th day both parents

were known gone from the nest for intervals up to 99 minutes. Whether or not both parents were absent from the territory simultaneously from the 11th day onward for any length of time was not determined.

Other species of passerine birds were tolerated within the territorial limits of nest 1 without known exception. The following species were observed within 30 yards of the nest while the blind was in operation:

Steller's Jay	<u>Cyanocitta stelleri</u>
American Magpie	<u>Pica pica</u>
Black-capped Chickadee	<u>Penthestes atricapillus</u>
Mountain Chickadee	<u>Penthestes gambeli</u>
White-breasted Nuthatch	<u>Sitta carolinensis</u>
Red-breasted Nuthatch	<u>Sitta canadensis</u>
Pygmy Nuthatch	<u>Sitta pygmaea</u>
Robin	<u>Turdus migratorius</u>
Mountain Bluebird	<u>Sialia currucoides</u>
Golden-Crowned Kinglet	<u>Regulus satrapa</u>
Cassin's Purple Finch	<u>Carpodacus cassinii</u>
Red Crossbill	<u>Loxia curvirostra</u>
Junco	<u>Junco (sp.)</u>

No nest of other birds were found within the territory of nest 1, although a Junco was constantly in the area and on two occasions was observed to use the top of the blind, when it was eight feet from the nest, as a perch while singing.

Both the Hairy Woodpecker (Dendrocepos villosus) and the Red-Shafted Flicker (Colaptes cafer) were frequently in the area. Both the male and the female would become alert when a flicker would give its kee-yer note within 50 or 75 yards of nest 1, but in no instance was a pursuit of a flicker noted. The Hairy Woodpecker was apparently

ignored, as was Richardson's Grouse (Dendragapus obscurus richardsoni) seen on several occasions in the Douglas Fir thicket within 50 feet of the nest.

The presence of a Red-Tailed Hawk (Buteo jamaicensis) approximately 300 yards from nest 1 was sufficient in one instance to cause the male to leave his territory and attack in company with the nutcrackers from nest 2. This was during the period of incubation at nest 1 and the building of nest 2. The pursuing nutcrackers usually kept above the hawk and made diving attacks at its back, causing it to swerve to the side as if to avoid being struck. In the other cases, however, the male remained at one of his territorial boundary perches and gave the regular call in an excited manner while the other two nutcrackers (of nest 2) gave chase to the hawk giving regular and bullfrog calls. The female, incubating on nest 1, became very alert during these conflicts. The Red-Tailed Hawk was not observed within one-half mile of either of nests 1 or 2 after the first week in April.

On April 1, when a Pygmy Owl (Glaucidium gnoma) was heard about 25 yards west of nest 1, the incubating female turned her head in the direction from which the calls came. She remained alert during the next one and one-half minutes turning back only when the owl had stopped calling.

No reactions were observed on the part of the nutcrackers on two occasions when Mule Deer (Odocoileus hemionus)

were observed within 25 yards of nest 1. On several occasions, however, the adults at nest 1 became alert while incubating, when a Chipmunk (Eutamias), which occupied an old stump less than 10 yards from the nest tree, would chatter. No other mammals were observed within territorial limits.

The nest building period. Clark's Nutcracker may begin nesting very early in the season, when weather conditions in its nesting areas are often severely cold, and where snow usually persists far into the spring months. Skinner (1916) reported that about "February 1, at Fort Yellowstone [Wyoming], elevation 6,300 feet above sea level, the birds are mated and the building of the nest begins". He further reported that the eggs are laid between February 28 and March 3 at Fort Yellowstone, though somewhat later at higher elevations.

When the findings of Bendire (1895), Bowles (1908), Bradbury (1917), Munro (1919), and Dixon (1934) are examined, it is found that Clark's Nutcracker usually begins egg deposition in March. Bent (1946) gives the following egg dates for Clark's Nutcracker: British Columbia, 11 records, March 9 to May 25; California: 32 records, March 7 to April 21, and 16 records March 24 to April 13; Colorado, 8 records, March 5 to April 16; and Utah, 6 records, March 23 to April 25. However, many may

begin in late February or in April. The start of nest building probably precedes the laying of the first egg by a minimum of 6 or 7 days.

Montana nesting records listed by Saunders (1921) include: gathering nesting material (courtship?) at Trego on February 26, 1916; a nearly completed nest in Norton Gulch, Silver Bow County, March 14, 1910, which held its first egg on March 18 and which held a total of 5 eggs; and a nest containing 2 "fully fledged" young in Charcoal Gulch, Silver Bow County on April 28, 1910. Saunders further says: "Nesting begins very early, and the almost impenetrable condition of the mountains at this season has made the nest, in spite of the abundance of the bird, a rare find. Since at least some individuals breed in the Transition Zone, the nest is by no means so hard to find as that of the Rocky Mountain Jay, which is probably always in Canadian or Hudsonian."

On Mitouer Ridge construction began on nest 1 about March 10, and on nests 2 and 3 on April 1 and April 15 respectively. A female wounded on February 25 at 4,100 feet on Mitouer Ridge laid a fertile egg in the laboratory on the morning of February 27. This female and her mate probably began nest building on or before February 20. The young nutcracker in nest 4 in the Bitterroot Mountains appeared identical in age to the two surviving young in nest 1 on April 27. It is probably that nest 4 was begun on about March 10.. These data clearly indicate that

Clark's Nutcracker in western Montana, at elevations between 4,000 and 4,800 feet above sea level, may begin nesting at least as early as February 20 and at least as late as April 15. There is no evidence to indicate that a second brood may be attempted after the successful rearing of one brood.

Steinfatt (1944) found in Rominte Heide (East Prussia in Europe) that the Thick-Billed Nutcracker (Nucifraga c. caryocatactes) began nesting in 1935 in the first part or middle of March, and in 1943, early in March. M. and H. Bartels (1929) found this same race of bird nesting in the Swiss Alps in March, finding an incomplete clutch (2 of later 4 eggs) on March 22, 1929. Other nests reported by the Bartels that year were found, one on March 23 with two eggs, and one on March 28 containing four eggs.

Grote (1947) reported the testes of the male Thin-Billed Nutcracker (Nucifraga caryocatactes macrorhynchos) of extreme northeastern European Russia and much of Siberia, reach their maximum size of 9mm at the end of March, that they return to about 3mm in the middle of April, and maintain a minimum of 1.5 to 2mm during the summer and fall. This would suggest March breeding for this race as well.

Early nesting is thus seen a common characteristic of behavior for at least two species (three sub-species) of the genus Nucifraga. In Europe and Asia, as well as

in North America, this early nesting has been at least partially responsible for the paucity of information regarding the nesting of members of this genus.

Four occupied nutcracker nests were found during March and April of 1947. Each nest was situated in a different type of location. The first three were found in an early stage of building, while the fourth was located on the day the one young left the nest.

Nest 1, 4,600 feet, was found March 11th on a southeast facing slope near the crest of Mitouer Ridge. It was placed next to the east face of the main trunk of a 25 foot Douglas Fir, 12 feet above the ground. The nest tree protruded into a small clearing surrounded on all sides except the east by trees similar in age and size to the nest tree (Figures 5, 9, 12, and 13).

Nest 2, 4,200 feet, found April 1st was located 417 yards down slope from nest 1 near the end of a heavily foliated branch of a lone 25 foot Douglas Fir. The nest was about four feet from the trunk of the tree and six feet above the ground when measured from immediately under the nest (Figures 5, 12, and 16).

Nest 3, 4,700 feet, found on April 15th, 144 yards northwest of nest 1 was placed in the tangled terminal portion of a south lateral branch about 80 feet up in a 125 foot Ponderosa Pine. The nest, twenty feet out from the main trunk of the tree could be seen from the

ground when the exact location was known (Figures 5, 12, and 15).

Nest 4, 4,300 feet, was found April 27th on a relatively open Ponderosa Pine and Douglas Fir southeast facing slope of the Bitterroot Mountain Range near Florence, Montana. Placed four feet from the trunk on a south horizontal limb, the nest was 25 feet up in a 50 foot Ponderosa Pine. The nest was visible from the ground (Figure 19).

Five additional nests, thought to be old nests of Clark's Nutcrackers were found during the nesting season. Their positions were similar to those noted above, except that one was on a west facing slope.

All nests found were very similar in composition and structure, except that the bowls of old nests had lost their shape and were generally filled with fragments of the lining. Nests 1 and 2 were measured early during the incubation period and collected later for examination of their component parts.

Measurements of nests 1 and 2 were very similar. Outside diameters varied from 11 to 13 inches. Nest 1 was about 7 inches deep and nest 2 about 6 inches deep. The inside measurements of the nest bowls were about 4 inches across and 3 inches deep. The floor and outer walls of nest 1 were composed of 247 counted dead twigs of the Douglas Fir and 8 additional miscellaneous twigs from deciduous shrubs. The outer walls and thinner floor of

nest 2 contained 193 dead Douglas Fir twigs. The diameters of the twigs varied from about one-sixteenth inch to slightly over three-sixteenths of an inch in diameter. Lengths ran up to about 12 inches, with 8 or 9 inches being most common. The twigs of nest 1 averaged larger than those of nest 2. The 255 twigs of nest 1 weighed 256 grams while the 193 from nest 2 weighed 144 grams. The outer portions of the bowls of each nest were composed principally of rotten wood pulp, while the inner lining, varying from $1\frac{1}{2}$ to 2 inches thick, was almost entirely dried grass with a few strips of inner bark from the Douglas Fir. Though nest 1 contained some mineral soil, nest 2 had a mat of soil about $\frac{1}{2}$ inch thick in the floor of the nest between the wood pulp base and the finer grass lining. This mineral soil was carried to the nest in damp pellets between one-quarter and three-eighths of an inch in diameter. Eight such pellets were found on the incompleting floor of nest 1 on March 15.

Except for the mineral soil layer and differences in the nest material source plants, these nests compared well with Clark's Nutcracker nests described by Bendire (1895) and Dixon (1934), and with a European Nutcracker (Nucifraga c. caryocatactes) nest described by Steinfatt (1944). No evidence of the landing platform described by Dixon was found associated with any of my nests.

It was apparent that though both members of the pair share the burden of nest building, the female did the bulk of the construction. It was noted that the two birds carried to the nest site approximately equal amounts of material. The female of each of nests 1 and 3 would remain at the nest and do considerable arranging and adjusting of material, whereas the male would leave the nest site almost immediately for a nearby lookout perch where he would remain occasionally for from 30 to 90 seconds before making another trip for material. This sex distinction was based on my familiarity with the individual birds of nest 1, and on an observed size difference between the adults of nest 3. The female of nest 3 when collected eight days after the nest building data were taken weighed 121.9 grams and the collected male, 150.5 grams.

Nest 1 was found during a heavy snowfall at 0940 on March 11. There were four to six inches of fresh snow on the ground in addition to old snow up to three feet in depth within 20 feet of the nest tree (Figures 9, 10, 11, and 13). One of the adults carrying a stick into the nest tree disclosed the position of the nest. During a total of 85 minutes of observed nest building activity, 40 minutes on March 11 (temperature 32° F.), and 45 minutes on March 13 (temperature 33° F.), 44 individual trips to the nest were made with nesting material. Thus each bird made on the average one trip about every four

minutes. Snow was falling throughout both periods of observation. Five times (10 trips) the birds flew together from the material area to the nest tree. Entrances into and exits from the nest tree were made in nearly every possible direction by both nutcrackers. The soft musical note was occasionally used by both birds especially when carrying sticks in their beaks. The male gave the regular call from 3 to 6 times on each of the 4 or 5 times he mounted a lookout perch between trips. Once, upon my approach to the nest, the female repeated the crackle-whistle call 5 or 6 times before retreating into the Douglas Fir thicket. The bullfrog and shrill calls were uttered by both birds on several occasions, especially when in the vicinity of the material trees.

Nest 3 found on April 15 at 1405, when the nutcrackers were seen carrying nest building material, was under observation that day for 75 minutes, during which time 51 trips were made. In about 20 cases (40 trips) the two birds flew in company with each other. Each bird thus made a trip about once every 3 minutes. The day was mostly clear, with the temperature 50° F. in the nest vicinity.

Sustained observations were not made at nest 2 found on April 1 at 0725 (temperature 31° F.) when the two birds were seen to enter the nest tree each with a stick. Whereas material for nests 1 and 3 was obtained within 125

yards of the nest, material observed gathered for nest 2 came from a distance of more than 600 yards. Intervals between arrivals at the nest were of necessity greater. On the 5 or 6 trips observed, the two birds kept in company, both upon leaving the nest area and upon returning to the nest tree.

Greatest nest building activity was observed during the morning hours. Usually the nutcrackers could not be found in the vicinity of their nests during the afternoon until after egg laying had commenced.

I feel confident that both nests 2 and 3 were discovered on the day they were begun, whereas nest 1 was probably found on the second day of construction. Nest 2 consisted of about 20 sticks at 0725 on April 1, and was already a well shaped nest at 1820 that evening. Nest 3 was so thin at 1405 on April 15 that the sky could be seen thru the center of the nest from about 80 feet below. Nest 1 was less advanced at 1100 on March 11 than nest 2 was at 1820 on its first day of construction.

Work on nests 1 and 2 continued until, but apparently not including, the day before the first egg was deposited. Because of the inaccessibility of nest 3 (Figure 15), the pair was collected at 1450 on the eighth day after the nest was begun. The female was incubating at the time and upon examination showed 3 freshly ruptured follicles in her ovary. No more ova were mature enough to rupture,

and no egg was present in the oviduct. It may therefore be concluded that three eggs had been laid, the last on or before the day of collection. Efforts to recover nest 3 were not successful. See Table 3 for a summary of nest building time schedules.

TABLE 3
SUMMARY OF NEST CONSTRUCTION TIMES

Nest	Date Found	Date const. Began	Date Completed	Date First Egg Laid	Construc- tion Time
1	Mar. 11	(Mar. 10) ¹	Mar. 17	Mar. 19	8 days
2	Apr. 1	Apr. 1	Apr. 5	Apr. 7	5 days
3	Apr. 15	Apr. 15	(Apr. 19) ²	(Apr. 21) ²	(5 days) ²

1--Judging from the rate of construction of nests 2 and 3 I feel that nest 1 was begun on March 10.

2--Based on 3 freshly ruptured follicles in the ovary of the female when collected at 1450 on April 23.

At 0910 on March 24, a pair of nutcrackers thought to be the same pair which on April 1 began construction of nest 2 were discovered carrying sticks to a Ponderosa Pine 142 yards north-northeast of their later successful nest (see broken "2" in Figure 5). These sticks were placed on an open crouch of a lateral branch about 10 feet above the ground. During the week following March 24, this pair carried material to this spot in considerable

quantity. At no time were more than 10 or 12 sticks observed at a time on this crouch, and usually only 2 or 3 remained in position (Figure 17). Though partially obscured by a fresh snowfall, there were already several hundred sticks present on the ground on March 24. Most of these sticks were obviously freshly broken from larger branches. By April 1, when nest 2 was begun, a pile of more than 2,500 Douglas Fir twigs of the usual nutcracker nest size had accumulated (Figure 18). A small amount of fresh inner bark strips were also present. A few twigs were also accumulated on a stump about 12 feet from the larger pile of material.

During an hour's observation on March 25 from 0900 to 1000 it was clearly seen that though both birds carried material, only one took pains with stick arrangement. This latter bird, appearing slightly smaller, was presumed to be the female. Trips for sticks were always made together. Upon return to the "stick tree", one, presumably the male, would leave his stick and quickly fly to a lookout perch nearby. The other bird would then spend 30 to 90 seconds arranging and rearranging the 5 to 10 sticks present. As this bird would crouch and turn about in the midst of the sticks, as though shaping the nest, one or more of the sticks would usually fall to the pile below the tree. Once when a stick fell, the bird dropped to

the pile, picked up a stick and flew up to the nest site with it and again went to arranging the material.

Material was collected in draws on either side of the "stick tree", and also from the slope across Mitouer Creek where material was later gathered for the successful nest 2. On one occasion the presumed male, on a return trip with material, flew past the "stick tree" to a lookout perch where he dropped his stick.

A trespassing nutcracker was pursued by both members of the pair in 5 or 6 circles about 80 to 100 yards in diameter in the vicinity of the "stick tree" before the intruder in direct flight left the area. Flight was silent, except for about once in each circuit when the three would dip near the ground, come close together fluttering and fighting, when they would engage in considerable squalling. This episode consumed about 5 minutes. Immediately after the third bird disappeared up toward nest 1 they resumed gathering nesting material.

Nice (1943) lists several instances where various species of birds have collected surpluses of nesting material. None of these instances, however, quite compare with the above observations where there appeared to be an inability to properly arrange materials so that they would remain in position.

Egg laying and incubation. Three eggs were deposited in each of nests 1 and 2, as well as probably in nest 3 (the latter based on freshly ruptured ovarian follicles). Bent (1946) states that "Clark's nutcracker lays, apparently usually, two or three eggs, but often four and occasionally as many as five or even six". According to Vogel (1873) the Thick-Billed Nutcracker of Europe (Nucifraga c. caryocatactes LINNAEUS) lays 3 or 4 eggs. Of 6 nests he observed, five held four eggs each and one held three eggs.

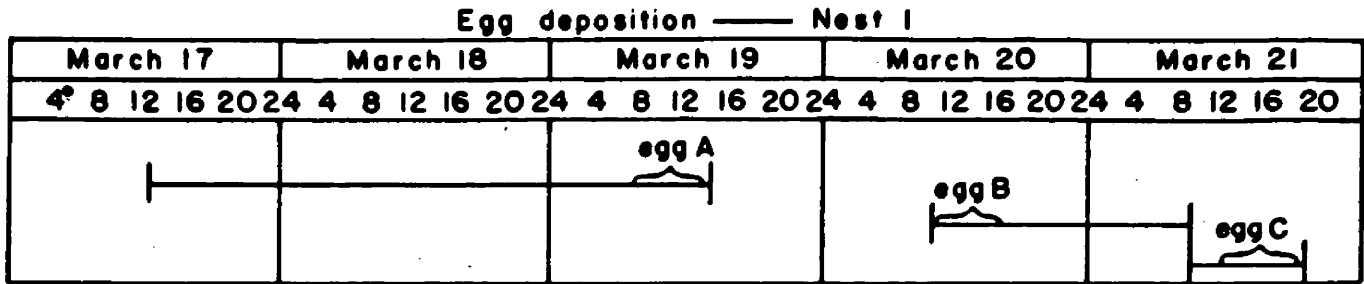
It is generally known that passerine birds usually lay one egg in the morning of each day until the clutch is completed. Accordingly the intervals between depositions are usually about 24 hours. Miller (1931) found that the intervals between layings for the Shrike (Lanius ludovicianus), are approximately 24 hours long with deposition usually before 0800 or 0900. He further states, however, that he found intervals of 26 to 28 hours in one clutch, with some of the eggs deposited, as near as could be determined, in the late afternoon. Nice (1937) found for the Song Sparrow (Melospiza melodia) that: "Eggs are laid in the early morning of succeeding days."

In nest 1 egg A was laid between 1300 on March 17 and 1435 on March 19, egg B between 1000 on March 20 and 0855 on March 21, and egg C between 0925 and 1850 on March 21. Each egg was marked with ink for identification

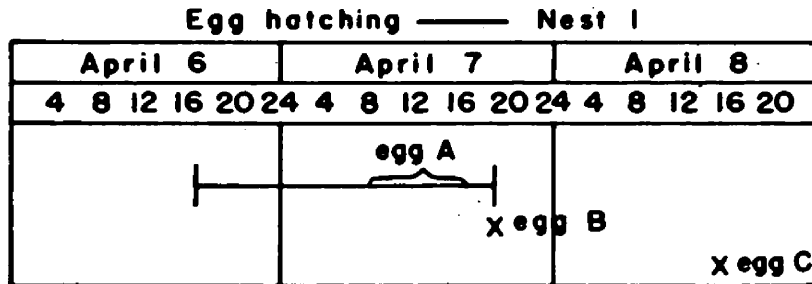
as soon as it was found after deposition. Inspection of these data plotted in Figure 6 reveals that since egg C was laid between 0925 and 1850 on March 21, that egg B must have been deposited between 1000 and probably 1800 on March 20 to allow 24 hours between layings. Because it is not likely that egg A was laid more than 30 hours before egg B, and because it is known that the egg was laid before 1435 on March 19, it is probable that egg A was laid between 0700 and 1435 on March 19.

Similarly in nest 2 egg D was deposited between 1700 on April 6 and 1835 on April 7, egg E between 0700 and 1700 on April 8, and egg F between 1700 on April 8 and 1845 on April 9. Again reference to Figure 6 discloses that the eggs of nest 2 were probably laid during the daylight hours on each of April 7, April 8, and April 9.

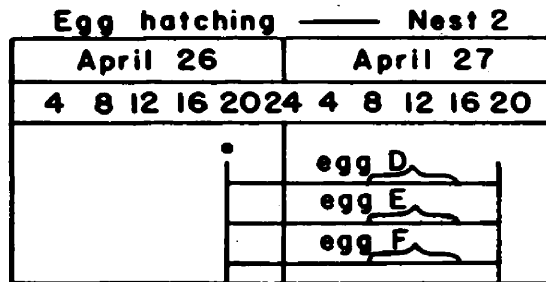
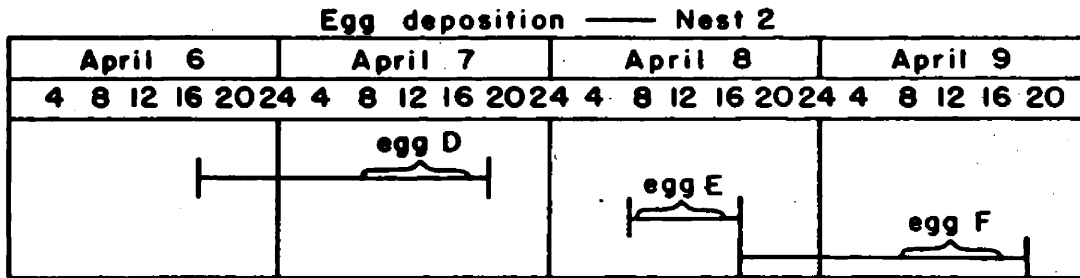
Because each egg was marked it was possible to note the changes in positions of individual eggs as well as the eggs in relation to each other. On each of the 14 visits made to nest 1 during incubation it was noted that the eggs had been turned and otherwise moved since the previous inspection. Though I could not actually see the incubating birds turn the eggs, it is felt that deep probing with their beaks into the lining of the nest served at least in part to turn and shift the position of the eggs.



*Hour of the day



X = Exact hatching time



* All 3 eggs pipped

Figure 6. Egg deposition and hatching in Clark's Nutcracker nests 1 and 2 in March and April of 1947. Lines (|-----|) indicate time between nest inspections when eggs were deposited or hatched. Brackets (|-----|) indicate probable deposition or hatching times.

For determination of length of incubation, the six laying times above are accepted as valid.

In nest 1 the times of hatching of eggs B and C are known within the hour. When the nest was examined at 1855 on April 7 egg A had already hatched, the egg shell was gone from the nest and the sparse white down on nestling A (from egg A) was dry. Because none of the three eggs was yet pipped at 1630 on April 6, egg A must not have hatched until April 7. At the same time nestling B was free of the larger pointed portion of the egg, though the smaller broad portion was still on its head. Egg C was not yet pipped, nor was it pipped at 0740 the next day (April 8). Continuous observations were made from the blind on April 8, from 0740 to 1605. Starting at about 1100 that day, the female was seen and heard on several occasions to peck at something with a hard surface in the nest. Upon flushing her at 1310 I found egg C slightly pipped, and around the larger end of the egg in line with the out-pushing, a ring of in-pushings apparently pecked there by the female. (The observation slit of the blind was at this time located about 8 feet from the nest.) The female returned to the nest within one minute after I returned to the blind. At 1508 the female backed to the edge of the nest and pecked at egg C for four minutes, at the end of which time, nestling C had hatched. Immediately thereafter the female proceeded to break off portions

of the shell about one-eighth of an inch in diameter and swallow them. She then settled back to brooding at 1516 without removing the shell from the nest. The shells of eggs B and C were removed from the nest and preserved shortly after hatching.

On April 26 at 1915 all three eggs in nest 2 were pipped. Egg D appeared to have a larger out-pushing than eggs E and F. At 1910 the next day (April 27 all three were hatched, and the egg shells gone.

Miller (1931) in speaking of the shrike (Lanius) states: "There is no evidence to indicate that eggs hatch at night but they may hatch at various hours of the day. A day-night rhythm of general activity is likely already in effect." Assuming that this pattern probably holds true for the nutcracker, egg A of nest 1 probably hatched between 0700 and 1700 on April 7, whereas egg B is known to have hatched just before 1855 on April 7 and egg C at 1512 on April 8. Because eggs D, E, and F of nest 2 were only pipped at 1930 (dusk) on April 26, it is thought most probable that all three hatched during the daylight hours prior to 1910 on April 27 when from the appearance of the young, they had obviously been hatched for at least one or two hours.

An inspection of the data for nest 2 in Figure 6 clearly shows that though the eggs were deposited on three successive days they hatched on the same day. Clark's

TABLE 4

SUMMARY OF ATTENTIVENESS AND INATTENTIVENESS
DURING INCUBATION AT CLARK'S NUTCRACKER NEST 1.

Date	April 1, 1947	April 3, 1947
Stage of incubation	14th day	16th day
Time of day	0800 - 1800	0715 - 1730
Total hours and minutes	10 hours	10 hrs. 15 min.
Weather conditions		
Air temperature		
Beginning and end	31 - 39	32 - 38
High and low	53 - 31	46 - 32
Hourly average	43	40
Wind velocity (est.)	0 to 15 m.p.h.	10 to 35 m.p.h.
Approximate % sunshine	10%	40%
Snow on ground at start	0 to 18 in	0 to 18 in.
Precipitation (% time)	20% rain & snow	15% snow
<hr/>		
Attentive periods - both		
Total number	5	6
Periods in minutes	(118), 69, 161 61, (190)	(30), 51, 194, 55, 272, (8)
Percent of total time	99.89%	99.19%
Inattentive periods - both		
Total number	4	5
Periods in minutes	0.08, 0.25, 0.25, 0.08	0.25, 0.25, 2.50, 1.50, 0.50
Percent of total time	0.11%	0.81%
Attentive periods - female		
Total number	3	3
Periods in minutes	(118), 161, (190)	(30), 194, 272
Percent of total time	78.20%	80.65%
Attentive periods - male		
Total number	2	3
Periods in minutes	69, 61	51, 55, (8)
Percent of total time	21.69%	18.54%

Periods in parentheses () were not completely clocked due to the arrival or departure of the observer. No interruption occurred except for the (8) minute period interrupted at 1730 on April 3 when the male flushed from the nest as I left the blind.

Nutcracker begins incubation immediately as the first egg is laid and continues with more than 99 percent attentiveness (see below) until the eggs are hatched. It is thus clearly shown that the two earlier eggs laid in nest 2 had longer incubation periods than the third. Eggs A and B of nest 1 hatched on the same day though deposited at least 24 hours apart. Although hatching of egg C was obviously not normal, it had an incubation period one day shorter than egg A.

Bendire (1895) gave the period of incubation for Clark's Nutcracker as nearly as he could judge as about 16 or 17 days. Skinner (1916, however, gives the incubation period as 22 days. The incubation periods of the six marked eggs in nests 1 and 2 were found to fall between those reported by Bendire and Skinner. According to Vogel (1873) eggs of Nucifraga c. caryocatactes are hatched between 17 and 19 days after the beginning of incubation. However, as M. and H. Bartels (1929) point out, Vogel assumed that incubation did not begin until the clutch was complete. The Bartels found that incubation was in progress before the third egg of a four egg clutch was deposited in the nest.

TABLE 5
 INCUBATION PERIODS OF SIX CLARK'S
 NUTCRACKER EGGS FROM NESTS 1 AND 2 IN 1947

Nest	Egg	Date Laid	Date Hatched	Days Incubated
1	A	March 19	April 7	19
1	B	March 20	April 7	18
1	C	March 21	April 8	18
2	D	April 7	April 27	20
2	E	April 8	April 27	19
2	F	April 9	April 27	18

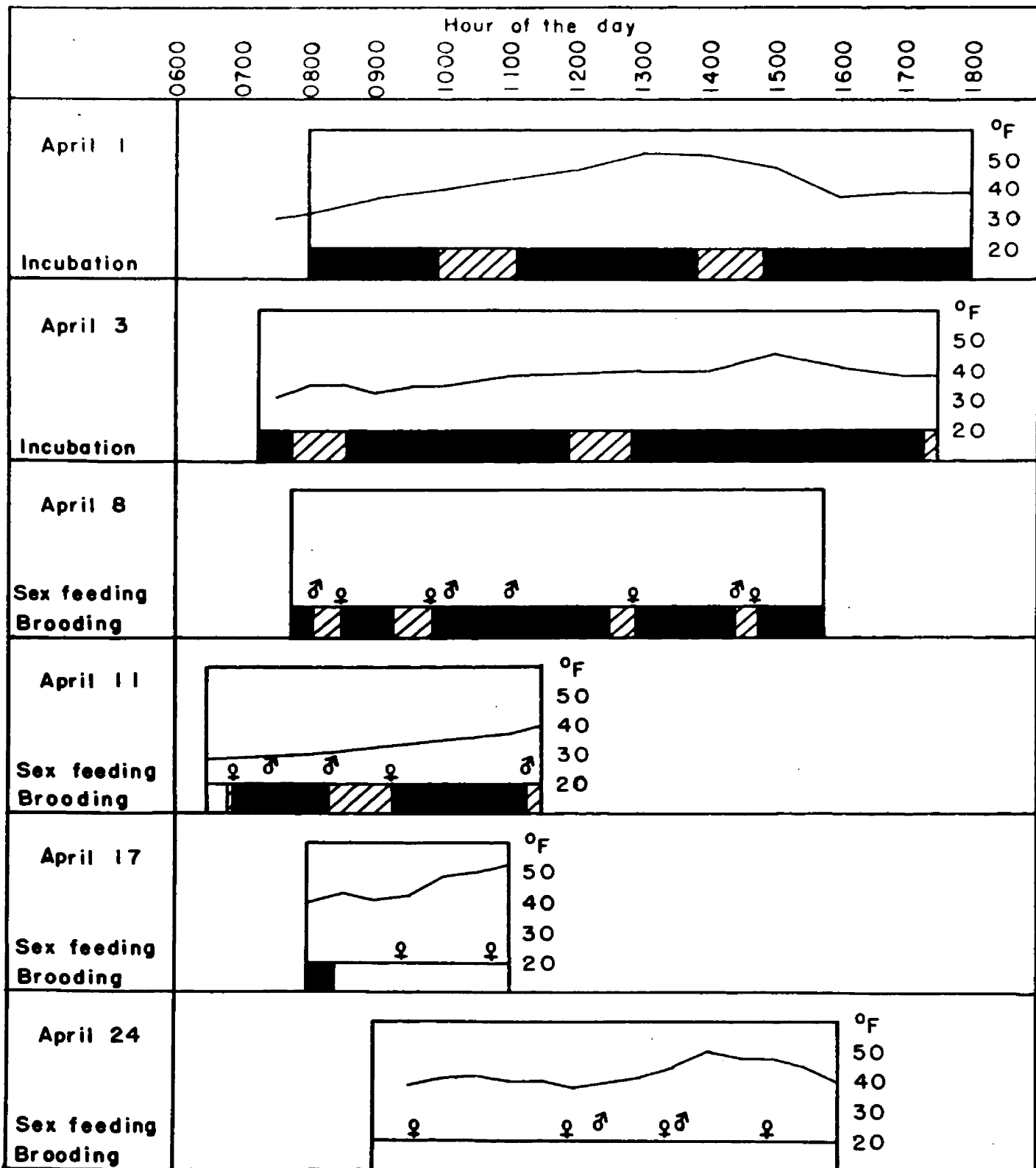
An inspection of Table 5 suggests that a stated average incubation period for eggs of this species would have little value, whereas averages for first eggs, second eggs, third eggs, etc. might have some significance when sufficient carefully derived data are available. Is it possible that fourth and fifth eggs in a Clark's Nutcracker clutch of five eggs have shorter incubation periods than the third egg? Does predepository embryonic development account for the shorter external incubation periods of later eggs laid?

That both sexes share in the incubation of the eggs of Clark's Nutcracker was reported by Skinner (1916). Dixon (1934) says: "Apparently the female does most of the incubation of the eggs, for we noticed in two instances that the sitting bird was fed upon the nest." Available information, though not conclusive, indicates that the female Thick-Billed Nutcracker of Europe does all the incubating while being fed by the male (Vogel 1895).

Twenty and one-quarter hours in two periods were spent observing from the blind at nest 1 in 1947. Beginning at 0800 on April 1, the 14th day of incubation, ten continuous hours were spent in the blind. On April 3, the 15th day of incubation, $10\frac{1}{4}$ continuous hours were spent in the blind, from 0715 to 1730 (see Figure 7 and Table 4).

On both days the female was incubating when the blind was entered (Figure 14). She responded to my presence within six to eight feet of the nest by opening her beak, closing it immediately as I disappeared inside the blind. So far as I could determine, both the female and the male not only completely ignored the blind, but also the occasional noises I could not prevent while shifting position in order to remain alert. When I left the blind at 1800 on April 1, the female again opened her beak, but did not flush from the nest. On the contrary, when I left the blind at 1730 on April 3, the incubating male first opened his beak, as my head protruded from the blind, and then flushed as I emerged completely. These incompletely clocked periods are enclosed in parentheses in Table 4.

As used in this paper, attentive periods represent quantities of time spent on the nest by one or the other or both of the adults, as specified, whether they were incubating, brooding, or otherwise employed. The short periods (totaling less than 10 minutes) when both adults



Female attentive
 Male attentive
 Both inattentive

Temperature in degrees Fahrenheit.
 ♂ ♀ Male or female feedings.

Figure 7. Clark's Nutcracker attentiveness and inattentiveness during the incubation and altricial periods at nest 1 on Mitouer Ridge in April 1947.

were present at the nest simultaneously during feedings are not duplicated in the data presentation. Inattentive periods alternate with attentive periods as specified.

Attentiveness of the sexes together was found to be 99.89% on April 1 and 99.17% on April 3 or 99.53% of the 20½ daylight hours on the two dates. No attempt will be made here to compare results for the two days, because conditions which might have affected the data appeared very similar. Of this total of 99.53% attentiveness (both dates) the female was attentive 79.44% and the male 20.09% of the time. There was less than ½ of 1% complete inattentiveness at nest 1 during the entire 20½ hours.

Disregarding interrupted periods of attentiveness, those in parentheses in Table 4, 14 hours and 23 minutes in daylight attentive periods of both sexes are available for inspection. The female incubated 161, 194, and 272 minutes for an average of 209 minutes. The male incubated 69, 61, 51, and 55 minutes for an average of 59 minutes. Thus it may be seen that the female incubated on the average between three and four times longer than the male during the fourteen hours and twenty-three minutes. More precise statistical treatment is not deemed advisable until more data are available. Which sex incubated at night remains to be determined.

As was seen in the previous section, one or the other of the pair of nest 1 was almost constantly attentive at

the nest. From the time that nest 1 was completed, until the first two eggs had hatched, the adults were not seen together on the nest. Incubation changes were usually made apparently on signal by the off-nest partner as it approached through the Douglas Fir clump. The eggs were left uncovered for from 0.08 to 2.5 minutes during these changes (see Table 4). It took 2.5 minutes to complete one transfer in duties because just as the female left the nest on the usual exchange of calls, the male became involved in a short territorial conflict with a trespassing nutcracker. He then came to the nest, where he remained unusually alert for the next 3.5 minutes, though no more nutcrackers were heard during the five minutes after his arrival.

Five different calls were used by the adults while making nine incubation duty changes. The absent partner in each instance, except possibly one, seemed to provide the change of duty stimulus by approaching the nest tree from a westerly direction through the Douglas Fir clump usually uttering a call. The male, while making five approaches used the regular call twice, the musical call once, and was silent twice, whereas the female while making four approaches uttered the musical call twice, the bullfrog call once, and was silent once. Upon being relieved four times, the male gave the regular call twice, the trumpet call once, and was silent once, while the

female upon being relieved five times uttered the musical call twice, a muffled regular call once, the bullfrog call once, and a weak whining like call once. In each instance the calls were uttered, they were repeated from one to seven times. In one instance the female after four hours and 32 minutes of constant incubation rendered the musical call six times in succession and was answered by the male some distance west of the clump giving the regular call four or five times. She then left the nest and the male appeared thirty seconds later, gave the regular call twice, and immediately settled on the nest.

On three different occasions the female, after having been on the nest for more than two hours (149, 180, and 260 minutes) without relief seemed to call to her mate. In each such instance the male was in the territory and was using his voice. She used the musical call each time (12, 4, and 8 times respectively), but apparently did not get the desired response for she remained on the nest. It may be noted that twice this happened twelve minutes before she was relieved and the other time fourteen minutes before the male assumed incubation duties, after, in each case, another exchange of calls immediately prior to each change.

The obvious cooperation between the sexes in making incubation shift changes as well as the high proportion (99.53%) of total attentiveness combine to indicate a

behavior pattern necessary to prevent chilling or even freezing of the eggs. The incubating bird was not known to leave the nest except upon contact with its mate, or upon my approach within about ten feet of him but the female submitted to capture by hand on one occasion and was frequently touched before she would leave the nest. Neither adult left the nest in defense of territory, though many nutcracker trespassers went unchallenged while the male was incubating or was absent from the nest territory. The male became very alert and would face in the direction of the trespasser's calls, but the female did not even appear to notice them unless her mate was actively engaged in territorial defense using his voice, when she too would become alert.

When the female was flushed from nest 1 she would almost always return to and settle on the nest within one or two minutes. The male, however, did not return to the nest after being flushed while I was yet in the nest vicinity. At nest 2 where the individuals were not distinguishable when flushed, the nest was usually, but not always covered within two minutes after the observer left the nest tree. It would appear that the bird which did most of the incubating, probably the female, was the more "stable" bird of the pair of nest 2. The greater "stability" of the female of nest 1 was clearly indicated.

Approaches to and departures from the nest were usually made over the same route lying west of the nest. Upon leaving the nest they would hop from the rim to a nearby limb, and then make a flying glide from the 12 foot nest level to within three or four feet of the ground at which level they would maintain flight until they were at least thirty feet away from the nest. Approaches were usually made at about six feet above the ground in several short stages with stops in two or more trees within thirty feet of the nest tree. The same convenient branch just below the nest was used for the approach as for departure. On one occasion the male left the east side of the tree upon relief by the female and immediately proceeded to drive off a trespassing nutcracker.

In those behaviorisms generally associated with incubating birds, other than reactions to outside influences (see above), the sexes were much alike. During the 965 minutes that the female was observed incubating, she shifted position (other than to leave the nest) 53 times, or on the average, about once every 18 minutes. Similarly during 244 minutes the male shifted position 14 times, for an average of about once every 17 minutes. These periods of restlessness varied in duration from about five seconds to several minutes and occurred at intervals of from one minute to sixty-two minutes. Restlessness did not appear to be correlated with the amount of time the bird had been incubating.

Several activities accounted, at least in part, for these shifts in position. The most common procedure was to raise up, back slightly toward the edge of the nest, probe down into the nest among and around the eggs, and then settle back moving from side to side facing in the same or a slightly different direction. It was noted that each time the relieving bird arrived at the nest its beak was a glossy black, but after the first probing into the nest it came up dusty gray. It was obvious that each bird actually probed into the lining of the nest. The dusty beaks can be accounted for by the mud pellets found in bowl of the nest during nest construction (page 60). In most of the rest of the cases the adult would preen itself, especially its breast or sides during these position shifts. On a few occasions, a shift in position took place without other noted activities. Outside stimulations; namely, calls of other nutcrackers, flickers, chipmunks, or a Pygmy Owl caused the bird to become more alert, but not shift position. In some cases, in fact, the incubating bird seemed to sink lower into the nest as a result of outside stimulations.

On both mornings that observations were made, the female appeared to sleep, or at least attempt to sleep while incubating. On April 1 from 0815 to 0835 she remained very still with her eye toward me closed for several

periods of from ten to twelve seconds each. During the rest of this twenty minutes this eye was either half closed or blinking at a rate of about thirty times a minute. Between 1012 and 1016 on April 3 she kept her beak tucked in the feathers of her left side, except for two intervals of from five to ten seconds each when strong gusts of wind shook the nest tree violently. During the afternoon of April 3 the female was observed yawning or gaping once on each of two occasions about an hour apart. The male was not observed to fully relax during any of his time on the nest.

During a snow squall at 0730 on April 3 the incubating female was seen to snap at falling snow flakes ten or twelve times. Though snow fell during about three of the 20½ hours, this behavior was not otherwise observed.

Brooding and feeding. Many characteristics of the incubation rhythm and of the incubation behavior pattern of the pair of Clark's Nutcrackers of nest 1 were carried over into the brooding and feeding period. This was especially true of about the first week of this later period. After this first week the attentiveness of the adults began to relax until they were seen at the nest only for feedings and for the removal of fecal sacs.

Observations were made from the blind on April 8, 11, 17, and 24, or the 2nd, 5th, 11th, and 18th days of the

altricial period (see Table 6). Interrupted observations were made on April 15 when motion pictures were taken of the nest, young, and adults. Attentiveness through April 15, the 9th day of brooding was nearly 100%. On April 17, the 11th day of incubation, the female was flushed from the nest after 25 minutes of brooding (0825) to make a check on the young. The blind had on this date been moved such that the aperture was but four feet from the nest. The female did not return to continue brooding but did return twice before 1100 for feedings. The male was present in the territory at least part of the three hours that day, being quite active in defense of his territory, but he did not come to the nest during the time that observations were in progress. Feeling that the blind was perhaps too close to the nest, I moved it back to six feet and discontinued observations for that day. When I returned three hours later to weigh the young, neither adult was on the nest. On the 13th day of the altricial period at 1550, the female was flushed prior to weighing the young. The nest was not visited on the 14th day but beginning with the 15th day neither adult was observed to remain at the nest other than the few minutes required for feeding and nest cleaning. On April 24th, the 18th day, the adults were not at the nest from 0900 to 1600 except at feedings, and then never there simultaneously.

SUMMARY OF ATTENTIVENESS AND INATTENTIVENESS DURING
BROODING AT CLARK'S NUTCRACKER NEST 1

Date	April 8, 1947	April 11, 1947	April 17, 1947	April 24, 1947
Stage of brooding	2nd day	5th day	11th day	18th day
Time of day	0745 - 1545	0659 - 1130	0800 - 1100	0900 - 1600
Total hours and minutes	8 hours	4 hours. 40 min.	3 hours	7 hours
Weather conditions				
Air temperature				
Beginning and end	Thermometer	28 - 39	40 - 52	37 - 40
High and low	accidentally	39 - 28	52 - 40	51 - 37
Hourly average	broken	33	46	42
Wind velocity (est.)	0 to 10 m.p.h.	5 to 10 m.p.h.	0 to 5 m.p.h.	0 to 15 m.p.h.
Approximate % sunshine	75%	5%	50%	30%
Snow on ground at start	0 to 12 in.	$\frac{1}{4}$ to 10 in.	0 to 8 in.	0 to 5 in.
Precipitation (% time)	None	15% snow	None	20% snow & rain
<hr/>				
Attentive periods - both				
Total number	9	5	3	6
Periods in minutes	(21), 25, 43, 37, 158, 25, 90 20, (61)	(3), 87, 58, 121, (11)	(25), 1, 2	1, 1, 1, $\frac{1}{2}$, $\frac{1}{2}$, 1
Percent of total time	99.96%	99.88%	15.56%	1.19%
Inattentive periods - both				
Total number	1	1	3	7
Periods in minutes	0.17	0.33	40, 99, (13)	(35), 139, 22, 65, 9, 81, (64)
Percent of total time	0.04%	0.12%	84.44%	98.81%
Attentive periods - female				
Total number	5	2	3	4
Periods in minutes	(21), 43, 158 90, (61)	87, 121	(25), 1, 2	1, 1, $\frac{1}{2}$, 1
Percent of total time	77.67%	74.17%	15.56%	0.83%
Attentive periods - male				
Total number	4	3	None	2
Periods in minutes	25, 37, 25, 20	(3), 58, (11)	None	1, $\frac{1}{2}$
Percent of total time	22.29%	25.71%	None	0.36%

Periods in parentheses () not completely clocked due to arrival or departure of observer.

Whether the young are covered at night after day time brooding has ceased, remains to be determined.

At nest 2, where twelve weighing visits were made in the 19 days of the known altricial period, one or the other of the adults was flushed from the nest through the 9th day. From the 10th day onward, however, neither adult was present on the nest when I arrived to make weighings.

For a comparison of attentiveness on the part of the two sexes of nest 1 while brooding was active the data for the twelve hours and forty minutes of the 2nd and 5th days will be lumped together and examined. Though weather conditions could not be classed as comparable on the two dates, the brooding rhythms were very similar. The male and female were each present for five completely clocked attentive periods totaling 664 minutes in all. Of the total, the female was attentive 499 minutes or 75.15% of the time, whereas the male was present 165 minutes for 24.85% of the block of ten completely clocked periods. Overlap time occurring when both of the pair were present at the nest simultaneously during feedings has been assigned to the bird remaining to brood after each feeding. (Figures 23-28).

Dixon (1934) reported concerning Clark's Nutcracker that "Insofar as we observed, the duties of brooding and feeding the young were equally borne by the two parents.

From casual observation we could not tell which was the male and which the female of the pair. Actual time records taken on the afternoon of the 9th of April, which was a warm sunshiny afternoon, revealed a change of brooding and feeding duties every thirty minutes on the average." Similarly Steinfatt (1944), though he too was unable to distinguish between the sexes of a pair of Thick-Billed Nuthackers (of Europe), gained the impression from their entire behavior pattern that both adult nuthackers did about equal parts in the collection of food for the young.

Though, as was seen above, the female of nest 1 brooded about three times as much as the male, data taken on feedings of the young of nest 1, where the adults were distinguishable, compare fairly well with the findings of both Dixon and Steinfatt.

During 22 hours and 40 minutes of altricial period observation, 21 feedings occurred for an average of about one every 65 minutes. The shortest interval between feedings was ten minutes, and the longest 140 minutes. Examination of Figure 7 discloses that each member of the pair was probably on a separate feeding schedule, and that these two schedules were probably not coordinated. Eight intervals between feedings by the female were 80, 88, 92, 100, 110, 140, 145, and 183 minutes for an average of about 117 minutes between feedings. Six intervals between feedings by the male were 50, 54, 75, 123, 179, and

205 minutes for an average of about 114 minutes between feedings. Though the averages are very close it is seen by inspection that the male's schedule was more erratic than the female's. The comparatively wide range of the interval lengths in the male's feeding schedule may be accounted for in part by his vigorous defense of territory without much, if any, aid from the female.

Steinfatt (1944) estimated, on the basis of observations on two successive and climatically similar days at a Thick-Billed Nuthacker nest in Europe, that 16 daily feedings occurred on each day. He found while observing from 1100 to 1930 on April 14 that the last feeding occurred at about 1737 (on April 19 at 1728). On the morning of April 15 he found the first feeding to be at 0525 while observing from 0500 to 1200. Steinfatt thus found an average feeding interval of about three quarters of an hour with the actual intervals between feedings varying from 17 minutes to 110 minutes.

Of 21 feedings observed at nest 1, twelve were made by the female and nine by the male. A typical feeding on either of April 8 or 11 was signaled by the off-nest bird using the musical call as it approached the nest tree by the usual route. The brooding bird would move to one edge of the nest striking a begging attitude with wings fluttering immediately after the just arrived bird reached another edge. (No definite pattern of moving to

consistent edges of the nest was established.) The begging bird would be ignored while the young in turn would be fed by the just arrived bird who would insert his beak well into their open mouths two or three times each. The feeding bird's throat would be quivering as it reached the nest and feedings were made by regurgitating the well lubricated partially broken up Ponderosa Pine seeds directly down into the throats of the young. The non-feeding bird would watch with apparent interest uttering a soft musical squalling call. When the feeding was finished the pair would together inspect the nest, while they constantly squalled quietly using a conversation-like musical call. One or both would then pick up surplus and spilled food and freshly voided fecal sacs, all of which would be promptly swallowed, usually by the bird remaining to brood. One of the adults would then hop to the usual convenient limb near the nest and leave while the other would settle over the young with its breast feathers well fluffed out. The procedure was much the same whichever bird arrived with food.

At 0951 on April 8 the female fed the young and relieved the brooding male. At 1009 the male arrived and proceeded to feed the young apparently ignoring the begging female. As he was feeding the young, she began working her throat muscles and also fed one of the young by regurgitation. This retaining of food in the crop while

incubating was also clearly demonstrated by the male shortly after he relieved the female at 1229 on April 1, but did not feed the young. At 1249 he backed to the edge of the nest, regurgitated a quantity of partially broken up well lubricated Ponderosa Pine seeds on the edge of the nest, and then re-ate the same seeds before he settled back onto the nest. When the female arrived and proceeded to feed the young five minutes later, the male also fed them.

At 0653 on April 11, the male was brooding on nest 1, when the female arrived to feed the young. He at first remained brooding, begging from his position while covering the young. When the female did not respond by feeding him he moved to the edge of the nest. On this particular occasion the male left while the female was still feeding the young.

Each of the six times the female arrived at nest 1 during the observations of April 8 and 11, she fed the young and relieved the brooding male. During this time the male made nine trips to the nest. On four trips he fed the young and relieved the brooding female, on three trips he fed the young but did not relieve the female, and on two trips he relieved the female without feeding the young.

After brooding ceased, the feedings by the adults separately followed basically the same procedure, except

that the excitement apparently provoked by the presence of both birds at the nest simultaneously, was absent. Actions on the part of the adults were much more deliberate and consumed less time. The larger fecal sacs, characteristic of this later period, were usually carried away.

During the first few days, apparently, being uncovered by the brooding adult was sufficient stimulus to cause the young of nest 1 to open their mouths wide with their long wavering necks extended to their full extent. Almost any loud noise, shock, or sudden movement appeared to be sufficient stimulus to cause the young to start calling for food. On April 24, their 18th day, at 1323 the two young remained crouched low in the nest when the female arrived on the edge of the nest. On this occasion the female remained perched a few seconds and then gave the musical call, which brought the heads of the young immediately up for feeding. Dixon (1934) states concerning Clark's Nutcracker: "The young birds conduct themselves in the normal crow manner, by trying to swallow anything thrust at them". These attempts at promiscuous swallowing were easily demonstrated on the young of both nests 1 and 2.

Fecal sacs were usually voided immediately after each feeding, when the adults would promptly pick them up and either swallow them or carry them away. Steinfatt (1944)

suggests that there must be a connection between the bill-papilla or some spot in the throat with the voiding of fecal sacs, because of the regularity he observed with which fecal droppings followed feedings in the case of a captive nestling Thick-Billed Nutcracker (of Europe). At nest 1, the female was seen to remove fecal sacs nine times (15 sacs), while the male was observed to make six such removals (10 sacs).

On April 17, the 11th day of the altricial period, one of the three young was obviously dying at 0825 and dead at 1100 in nest 1. The dead nestling was trampled by the other two nestlings into the loose grass on the floor of the nest. It had not been removed by the adults by 1400 at which time I removed the bird and preserved it. In nest 2, a nestling which ceased to gain weight in its 9th day, which was still present but losing weight in its 13th day, had disappeared from the nest on its 15th day and could not be found.

The pair of European nutcrackers observed by Steinfatt (1944) in April of 1944, obtained some of their food for feeding their young on the borders of their nesting territory some 50 to 80 meters from the nest. The bulk, however, he found was obtained from open timber stands and clearings beyond the nesting territorial limits.

Dixon (1934) found Clark's Nutcrackers feeding young in the nests in April near June Lake in Mono County, California. He was able to determine that one pair obtained a large share of the food for their young from the "half frozen meadow land on the floor of the valley some 400 feet lower in elevation and at least one-half mile distant in an air line" from their nest. He also observed with binoculars that some nutcrackers flew more than one and one-half miles from suitable feeding grounds in the meadows to their nest locations. Food gathered consisted apparently almost entirely of animal matter. During this period he "did not see the birds working the trees for pine nuts at any time."

Though the actual feeding area or areas utilized by the pair of nutcrackers of nest 1 were not determined, it was apparent that little or no foraging was done within the nesting territory. The male was conspicuously absent from his territory usually about one-half of the daylight hours. Food fed to the young of nest 1 consisted almost entirely of Ponderosa Pine seeds, though some insect material was included in the feedings on April 24. The Ponderosa Pines in the immediate vicinity of the territory surrounding nest 1 did not hold a substantial seed crop, but areas supporting fairly good seed crops were known at a distance of about one-half mile in the direction that the birds flew to feed.

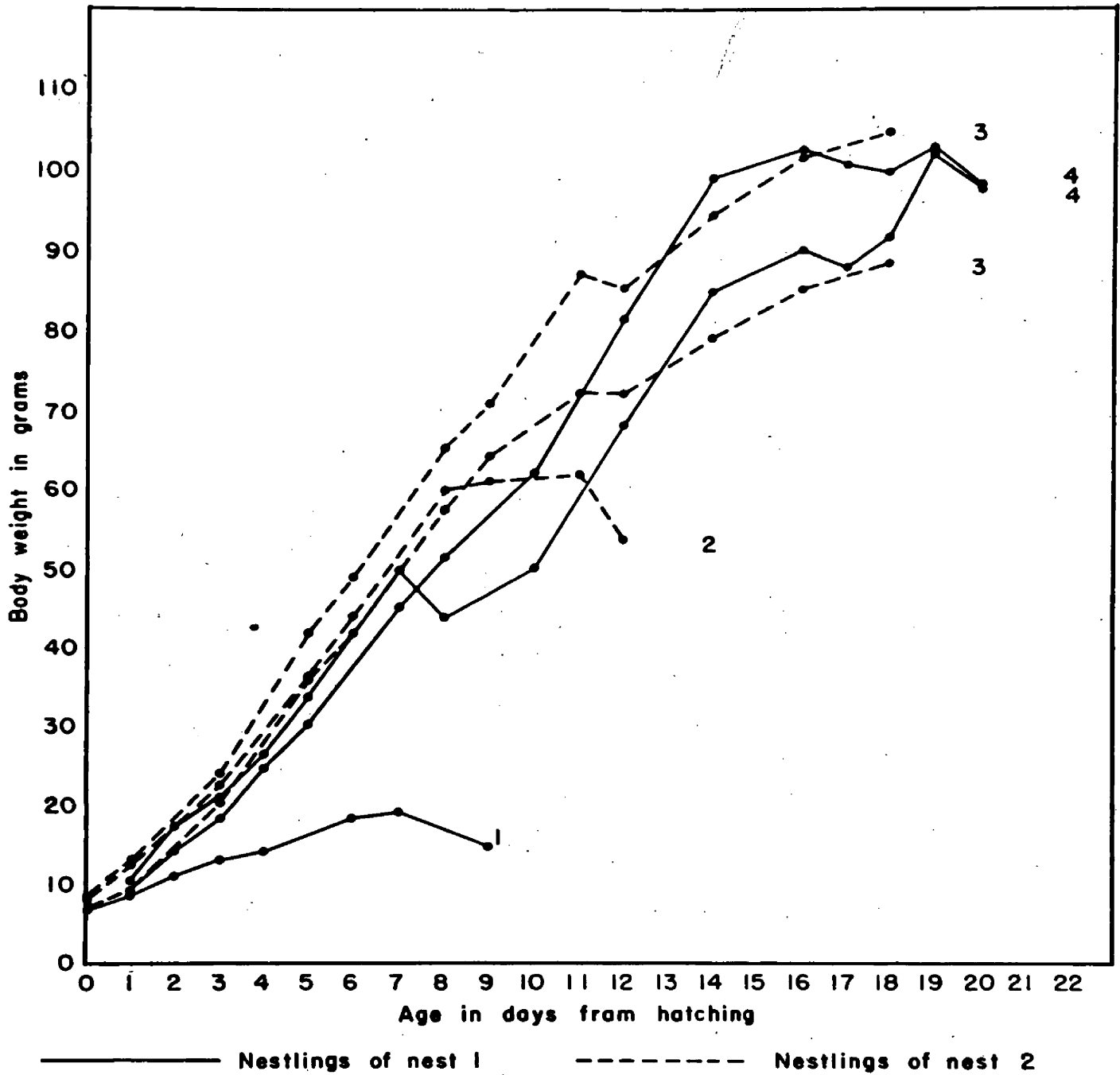
Development of the young. Weights of six young, three in each of nests 1 and 2 were taken at least every other day during their tenure in the nest. A laboratory balance accurate to one-tenth of a gram was employed. The young were weighed in a cotton filled paper carton which was reweighed each day to make allowance for variable moisture content. Fecal sacs, when detectable, were eliminated before weighing. Most weighings were made between 1700 and 1900. The down of each nestling of nest 1 was marked with ink in the order of hatching to keep them separate until U. S. Fish and Wildlife Service aluminum and colored bands could be attached. Because the three young of nest 2 hatched on the same day during hours when I was not present, I arbitrarily marked the young at the end of that day for individual identification until banding was possible. The young were able to hold number 4 bands when they weighed about 60 grams, or at about 8 to 10 days of age.

Of the six young, four were weighed on their day of hatching. Their weights were 7.1, 7.5, 8.0, and 8.2 grams each. The first mentioned (7.1 grams) was knowingly weighed before its initial feeding after 18 days incubation. The two weighing 7.1 and 8.0 grams did not survive to leave the nest. The four surviving young gained an average of about 87.5 grams during their first 16 days in the nest to weigh on the average 95.3 grams each. It

may thus be seen that they gained an average of about 5.5 grams per day for the first 16 days. After the 16th day no substantial gains in weight were made before leaving the nest. Figure 8 shows the weight record of each of the six young.

One young from each nest failed to survive the nestling period. The third to hatch in nest 1 failed to make significant weight gains from the first day onward. It weighed 14.5 grams at death when nine days of age and when its nest mates showed weights of 50.2 and 62.3 grams. The immediate cause of death was probably starvation, for when the adults arrived for feeding, the two larger nestlings almost always crowded the smallest to the side where it seldom received food. On the day of its death, the larger nestlings, in their struggles begging for food, literally sat on the smallest. The nestling of nest 2 which failed to survive stopped making significant weight gains on its 9th day and disappeared from nest 2 when 13 or 14 days of age. No apparent cause for this latter fatality was determined and it could not be found in the vicinity of the nest.

Bendire (1895) says that the young nutcrackers remain in the nest about 18 days, whereas, Bradbury (1917) gives about three weeks and Skinner (1916) implies a four week altricial period. Steinfatt (1944) estimated that two nestling European nutcrackers (Nucifraga c. caryocatactes)



- 1 Died in nest 1 at 9 days of age.
- 2 Gone from nest 2 on its 14th day after hatching.
- 3 Gone from nest 2 on their 20th day after hatching.
- 4 Gone from nest 1 on their 22nd day after hatching.

Figure 8. Weight increases of nestlings Clark's Nutcrackers in nests 1 and 2 on Mitouer Ridge in April and May of 1947.

he had under observation from about their tenth day onward, left their nest in the forenoon of their 23rd day.

The two young Clark's Nutcrackers of nest 1 were gone from their nest at 0730 on April 29 and were not again seen. They had been last observed and weighed at 1930 on April 27 when 20 days old. On April 26 one of the two young left the nest after weighing, but remained after being placed in the nest a second time. It is probable that they left the nest on April 28 when they were 21 days of age. The banded adult female of nest 1 was collected for sexing about 100 yards from nest 1 on April 29.

The two nestlings of nest 2 were last observed in their nest at 1600 on May 15 when they were 18 days old. They were gone from their nest on May 17, and were not again observed. Because there was no indication of predation, it is felt probable that they left their nest on either May 16 or 17, when they were either 19 or 20 days of age.

The newly hatched nutcrackers have a sparse to liberal covering of white down on their principal feather tracts. They appeared otherwise quite typical of the newly hatched young of other passerine species. On their first day they responded to sound and touch by raising their heads and opening their mouths wide. When four

days old dark pigmentation was first apparent in their capital, spinal, caudal, and alar tracts. At five days of age the eye openings were noticed as short narrow slits between the eye-lids, especially when the nestlings struck a begging attitude. At about eight days, the young first squealed in apparent protest at being handled for weighing. By the time they were eleven days old their eyes were well open, the gray iris being very evident. At 16 days of age the young first struck defensive attitudes, and squalled loudly when handled. At about 18 days, when the feathers are developed sufficiently to cover all aptera, the nestlings make attempts to escape when being approached or handled. Although unable to fly, they at this age fan their wings violently at times while in the nest and spread them when falling. When leaving the nest the four non-sexed surviving nutcrackers weighed between about 65% and about 80% of average adult weights depending upon the sex of adults (adult females about 123 grams and adult males about 137 grams).

SUMMARY

A study of Clark's Nutcracker (Nucifraga columbiana WILSON) from October 1946 through April 1948, provided the basic material for this thesis. The study areas, restricted for the most part to central western Montana, fall well within the normal range of this species. More than 900 hours were spent in active field observation while traveling in excess of 1,000 trail miles on foot (exclusive of road hours and miles). Running notes, correlated with time, elevation, and linear distance, were taken on all field trips. More than 230 specimens were collected in every month of the study. Certain data from these specimens were used in this thesis.

Although nutcrackers were found most abundantly between 4,000 and 5,000 feet, they were observed from below 3,000 feet to over 9,000 feet. Most nutcrackers left the study areas during the summer of 1947, leaving a residual population of only adult birds. Large flocks of yearlings present during the winter of 1946-47, were not found during the winter of 1947-48.

Ten types of nutcracker calls are described, six of which may be classified as variations of the regular, or most commonly uttered call. Nutcrackers were more frequently heard than seen. Most contacts with the species were a direct result of first hearing nutcrackers and then seeing them.

Courtship was observed from February to April. Both sexes participate. One of the adults, probably the male, characteristically carries a stick in its beak during certain parts of courtship.

Clark's Nutcrackers defend definite territories around their nests. The territory around nest 1 was about 2.1 acres in extent. Courtship, the gathering of nest material, and foraging for food were not restricted to the nest territory. Although both females and males were known to take part in intraspecific territorial defense, at nest 1, only the male was observed to actively drive off trespassing nutcrackers. Certain mammals and species of birds other than nutcrackers were tolerated in the nest area. Territories were defended from at least the nest-building period until the young left the nest.

Four occupied nests were found in March and April of 1947. Two of these were under observation from nest-building to nest-leaving. Still and motion pictures document the nesting study. Construction of nests began in February, March, and April. The nests under observation in 1947 were from 4,200 to 4,700 feet in elevation above sea level. Both adults shared the burden of gathering nest material but the female did most of the actual nest construction. Building activity was greatest in the morning. During periods of active construction,

each adult made trips to the nest with material about once every three or four minutes, when such material was being collected less than 150 yards from the nest site (2 nests -- 160 minutes). At least some of the material for another nest was collected more than 600 yards from the nest tree. Nest construction consumed from five to eight days on each of three nests. Nests found, occurred in a variety of locations in Ponderosa Pines and Douglas Firs, either next to the main trunk of the tree or on a lateral branch. Height above the ground varied from six to eighty feet. Douglas Fir twigs, wood pulp, bark fibers, and grass were the principal materials employed. Mineral soil was deposited in the floor of nests in varying amounts.

An instance of incomplete nest building behavior pattern was observed, where the female was apparently unable to place the twigs of the nest platform so that they would remain in position. A pile of more than 2,500 twigs accumulated below this attempted nest.

Incubation began with the deposition of the first of three eggs deposited in each two Clark's Nutcracker nests. Periods of incubation varied from 18 to 20 days (6 eggs -- 3 in each of two nests). Later eggs laid in each clutch had shorter periods of incubation than earlier eggs deposited in the same clutch.

Total attentiveness during $20\frac{1}{4}$ daylight hours of observation on the 14th and 16th days of incubation was about 99.5%. Of this time the female was attentive nearly four times as long as the male. Completely clocked periods of attentiveness for the female averaged 209 minutes (3 periods), and for the male averaged 59 minutes (4 periods). Incubation duty changes were made upon an exchange of calls between the adults. Neither bird was known to leave the nest except upon signal for exchange of duties between the adults or when flushed by man. Both adults recognized calls uttered by their mates.

Brooding attentiveness during the first nine days of the altricial period was nearly 100%. After the 9th day, brooding probably did not occur during daylight hours. Exchanges of brooding duties were accomplished when both adults were simultaneously present on the rim of the nest. During twelve hours and forty minutes of observation on the 2nd and 5th days of brooding the female was attentive about 75% of the time with an average of 100 minutes per period (5 periods). The male, attentive about 25% of the time averaged 33 minutes per attentive period (5 periods).

Twenty-one feedings occurred during 22 hours and 40 minutes of observation during the altricial period. Intervals between feedings averaged 65 minutes with

extreme intervals varying from 10 to 140 minutes. The female's feeding rhythm was more constant than that of the male. Fecal sacs were removed by both adults immediately after feeding the young.

Four young averaged 8.0 grams on their day of hatching. Four young averaged about 97 grams when they left the nest. Four surviving young apparently left the nest between their 19th and 22nd days after hatching.

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Figure 9

Vicinity of nest 1 on March 11, 1947. Arrow indicates the position of the nest tree.

Figure 10

Valley of the Clark's Fork River from the site of nest 1 on Mitouer Ridge. Photograph was taken on March 11, 1947, from 4,600 feet. The valley floor is about 3,250 feet in elevation.

Figure 11

Vicinity of nest 1 on Mitouer Ridge. Photograph was taken on March 11, 1947.

Figure 12

South facing slope of Mitouer Ridge in late March from about 4,150 to about 4,750 feet. Sites of nests 1, 2, and 3 are indicated by arrows.

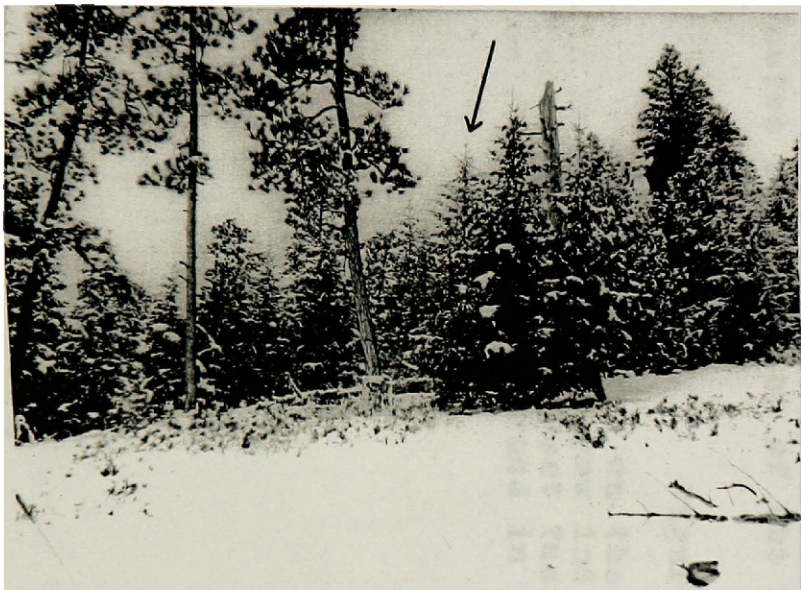


Figure 9



Figure 10



Figure 11



Figure 12

Figure 13

The Douglas Fir holding nest 1 taken on March 11, 1947.

Figure 14

The blind at nest 1 on Mitouer Ridge in May of 1947. The position of the nest is indicated by an arrow.

Figure 15

Site of nest 3 on Mitouer Ridge. Arrow indicates the position of the nest.

Figure 16

Site of nest 2 on the slope below Mitouer Ridge in May of 1947. Arrow indicates the position of the nest. Notice the west facing slope across Mitouer Gulch which was burned in the 1910 fire.



Figure 13



Figure 14

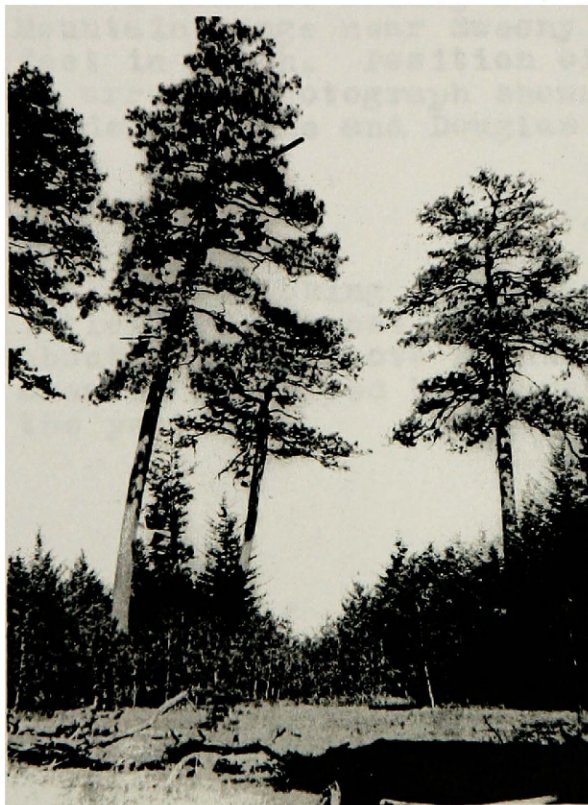


Figure 15

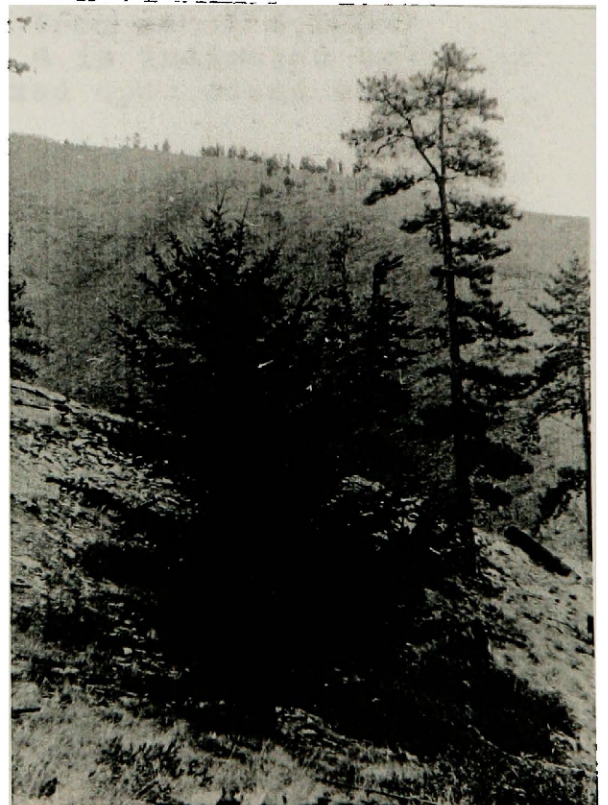


Figure 16

Figure 17

Position (indicated by arrow) where pair of Clark's Nutcrackers made an unsuccessful attempt to construct a nest in March of 1947.

Figure 18

Pile of Douglas Fir twigs numbering more than 2,500 that accumulated below the branch pictured in Figure 17.

Figure 19

Southeast facing lower slope of the Bitterroot Mountain Range near Sweeny Creek from about 4,300 feet in March. Position of nest 4 is indicated by an arrow. Photograph shows a mixed open stand of Ponderosa Pine and Douglas Fir.

Figure 20

View looking toward the north up the Rattlesnake Valley from a west facing slope (at about 4,700 feet) about 3 miles above Franklyn Station in April. This area is inhabited by Clark's Nutcrackers throughout the year.



Figure 17



Figure 18



Figure 19



Figure 20

Figure 21

Incubating Clark's Nutcracker on nest 2 on the slope below Mitoner Ridge in April of 1947.

Figure 22

Female Clark's Nutcracker incubation on nest 1.

Figure 23

Female Clark's Nutcracker brooding 3 young in nest 1. Note that the branch over the nest was removed to take motion pictures.

Figure 24

Three nestling Clark's Nutcrackers in nest 1 on April 11, 1947.



Figure 21



Figure 22



Figure 23



Figure 24

Figure 25

Adult Clark's Nutcrackers at nest 1 on April 11, 1947, the fifth day of the brooding-feeding period. Bird on the left is feeding the nestlings.

Figure 26

Adult Clark's Nutcrackers at nest 1 on April 11, 1947, the fifth day of the brooding-feeding period.

Figure 27

Adult Clark's Nutcrackers inspecting nest 1 on April 11, 1947.

Figure 28

Adult Clark's Nutcrackers touching beaks at nest 1 on April 8, 1947.

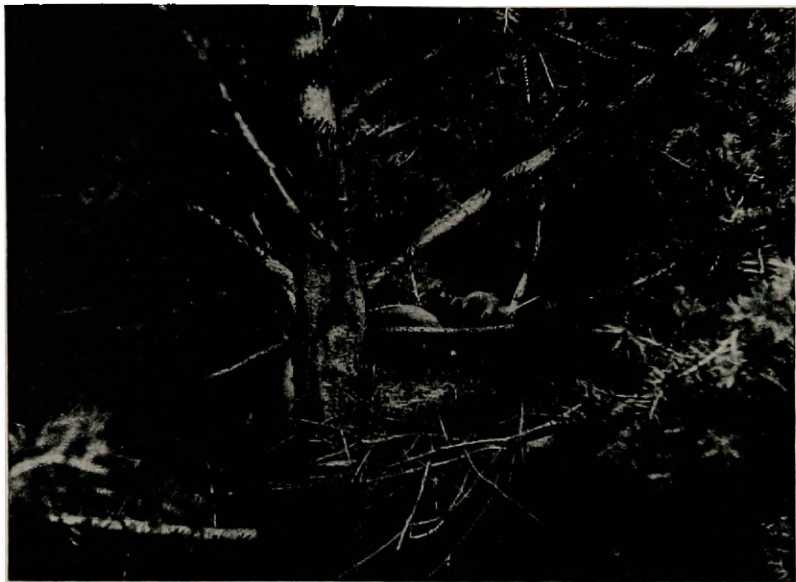


Figure 25



Figure 26



Figure 27

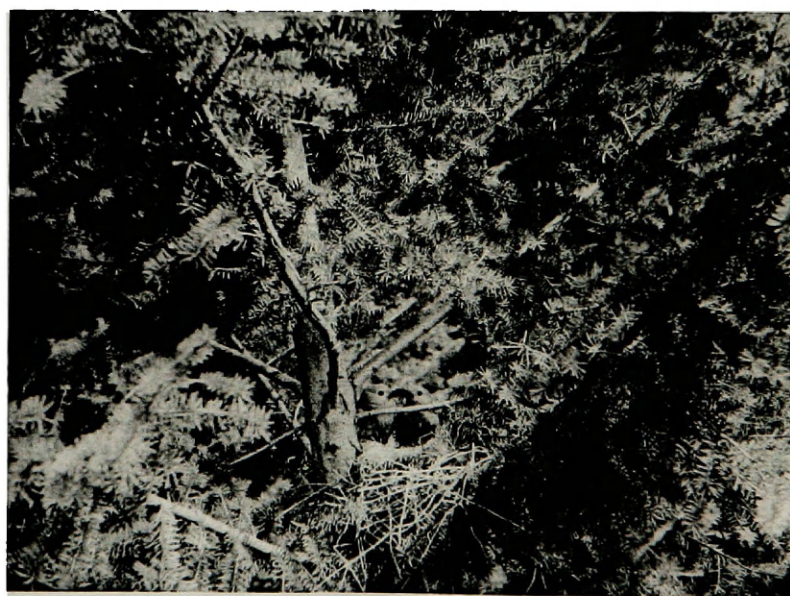


Figure 28