AN ABSTRACT OF THE THESIS OF

LEONARD HAROLD SISSON for the MASTER OF SCIENCE
(Name) (Degree)

in WILDLIFE SCIENCE presented on July 20, 1967
(Major) (Date)

Title: CALLING BEHAVIOR OF BAND-TAILED PIGEONS IN REFERENCE TO A CENSUS TECHNIQUE

Abstract Approved: Signature redacted for privacy.
Howard M. Wight

Calling of captive and free-living band-tailed pigeons (*Columba fasciata*, Say) was studied between June, 1965, and June, 1967, in western Oregon.[1] Vocalizations of captive band-tails were observed during mornings and afternoons in 1965 and 1966; calling of free-living band-tails was observed in mornings during call-counts and point observations in 1966. Data were collected on types of vocalizations, effects of certain physical and biological factors on calling, and variation in band-tailed pigeon call-counts. The perch-call normally uttered by adult male band-tails was the only vocalization heard which was considered sufficiently audible for use in an audio-census. Captive and free-living band-tails called most frequently from approximately 1/2 hour before sunrise to 1 1/2 hours after sunrise

[1] This study was supported by the Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, and the Oregon Agricultural Experiment Station, Corvallis.

in mornings. In afternoons, captive pigeons called most frequently from 3 1/2 to 1 1/2 hours before sunset. Calling of captive pigeons lacked a definite seasonal trend. Free-living band-tails heard during call-counts began calling between May 18 and June 10, and continued calling until mid-August. There were no significant linear correlations at the 95 percent level between each of several weather factors and calling of captive band-tails or numbers of pigeons heard during call-counts. Calling of captive male band-tails in different stages of the reproductive cycle was observed. Unmated males called at least eight times more frequently than mated males in mornings ($P < 0.01$), and significantly more frequently than mated males in afternoons ($P < 0.01$). The probability of hearing an unmated captive male pigeon call during a 3-minute interval was at least seven times that of hearing a mated male in mornings ($P < 0.01$). The probability of hearing an unmated male was significantly higher than that of hearing a mated male in afternoons ($P < 0.02$). Although no quantitative data were collected on audibility of the perch-call, the maximum audible range of the call was estimated to be 1/4 mile. Numbers of band-tails heard, calls heard, and pigeons seen during 31 call-counts on seven routes in western Oregon in 1966 were subjected to analysis of variance. Estimates of variance between routes were higher than estimates of variance among counts within routes. Based on these data, the sample arrangement resulting in least variance or highest precision for a fixed total number of counts was one count per route. Numbers of band-tails seen varied more than numbers of pigeons heard or numbers of calls heard. It was estimated that numbers of band-tails heard or numbers of calls heard during one call-count on each of 40 routes annually would allow detection at the 95 percent level of approximately a 25 percent change in numbers of pigeons present. A recommended procedure for conducting band-tailed pigeon call-counts was outlined.

Calling Behavior of Band-tailed Pigeons in Reference to a Census Technique

by

Leonard Harold Sisson

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

June 1968

ACKNOWLEDGMENTS

I wish to express my appreciation to Mr. H. M. Wight, Associate Professor of Wildlife Ecology, Oregon State University, who served as my major advisor and who contributed materially to the completion of this research. Dr. B. J. Verts, Assistant Professor of Wildlife Ecology, and Dr. J. A. Wiens, Assistant Professor of Zoology, Oregon State University, served as members of my committee.

Mr. C. H. Lostetter, Assistant Regional Supervisor, Bureau of Sport Fisheries and Wildlife, and Mr. R. U. Mace, Chief, Upland Game, and other biologists of the Oregon State Game Commission assisted in collection of data. Mr. J. A. Chapman, Oregon State University, aided in conducting censuses. Mr. R. M. Black, Associate Professor of Meteorology, Oregon State University, made records of the Oregon State University Weather Station available for use in this study. Dr. W. S. Overton, Professor, Department of Statistics, Oregon State University, provided statistical advice. Mr. E. D. Silovsky, Oregon State University, made helpful suggestions concerning interpretation of data.

I am sincerely grateful for the assistance, encouragement, and patience of my wife, Edith, during this study.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CALLING BEHAVIOR OF BAND-TAILED PIGEONS IN REFERENCE TO A CENSUS TECHNIQUE

INTRODUCTION

The band-tailed pigeon (Columba fasciata, Say) is a migratory game bird belonging to the Family Columbidae. Band-tails of the Pacific Coast winter in southern California, and nest from southern California to British Columbia during spring and summer. Band-tails have a low reproductive potential; the normal clutch is one egg (Bent 1932, Morse 1949, and Glover 1953). Although the average number of broods produced by a pair of band-tails annually in Oregon has not been determined, an average yearly production of one successful brood per pair is probable (Wight, Mace, and Batterson 1967). Band-tails are subjected to hunting in California, Oregon, Washington, and British Columbia during fall and winter. The annual harvest, as determined by mail questionnaires, was approximately one-half million in 1965 and 1966 demonstrating the importance of this species as a game bird. The low productivity of the band-tail, and the increasing importance of this species as a game bird suggest the need for careful management of band-tail populations.

Effective management of an animal population is based on knowledge of its size and its composition (Quick 1963). The band-tailed pigeon is managed presently without methods of estimating its abundance, or detecting changes in its abundance. Since 1950, the Oregon State Game Commission has attempted to determine trends in population size of band-tails by direct counts of concentrations of birds at mineral springs in Oregon during late summer each year (Morse 1950). These counts are limited to relatively few areas having natural mineral springs. In addition, the capability of these counts to measure changes in abundance of pigeons has not been determined.

Call-counts have been used as indices to abundance of several species of game birds including the mourning dove, Zenaidura macroura (McClure 1939); the ring-necked pheasant, Phasianus colchicus (Kimball 1949); the bobwhite quail, Colinus virginianus (Rosene 1957); the Gambel quail, Lophortyx gambeli (Smith and Gallizioli 1965); the blue grouse, Dendragapus obscurus (Rogers 1963); and the chukar partridge, Alectoris graeca (Williams 1961). Counts of drumming male ruffed grouse, Bonasa umbellus (Petraborg, Wellein, and Gunvalson 1953), and peenting male woodcocks, Philohela minor (Pitelka 1943) have also been used as indices to abundance.

Establishment of coo-counts as an index to abundance of mourning doves, a species closely related to the band-tail, has required extensive research to determine variation, and factors affecting variation of these counts. McClure (1939) measured effects of time of day, time of year, and weather on cooing of free-living male doves. He was the first to describe the use of coo-counts for censusing breeding populations of mourning doves. Further investigations by the U. S. Fish and Wildlife Service (1952), McGowan (1953), Lowe (1956), and Foote, Peters, and Finkner (1958) resulted in establishing dove coo-counts for estimating trends in population size on a nationwide basis. Frankel and Baskett (1961) conducted an intensive study of effects of breeding and weather on cooing of captive male mourning doves. Jackson and Baskett (1964) and Mackey (1965) conducted similar studies on marked free-living doves.

Calling of male band-tailed pigeons heard during the breeding season suggested the possible use of call-counts for censusing pigeons. Although several authors (Wales 1926, Bent 1932, Neff 1947, Glover 1953, Peeters 1962, and Houston 1963) reported on vocalizations of band-tails, adequate quantitative information was not available for determining the value of call-counts for censusing pigeons.

This is a report on calling behavior of captive and free-living band-tailed pigeons observed during 1965 and 1966 in western Oregon. The objectives of this research were to describe vocalizations of band-tails, to determine effects of certain physical and biological factors on calling of band-tails, and to determine the value of call-counts as a technique for censusing populations of band-tails during the breeding season.

METHODS

Observation of Captive Band-tailed Pigeons

Calling behavior of captive band-tailed pigeons was observed during the summer of 1965, and the winter, spring, and summer of 1966. Pigeons observed were held in pens approximately five miles west of Corvallis, Oregon, near the Pacific Cooperative Water Pollution and Fisheries Research Laboratories. Six pens (each 8 feet long, 6 feet high, and 6 feet wide) and an observation blind were located in a 100 foot by 100 foot enclosure bounded by an electrified woven-wire fence. The pens were numbered I through VI. Pens I, II, III, V, and VI contained pigeons under observation, while pen IV was used to hold additional band-tails. The pigeons were provided with commercial pigeon feed, calcium grit, and water, *ad libitum*. An artificial nest cone made from 1/4-inch mesh wire screen was placed in each of pens I, II, V, and VI. The nest cones were approximately 12 inches in diameter and 3 inches deep.

Captive band-tails observed included five adult males and five adult females caught in live traps at Humboldt State College at Arcata, California. Two adult males and two adult females caught by use of a cannon net near Oregon State University at Corvallis, Oregon, and three pen-reared squabs were also observed. The captive pigeons were placed in the pens in May, 1965. Male pigeons observed were designated by numbers 1 through 7; females observed were designated by letters A through G. Numbers and letters assigned to males and females present in each of the pens during observations are presented in Appendix Tables A.1 and A.2. An effort was made to observe calling of mated as well as unmated male pigeons. Because only two captive pigeons (male 1 and female A) formed a pair bond in 1965, different combinations of males and females were placed in observation pens in 1966 in an attempt to induce reproduction.

Preliminary observations in June, 1965, indicated that calling by captive male band-tails was most intensive in early morning and late afternoon hours. Subsequent observations were limited to specific morning and afternoon periods. In 1965 observations were made from 1/2 hour before sunrise to 4 1/2 hours after sunrise, and from 5 hours before sunset to sunset. Because the lengths of these observation periods were excessive, observations in 1966 were made from 1/2 hour before sunrise to 3 hours after sunrise, and from 4 1/2 to 1 1/2 hours before sunset. Captive pigeons were observed on 22 mornings and ten afternoons between June 11 and August 15 in 1965. In 1966 observations were made on 36 mornings and 15 afternoons between January 13 and August 16.

Each vocalization heard during observations of captive band-tails was classified according to type. Because the terms "coo" and "coo-call" have been used extensively to refer to one of the vocalizations of the mourning dove, the term "perch-call" will be used to refer to the "coo" of the band-tailed pigeon in this report. The terms "call" and "calling," used in reference to band-tailed pigeons, will refer only to the perch-call unless otherwise specified. Detailed records were kept only on perch-calls normally uttered by adult males. Numbers of calls were recorded for each pigeon for 1-minute intervals. Records were also kept on the breeding status of each captive pigeon. The following stages of matedness were recognized: (1) unmated, (2) mated: copulation and nest building, (3) mated: incubation, and (4) mated: brooding.

Ambient temperature was recorded at approximately 1-hour intervals during observations. Cloud cover was estimated as 0, 25, 50, 75, or 100 percent. Precipitation was recorded as absent, light, or heavy. Wind velocity, relative humidity, and barometric pressure, recorded approximately 7 miles east of the pens at the Oregon State University Weather Station, were used as an indication of these characteristics of weather at the pens.

Band-tailed Pigeon Call-counts

Band-tail call-counts were made on sections of roads in nine western Oregon counties during the spring and summer of 1966. These counts were made through cooperation of personnel of the

Department of Fisheries and Wildlife at Oregon State University, the Oregon State Game Commission, and the United States Fish and Wildlife Service. Oregon State Game Commission biologists conducted 21 counts on ten different routes during June, 1966. Members of the Department of Fisheries and Wildlife at Oregon State University conducted 27 call-counts on three different routes between April 27 and August 13 in 1966. Locations of routes and numbers of counts conducted on each route are presented in Appendix Table A. 3. These routes were established in areas thought to be inhabited by breeding band-tails. Each route consisted of 20 listening points or "stops" on a section of road 10 or 20 miles long, with exception of the MacDonald Forest route which consisted of ten stops on a section of road 5 miles long. Stops were spaced approximately 1 mile apart on routes 20 miles long, and 1/2 mile apart on routes 5 or 10 miles long. On the MacDonald Forest route a count was made by listening at each of the ten stops while proceeding in one direction, then listening at the same stops again in reverse order. Although it was not possible to establish all routes of the same length, all counts consisted of 20 3-minute observations each.

Although observers were instructed to start counts at local official sunrise, actual starting times varied between 1/2 hour before and 1/2 hour after sunrise. Numbers of band-tails heard calling, numbers of calls heard, and numbers of pigeons seen during a

3-minute interval at each listening point on a route were recorded. Numbers of pigeons seen while driving between stops were also recorded.

Ambient temperature, an estimate of wind velocity, and an estimate of percent cloud cover were recorded at the first and last stops on each count. Wind velocity, relative humidity, and barometric pressure, recorded approximately 7 miles east of the MacDonald Forest route at the Oregon State University weather station, were used as an indication of these characteristics of weather during counts on that route. Observers were instructed not to conduct counts in heavy rain or fog, or when wind exceeded Beaufort 3 (8 to 12 miles per hour).

Point Observations

Calling of free-living band-tails was observed at a fixed point on the MacDonald Forest census route during six mornings between July 15 and August 2 in 1966. Numbers of calls heard were recorded for 1-minute intervals from 1/2 hour before sunrise until at least 2 hours after sunrise. The observer was usually unable to see band-tails heard at this station. Because individual pigeons often called from different points during a single observation period, numbers of pigeons calling could not be determined. Temperature, an estimate of wind velocity, and an estimate of percent cloud cover were recorded at the start and end of observation periods.

Statistical Procedures

Statistical procedures used in analyses of data presented in this report were adapted from those of Steel and Torrie (1960). Differences between means and significance of correlation coefficients were tested by Student's t tests. Significance was considered to be the 90 percent level unless otherwise stated.

RESULTS

Vocalizations of the Band-tailed Pigeon

Several authors (Wales 1926, Bent 1932, Neff 1947, Glover 1953, Peeters 1962, and Houston 1963) described different types of vocalizations of band-tailed pigeons. Peeters (1962) described the principal vocalizations of band-tails as: (1) cooing, and (2) excitement calls.

The most frequently heard vocalization of band-tails was the perch-call. The perch-call was normally produced by male pigeons during the breeding season. Wales (1926) described the calling performance of the male band-tail in detail. He described the call as a faint oo followed by a series of whoo-oo's. Peeters (1962) described the call as: whōō-hōō----whōō-hōō----whōō-hōō----whōō-rŏo----whōō-rŏo. My interpretation of the call was as follows: oo(very faint)----whó-whòō----whó-whòō--. . . . --whó-whòō. Most calls consisted of four to eight consecutive whó-whòō's. The first syllable (whó) was usually shorter in duration and had greater stress than the last syllable (whòō). Although calling of captive band-tails was usually restricted to adult males, a captive adult female was observed calling once during the study. Female B uttered four calls on August 16, 1966, while brooding a squab. Calling of the female was similar to that of males but seemed to be of less intensity.

Excitement calls described by Peeters (1962, p. 452) included "chirping," "crowding grunts," and a "nest exchange call." According to the latter author (1962, p. 451) a good imitation of chirping "may be obtained by running one's finger over the teeth of a comb." Chirping is apparently uttered by male band-tails engaged in display flights. I did not hear this vocalization while observing captive band-tails. However, chirping was observed twice during band-tail call-counts conducted in July and August, 1966, on the Burnt Woods census route. On each occasion the sound was produced by a pigeon engaged in a circular gliding flight. Chirping seemed much lower in intensity than calling. The crowding grunt was also of relatively low intensity. Peeters (1962, p. 447) described the crowding grunt as a "nasal, grunt-like call, lasting approximately two seconds" which occurred when one band-tail approached another too closely. In the present study captive males and females uttered crowding grunts when approached within approximately 3 inches by another pigeon, except during copulatory activities. Males attempting to copulate with non-receptive females were often repelled with vigorous pecking and crowding grunts. Crowding grunts were not heard during band-tail call-counts. Neff and Niedrach (1946) described a vocalization produced by brooding males during nest exchanges. Peeters (1962, p. 452) mentioned similar vocalizations which he described as "short, low-pitched calls sounding somewhat like croo." Captive male and female band-tails I observed often produced such a vocalization while incubating and brooding. However, this vocalization did not appear to be related to any specific activity, such as nest exchange. No observations were made of nesting free-living band-tails during this study.

An additional vocalization, produced by squabs prior to feeding, was described by Neff (1947) and Peeters (1962). The latter author (1962, p. 452) referred to this vocalization as a "begging call," and described it as "quite weak" and "barely audible 20 feet away." Three pen-reared band-tail squabs I observed from distances of 20 to 30 feet were not heard vocalizing.

Results of this study indicated that the perch-call of male band-tails was the only vocalization of this species sufficiently audible for use in conducting audio-censuses.

Effects of Certain Physical and Biological Factors on Calling Activity

Time of Day

Various authors have described diurnal trends in calling activity of band-tailed pigeons. Glover (1953) found that free-living band-tails in northwestern California called most frequently between 9 a.m. and 12 a.m. He suggested that calling activity reached a peak earlier in the morning when weather was clear than when it was foggy or cloudy. Houston (1963) reported a similar distribution of daily calling activity in northwestern California. However, Peeters (1962, p. 451) reported that band-tails in the San Francisco Bay area of California "seldom vocalized during morning and early afternoon hours." Eight free-living males which he observed called most frequently between 5 p.m. and 6:30 p.m.

The effect of time of day on calling of captive and free-living band-tailed pigeons was determined by comparing frequencies of calling for 3-minute intervals in consecutive order beginning at sunrise. The frequency of calling for a 3-minute interval was the number of calls heard during the interval divided by the number of days on which observations were made during that interval. Frequencies of calling were calculated for individual captive pigeons. Frequencies of calling for free-living band-tails heard during call-counts or point observations were not calculated on a per bird basis because numbers of individual birds present were not known. Therefore, absolute values of frequencies of calling for captive and free-living pigeons could not be compared.

Distributions of frequencies of calling for unmated captive males observed in 1965 and 1966 are presented in Figures 1 and 2. Frequency of calling by males 5, 6, and 7 was highest approximately 1/2 hour after sunrise during mornings in 1965. In 1966, males 2

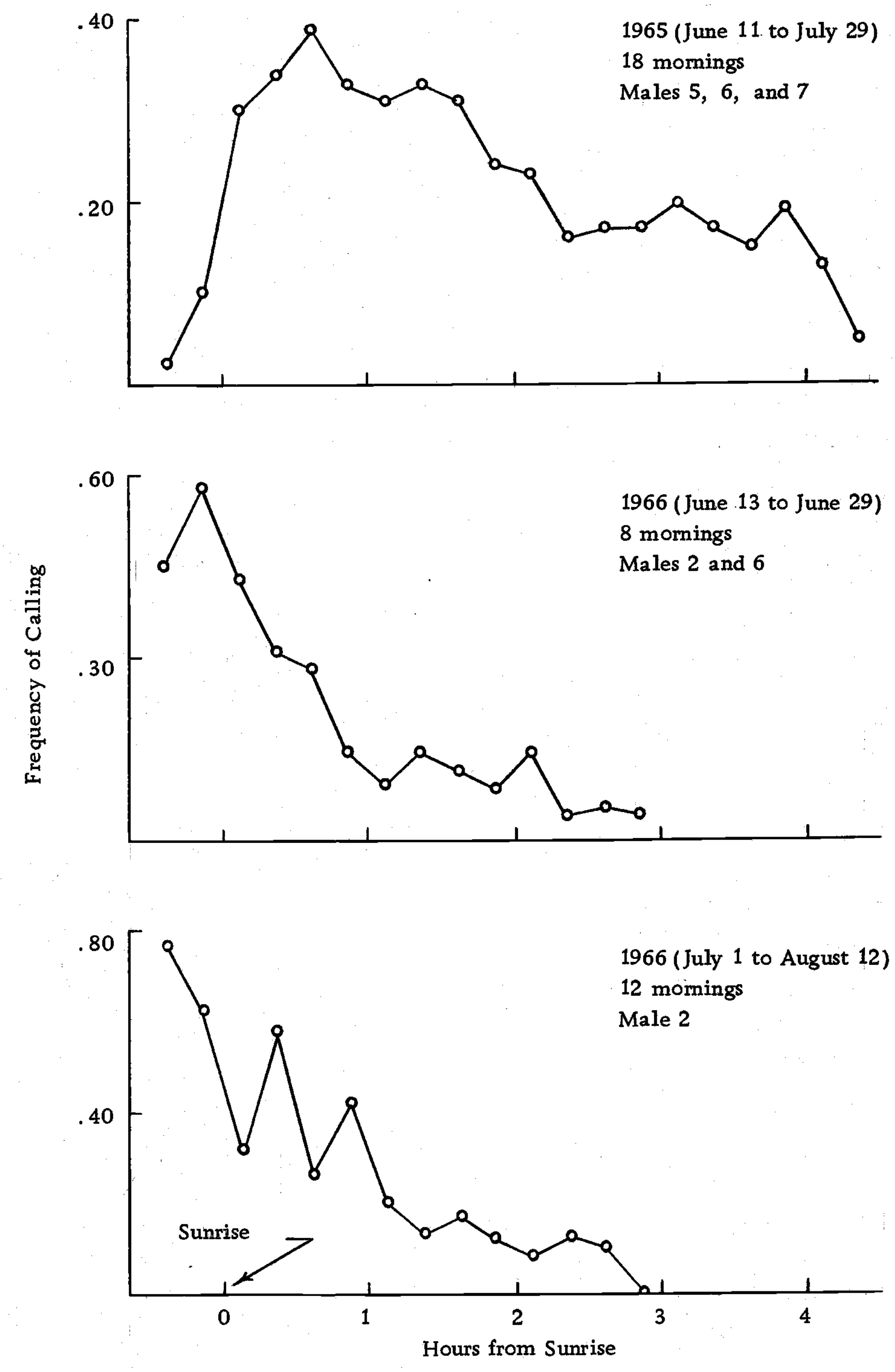

Figure 1. Frequency of calling (average number of calls per bird per 3-minute interval) as a function of time of morning for unmated captive male band-tails observed in 1965 and 1966.

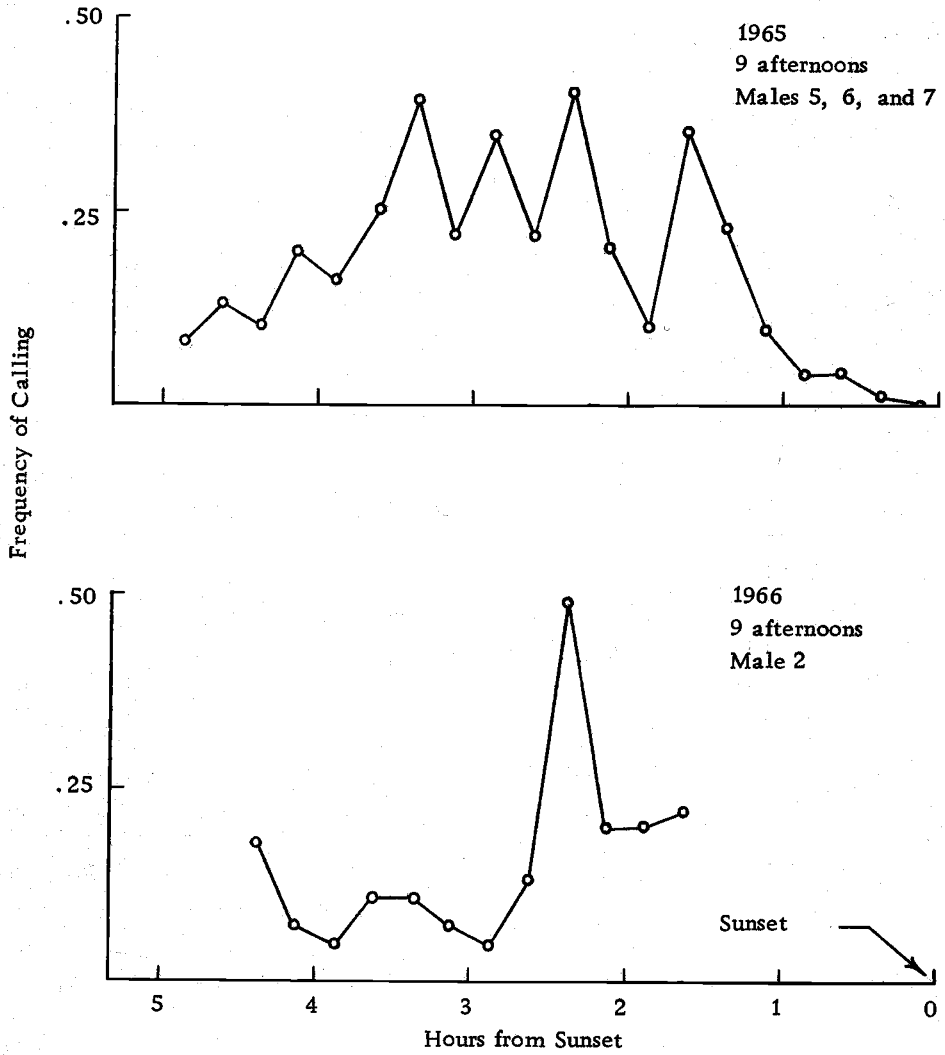

Figure 2. Frequency of calling (average number of calls per bird per 3-minute interval) as a function of time of afternoon for unmated captive male band-tails observed in 1965 and 1966.

and 6 called most frequently at approximately sunrise during mornings. Frequencies of calling by males 5, 6, and 7 fluctuated widely in afternoons with highest frequencies between 3 1/2 and 1 1/2 hours from sunset. In 1966, male 2 was the only unmated male observed in afternoons. Frequency of calling in afternoons for male 2 was highest approximately 2 1/2 hours from sunset.

The approximate length of time required to conduct a band-tail call-count on a route having stops at 1/2-mile intervals was 2 hours. Two-hour periods which included the highest frequencies of calling in morning and afternoon observation periods were selected as a basis for comparison of morning and afternoon calling activity of captive pigeons. The morning period was from 1/2 hour before sunrise to 1 1/2 hours after sunrise; the afternoon period was from 3 1/2 to 1 1/2 hours before sunset. These periods are referred to as the simulated morning census period and the simulated afternoon census period, respectively. Numbers of calls heard while observing unmated captive male pigeons during morning and afternoon simulated census periods were compared. In 1965, there were no significant differences between mean numbers of calls uttered by males 5, 6, and 7 during morning and afternoon simulated census periods ($\underline{t} = 0.10$, df = 76). In 1966, males 2, 6, and 7 while unmated called significantly more frequently during morning simulated census periods than during afternoon simulated census periods

($P < 0.02$, $\underline{t} = 2.48$, df = 41).

Observations of free-living band-tails were made only during mornings. Distributions of frequencies of calling in mornings for free-living band-tails are presented in Figure 3. Free-living pigeons called most frequently at approximately sunrise on mornings in 1966. Average frequencies of calling during consecutive 15-minute intervals for unmated captive males 2 and 6, and free-living band-tails heard on call-counts, during June, 1966, were significantly correlated at the 99 percent level ($r = +0.86$, df = 6).

Distributions of frequencies of calling in mornings for captive and free-living band-tails indicated that call-counts made in western Oregon should begin 1/2 hour before sunrise and end approximately 1 1/2 hours after sunrise.

Time of Year

Peeters (1962) observed band-tails calling in the San Francisco Bay area in California as early as the first week in April, and as late as mid-August, with greatest activity from late May to mid-July. Glover (1953) reported that calling was first heard on April 27 on his study area in northwestern California, and Houston (1963) first heard calling in the same locality on May 10. Glover (1953) reported that calling reached a peak during late June and early July, and was last heard in mid-August on his study area.

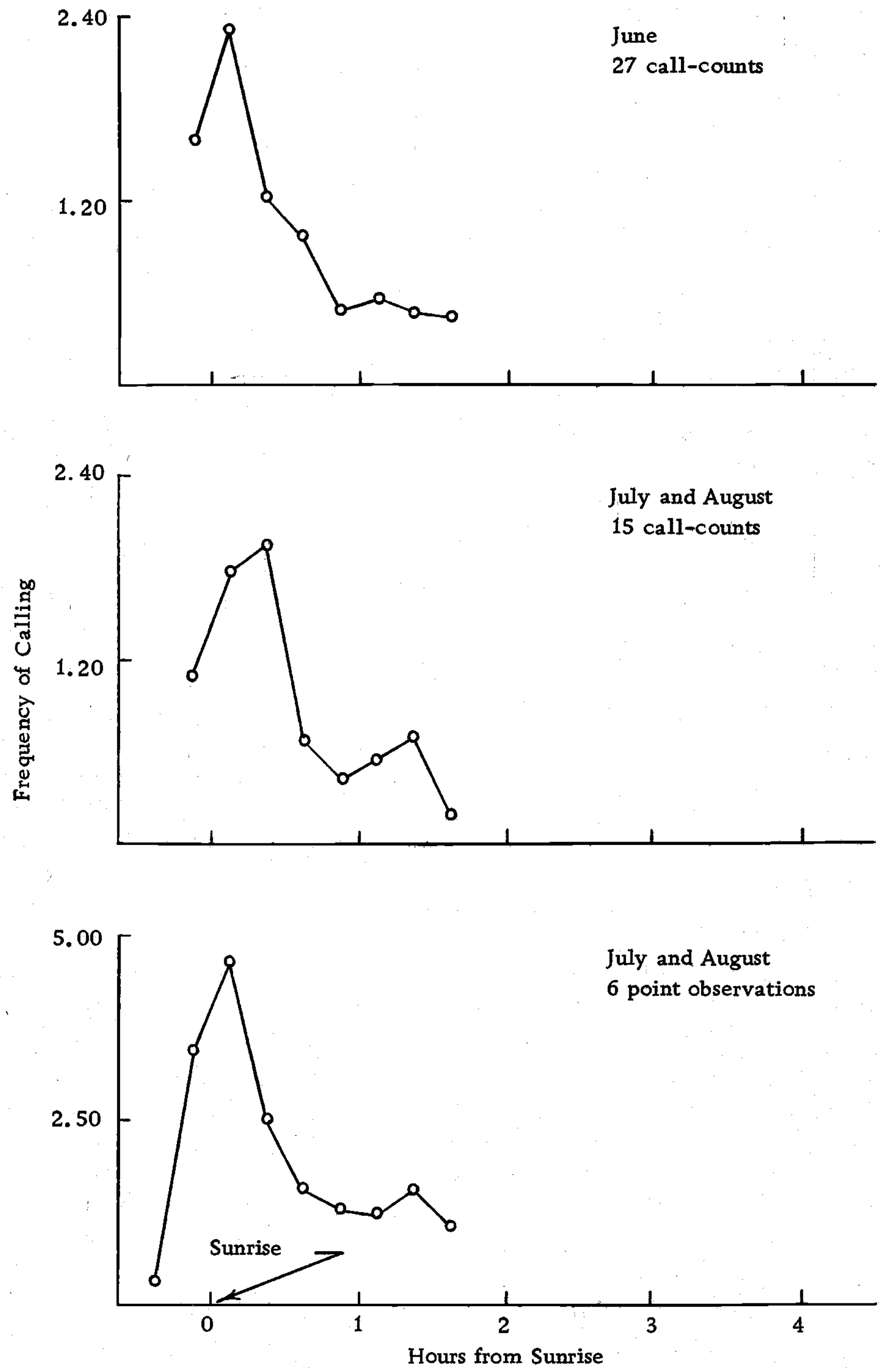

Figure 3. Frequency of calling (average number of calls heard per 3-minute interval) as a function of time of morning for band-tails heard during call-counts and point observations in 1966.

Numbers of calls I heard while observing unmated captive male band-tails during morning and afternoon simulated census periods at different times of the year are presented in Figures 4 and 5. Calling activity of males 5, 6, and 7 fluctuated widely during morning and afternoon simulated census periods in 1965, lacking a definite seasonal trend. Captive pigeons were not heard calling after mid-August in 1965. In 1966, captive males were first heard calling on the morning of February 24. Observations were not made during March in 1966. Male 2 called from late April through the last observation on August 16 in 1966. This pigeon was the only captive male remaining unmated throughout the 1966 observations.

Numbers of pigeons heard calling and numbers of calls heard during call-counts on the MacDonald Forest route are compared in Figure 6. Because no counts were made between May 18 and June 10, the complete seasonal trend in calling of band-tails in MacDonald Forest was not determined. Band-tails along this route apparently began to call between May 18 and June 10, and continued calling until mid-August (Figure 6).

Weather

There were no significant linear correlations at the 95 percent level (Tables 1 and 2) between numbers of calls of captive band-tails and individual weather factors recorded during morning and afternoon

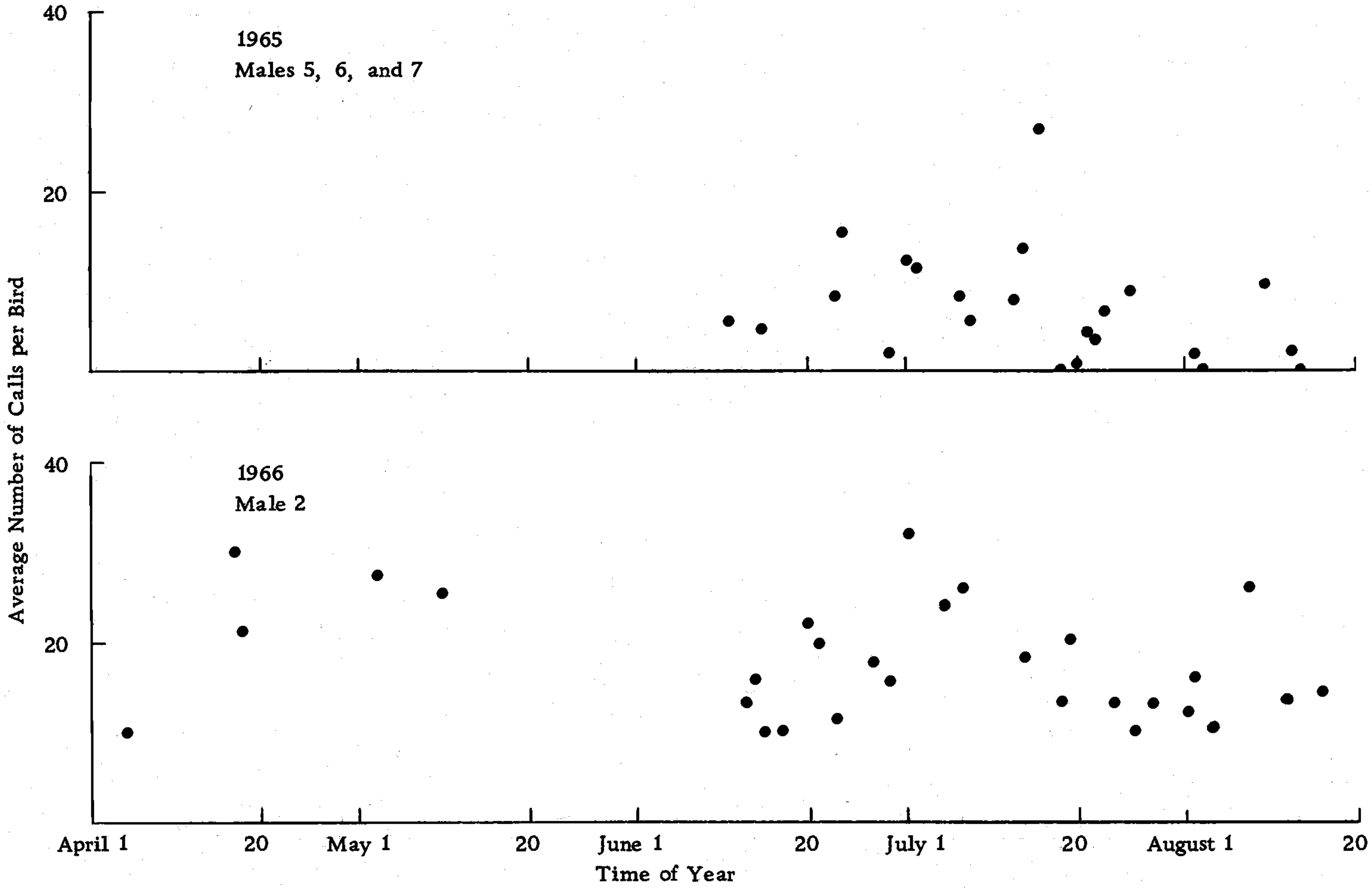

Figure 4. Numbers of calls heard during a morning simulated census period as a function of time of year for unmated captive male band-tails observed in 1965 and 1966.

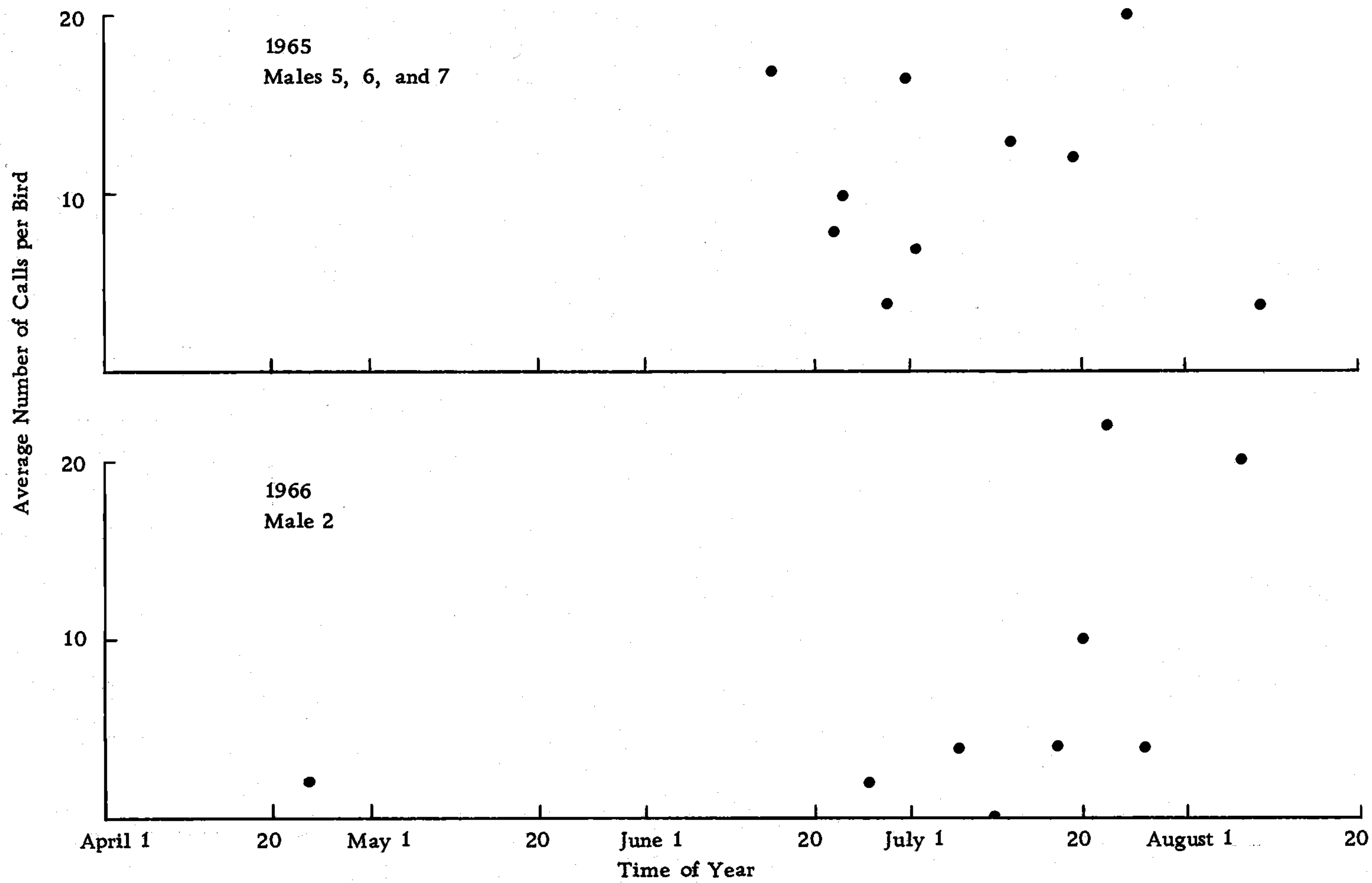

Figure 5. Numbers of calls heard during an afternoon simulated census period as a function of time of year for unmated captive male band-tails observed in 1965 and 1966.

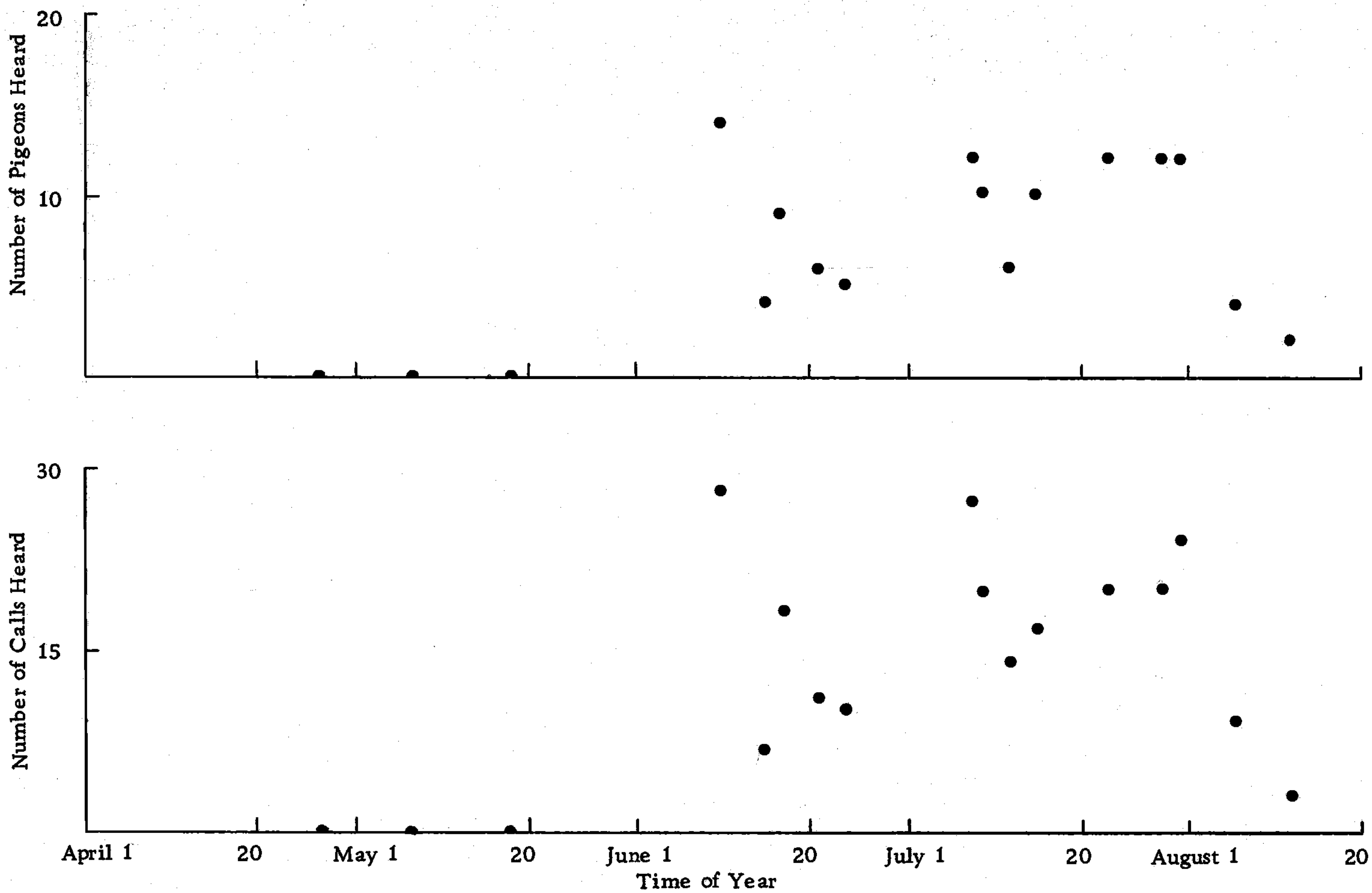

Figure 6. Numbers of band-tails heard calling and numbers of calls heard during call-counts on the MacDonald Forest census route as a function of time of year in 1966.

Table 1. Coefficients of linear correlation of numbers of calls heard and each of several weather factors during observations of unmated captive male band-tails in the morning simulated census period in 1965 (males 5, 6, and 7) and 1966 (male 2).

Weather Factors	Coefficient of Correlation 1965*	1966**
Temperature	+0.07	-0.03
Relative Humidity	-0.34	+0.13
Barometric Pressure	+0.05	-0.33
Wind	-0.17	+0.08
Present Cloud Cover	-0.31	+0.38

*Nineteen mornings between June 11 and July 29.

**Twenty mornings between May 3 and July 28.

Table 2. Coefficients of linear correlation of numbers of calls heard and each of several weather factors during observations of unmated captive male band-tails in the afternoon simulated census period in 1965 (males 5, 6, and 7) and 1966 (male 2).

Weather Factors	Coefficient of Correlation 1965*	1966**
Temperature	-0.11	+0.11
Relative Humidity	+0.10	-0.26
Barometric Pressure	-0.59[a]	-0.20
Wind	-0.48	+0.60
Percent Cloud Cover	+0.45	-0.63

*Nine afternoons between June 15 and July 25.

**Seven afternoons between June 26 and July 27.

[a]Significant ($P < 0.10$).

simulated census periods. Correlation between numbers of calls and barometric pressure in afternoons in 1965 was the only relationship significant at the 90 percent level (Table 2). There were no significant linear correlations at the 90 percent level (Table 3) between numbers of band-tails heard and individual weather factors during call-counts on the MacDonald Forest census route in 1966.

Table 3. Coefficients of linear correlation of numbers of pigeons heard calling and each of several weather factors during 15 band-tail call-counts conducted between June 15 and August 2 in 1966 on the MacDonald Forest census route.

Weather Factors	Coefficient of Correlation
Temperature	+0.06
Relative Humidity	+0.26
Barometric Pressure	-0.29
Wind	-0.21
Percent Cloud Cover	+0.07

The only time rain was recorded during spring and summer observations of captive pigeons was on the morning of July 20, 1965. No calls were heard during that morning observation period. No rain was recorded during call-counts on the MacDonald Forest route. However, free-living band-tails were heard calling in heavy rain on June 23, 1966, during a count on the Salmon Creek route in Lincoln County, Oregon

Breeding Status

Peeters (1962, p. 452) reported that calling of male band-tails in the San Francisco Bay area was apparently associated with "early stages of sexual activity." He found that vocalizations stopped "abruptly" with onset of incubation. In 1966, I observed four captive male band-tails in different stages of matedness. Males 1 and 7 were mated throughout the period of observations. Male 6 was unmated until July 1, and mated during the remaining observations. Male 2 was unmated during all observations. Mean numbers of calls uttered by males in different stages of the reproductive cycle during morning and afternoon simulated census periods are presented in Table 4. Captive unmated males called at least eight times more frequently than mated males during morning simulated census periods ($P < 0.01$, $\underline{t} = 13.13$, df = 75). Unmated males also called significantly more than mated males during afternoon simulated census periods ($P < 0.01$, $\underline{t} = 2.87$, df = 26). These results suggested that the primary function of calling was to attract a mate. However, calling of free-living band-tails continued throughout the summer or nesting season of 1966 in MacDonald Forest (Figure 3).

Audibility of the Perch-call

Peeters (1962, p. 451) wrote: "the coo is tonally low and weak and carries little more than 50 yards, particularly in dense forest."

Table 4. Means and standard errors of means of numbers of calls heard during observations of captive male band-tails in different stages of the reproductive cycle during morning and afternoon simulated census periods in 1966.

Breeding Status	Mean Number of Calls: Mornings	Mean Number of Calls: Afternoons
Unmated	14.56 ± 1.15(34)*	8.22 ± 2.42(9)
Mated (Total)	0.93 ± 0.16(43)	2.37 ± 0.83(19)
Copulation and Nest Building	0.33 ± 0.17(9)	0.00 (7)
Incubation	0.96 ± 0.22(28)	3.75 ± 1.16(12)
Brooding	1.67 ± 0.21(6)	----**

*Number of days of observation.

**No observations made.

No quantitative data were collected on the audible range of the perch-call during the present study. Audibility appeared to differ considerably under different wind and vegetative cover conditions. Wind velocity exceeding Beaufort 3 seemed to greatly reduce ability to hear calling pigeons during call-counts. Free-living band-tails calling from high perches in trees could apparently be heard farther than captive male pigeons calling from pens. Captive males could be heard at approximately 100 yards on a calm (wind velocity less than 1 mile per hour) day. I observed free-living band-tails calling from tops of tall conifers at the edge of a clear-cut area during call-counts on the Burnt Woods census route in 1966. These pigeons could be heard at approximately 300 yards on a calm (wind velocity less than 1 mile per hour) morning. Noise from streams near a few listening points on the MacDonald Forest and Salmon Creek census routes seemed to reduce ability to hear band-tails at those stops. During a few counts on the MacDonald Forest census route noise from railroad trains more than 2 miles away interfered with ability to hear pigeons at several listening points. Noise from logging operations also interfered with listening during at least one call-count in MacDonald Forest. I did not investigate the effects of differences in hearing abilities of observers on band-tail call-counts.

Probability of Hearing a Band-tailed Pigeon Call

The average probability of hearing each of males 1, 2, 6, and 7 call during a 3-minute interval was calculated for each morning and afternoon simulated census period during the summer of 1966. The probability of hearing an individual pigeon call during a simulated census period was calculated by dividing the number of 3-minute intervals in which the pigeon was heard calling by the number of 3-minute intervals in the period. Mean probabilities of hearing a band-tail in different stages of matedness are presented in Table 5. The probability of hearing an unmated male call was at least seven times that of hearing a mated male call during a morning simulated census period ($P < 0.01$, $\underline{t} = 16.13$, df = 74). During afternoon simulated census periods the probability of hearing an unmated male was also significantly greater than that of hearing a mated male ($P < 0.02$, $\underline{t} = 2.67$, df = 26). The probability of hearing an unmated male was significantly greater in morning simulated census periods than in afternoon simulated census periods ($P < 0.01$, $\underline{t} = 3.40$, df = 41).

Because calculation of probability depended on knowledge of numbers of pigeons present during observations, the probability of hearing a free-living band-tail could not be determined from data collected during this study. Calling activity of unmated captive male pigeons heard during morning simulated census periods was

Table 5. Means and standard errors of means of the probabilities of hearing a captive male band-tail call in different stages of matedness during a 3-minute interval in a morning or afternoon simulated census period (based on observations of males 1, 2, 6, and 7 in 1966).

Breeding Status	Mean Probability: Mornings	Mean Probability: Afternoons
Unmated	0.28 ± 0.02(33)	0.14 ± 0.04(9)*
Mated (Total)	0.03 ± 0.01(43)	0.05 ± 0.02(19)
Copulation and Nest Building	0.01 ± 0.01(9)	0.00 (7)
Incubation	0.03 ± 0.01(28)	0.08 ± 0.02(12)
Brooding	0.05 ± 0.01(6)	----**

*Number of mornings or afternoons observed

**No observations.

compared to that of free-living band-tails heard during call-counts on the basis of rate of calling. Rate of calling was defined as the average number of calls heard per pigeon per 3-minute interval in which a pigeon was heard calling. Rates of calling for captive males were determined for each morning simulated census period. Rates of calling for free-living band-tails were determined for each call-count. The mean rate of calling for unmated captive males was 1.25 calls per 3-minute interval. The mean rate of calling for free-living band-tails was 1.82 calls per 3-minute interval. The difference between means was significant ($P < 0.01$, $\underline{t} = 6.76$, $df = 57$). The relationship between rate of calling and probability of calling could not be determined. However, differences in rates of calling suggested that the probability of hearing free-living band-tails in undetermined stages of the reproductive cycle was greater than the probability of hearing unmated captive male pigeons.

Band-tailed Pigeon Call-counts

Precision of Call-counts

A census technique based on a population index, such as call-counts, provides a means for estimating changes in abundance of an animal species. The value of such a technique depends on its precision (Davis 1963).

An effort was made to determine the precision of band-tail call-counts conducted during June and July, 1966, in western Oregon. Results of these counts are presented in Table 6. Data recorded during counts conducted on routes which were sampled three or more times were subjected to analysis of variance (Tables 7, 8, and 9). Estimates of variance between routes ($\hat{\sigma}^2_N$) and among counts within routes ($\hat{\sigma}^2_C$) indicated that the greatest proportion of variance was caused by differences between routes.

Estimates of variance were used to calculate estimated coefficients of variation of overall mean numbers of pigeons heard, calls heard, and pigeons seen, assuming a sample size of one count on each of 40 routes (Tables 7, 8, and 9). Estimated coefficients of variation gave a measure of the precision of data collected during call-counts. Numbers of pigeons heard and numbers of calls heard varied less than numbers of pigeons seen. A significant change in the mean number of pigeons heard calling or calls heard from one sampling period to another should indicate a change in abundance of band-tails, assuming the same proportion of pigeons call during each sampling period. The percent which the overall mean number of pigeons heard or calls heard must change from one sampling period to another for significance ($P < 0.05$) is approximately equal to twice the coefficient of variation of the overall mean for a constant number of routes and counts per route. Thus, on the basis of analysis of

Table 6. Means and standard errors of means of numbers of band-tails heard calling, numbers of calls heard, and numbers of band-tails seen during call-counts on routes in western Oregon during June and July in 1966.

Route	Number of Counts	Pigeons Heard	Coo-calls Heard	Pigeons Seen
MacDonald Forest	12	9.3 ± 0.9	18.6 ± 1.7	2.3 ± 1.0
Burnt Woods	4	19.0 ± 2.8	34.3 ± 6.4	10.5 ± 5.7
Sugar Loaf Mtn.	3	10.3 ± 2.8	16.0 ± 6.0	14.3 ± 2.2
Patterson Creek	3	25.0 ± 9.6	44.7 ± 14.7	28.0 ± 5.0
Mary's Peak	3	3.7 ± 1.2	7.7 ± 3.9	3.0 ± 0.6
North Beaver Creek	3	7.7 ± 1.2	15.0 ± 5.5	7.3 ± 1.2
Elk Creek	3	2.0 ± 1.2	3.3 ± 1.9	2.0 ± 1.0
Salmon Creek	2	15.0 -*	30.5 -	6.5 -
Cedar Flat	2	0.0 -	0.0 -	0.0 -
Table Mtn.	1	2.0 -	3.0 -	10.0 -
Walker Creek	1	3.0 -	3.0 -	6.0 -
Millicoma	1	3.0 -	--** -	4.0 -
Banks-Manning	1	0.0 -	0.0 -	2.0 -

*Insufficient sample.

**Not recorded.

Table 7. Analysis of variance for numbers of band-tailed pigeons heard calling during 31 call-counts on seven routes in western Oregon in June and July, 1966.

Source of Variation	df	SS	MS	MS is an Estimate of
Between Routes (N)	6	1318.01	219.67	$\sigma_C^2 + 4.07\sigma_N^2$
Among Counts Within Routes (C)	24	494.12	20.58	σ_C^2
Total	30	1812.13		

$\bar{\bar{X}} = 10.74$ $\quad$ $CV(\bar{X}) = 77.65$*

$\hat{\sigma}_N^2 = 48.92$ $\quad$ $CV(\bar{\bar{X}}) = 12.29$**

$\hat{\sigma}_C^2 = 20.58$

*Estimated coefficient of variation per route (based on a sample of one count).

**Estimated coefficient of variation of the overall mean number of pigeons heard per count (based on a sample of one count on each of 40 routes).

Table 8. Analysis of variance for numbers of calls heard during 31 band-tail call-counts on seven routes in western Oregon in June and July, 1966.

Source of Variation	df	SS	MS	MS is an Estimate of
Between Routes (N)	6	4,074.30	679.05	$\sigma^2_C + 4.07\,\sigma^2_N$
Among Counts Within Routes (C)	24	2,669.70	111.24	σ^2_C
Total	30	6,744.00		

$\bar{\bar{X}} = 20.00$

$\hat{\sigma}^2_N = 139.51$

$\hat{\sigma}^2_C = 111.24$

$CV(\bar{X}) = 79.15$*

$CV(\bar{\bar{X}}) = 12.52$**

*Estimated coefficient of variation per route (based on a sample of one count).

**Estimated coefficient of variation of the overall mean number of calls heard per count (based on a sample of one count on each of 40 routes).

Table 9. Analysis of variance for numbers of band-tails seen during 31 call-counts on seven routes in western Oregon in June and July, 1966.

Source of Variation	df	SS	MS	MS is an Estimate of
Between Routes (N)	6	1,908.67	318.11	$\sigma^2_C + 4.07\sigma^2_N$
Among Counts Within Routes (C)	24	715.01	29.79	σ^2_C
Total	30	2,623.68		

$\bar{\bar{X}} = 7.55$ $\quad$ $CV(\bar{X}) = 132.85$*

$\hat{\sigma}^2_N = 70.84$ $\quad$ $CV(\bar{\bar{X}}) = 21.01$**

$\hat{\sigma}^2_C = 29.79$

*Estimated coefficient of variation per route (based on a sample of one count).

**Estimated coefficient of variation of the overall mean number of pigeons seen per count (based on a sample of one count on each of 40 routes).

data in Table 7, numbers of band-tails heard calling during one count on each of 40 routes annually would be expected to allow detection ($P < 0.05$) of a change of 24.58 (2 x 12.29) percent in the number of birds present.

Relationship of Sample Size and Arrangement to Precision

A decision regarding use of a wildlife management technique ultimately depends on the cost necessary for functional application of the technique. The cost of a call-count program would include man-hours, transportation, and other expenses necessary for establishing census routes, making counts, and analysing data. An agency planning to use call-counts on an annual basis must determine the size and arrangement of the sample (number of routes and counts per route) expected to produce highest precision for a specific cost.

An effort was made to determine the relationship between sample arrangement and precision for a sample size limited by cost. The following assumptions were made: (1) the cost of conducting each call-count was the same, and (2) the sample size (total number of counts) was fixed by a specific cost. Estimates of variance between routes ($\hat{\sigma}_N^2$) and among counts within routes ($\hat{\sigma}_C^2$) in Tables 7 and 8 were used to calculate estimated variances of overall mean numbers of pigeons heard and calls heard for different arrangements of a fixed sample of 60 counts per year. Variance was expressed as a function of sample arrangement for numbers of pigeons heard (Figure 7) and numbers of calls heard (Figure 8). These data indicated that one count per route results in the highest precision for a fixed sample size. For example, estimates of variance of the mean number of pigeons heard for one count on each of 60 routes was approximately one-third that for four counts on each of 15 routes (Figure 7). Thus, the most precise sample arrangement for a sample size limited by a specific cost is one count per route.

Estimated coefficients of variation were expressed as a function of numbers of routes and counts per route for numbers of pigeons heard and numbers of calls heard, respectively (Figures 9 and 10). The percent change in the mean number of pigeons heard or calls heard from one sampling period to another necessary to indicate a change in abundance ($P < 0.05$) of calling birds for a constant number of routes and counts per route can be estimated by doubling the corresponding coefficients of variation (Figures 9 and 10). For example, the mean number of calls heard, assuming a sample arrangement of one count on each of 60 routes, must change approximately 21 percent from one sampling period to another to indicate a significant ($P < 0.05$) change in abundance of calling band-tails (Figure 10).

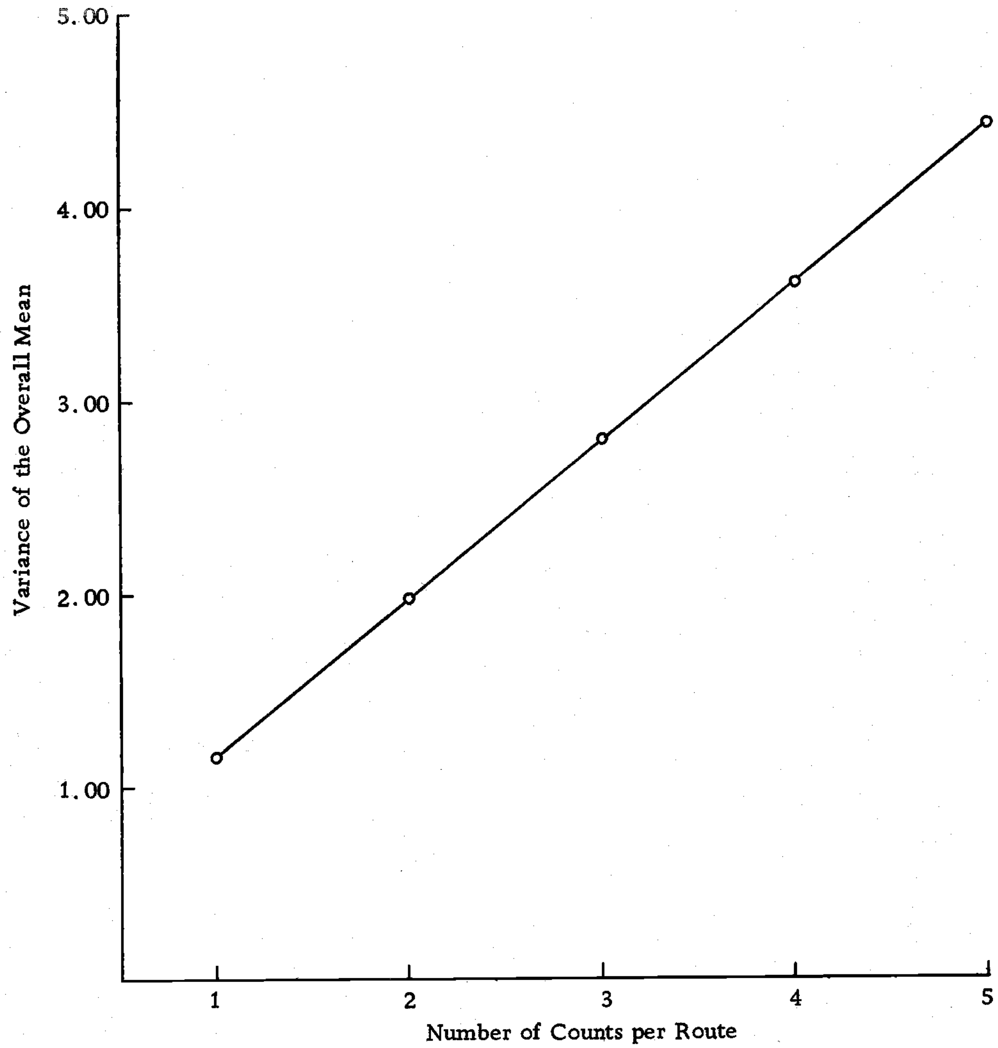

Figure 7. Estimated variance of the overall mean number of band-tails heard per call-count as a function of the arrangement of a fixed sample of 60 counts, based on 31 call-counts conducted on seven routes in western Oregon in 1966.

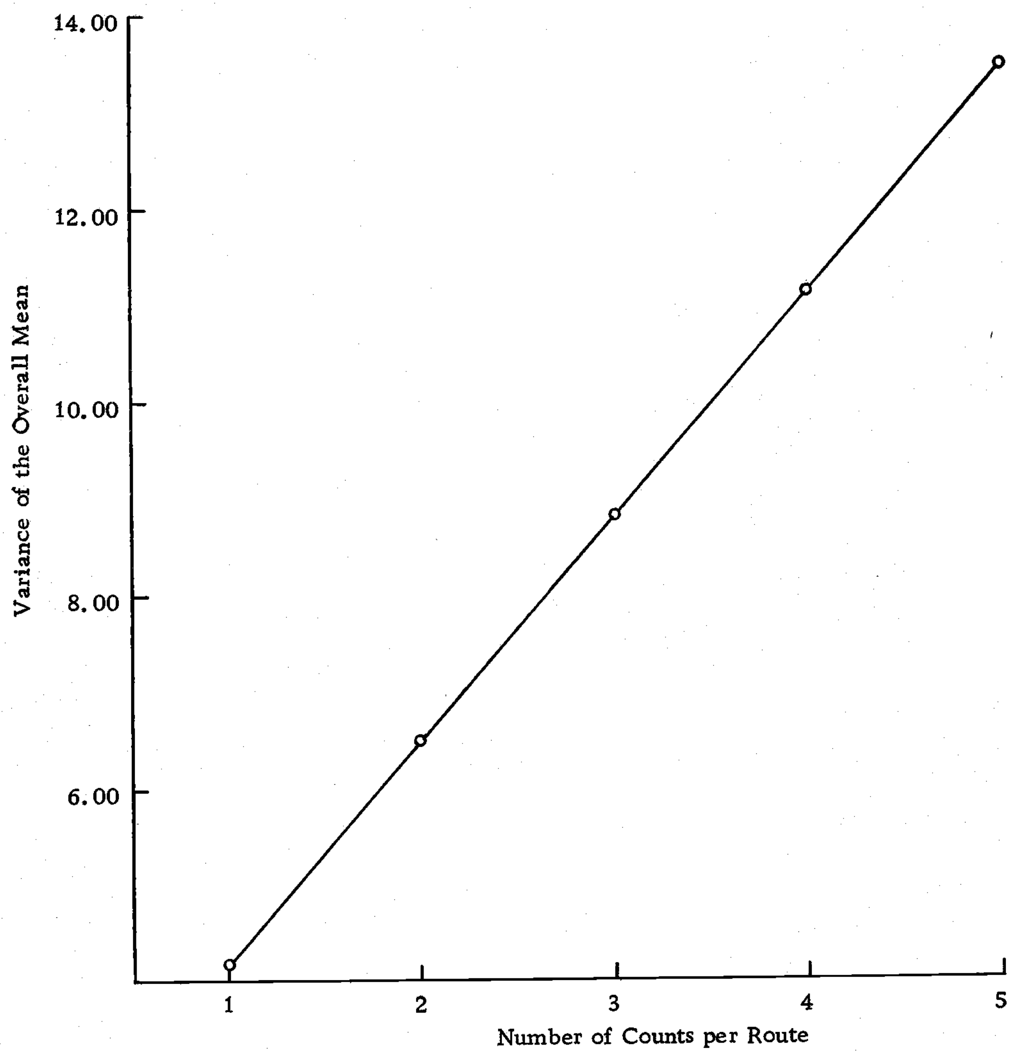

Figure 8. Estimated variance of the overall mean number of calls heard per call-count as a function of the arrangement of a fixed sample of 60 band-tail call-counts, based on 31 counts conducted on seven routes in western Oregon in 1966.

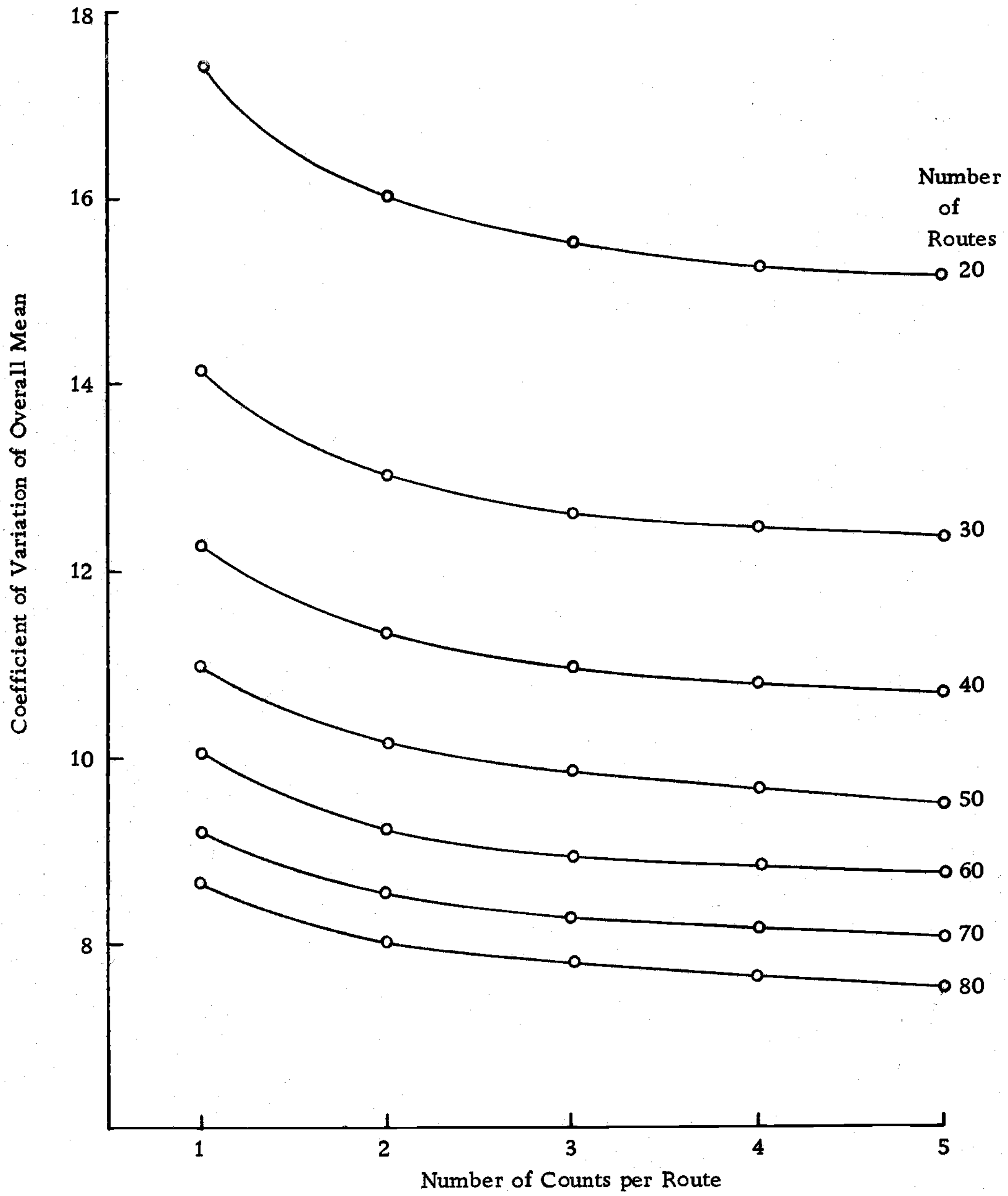

Figure 9. Estimated coefficients of variation of the overall mean number of band-tails heard per call-count as a function of sample size and arrangement, based on 31 counts conducted on seven routes in western Oregon in 1966.

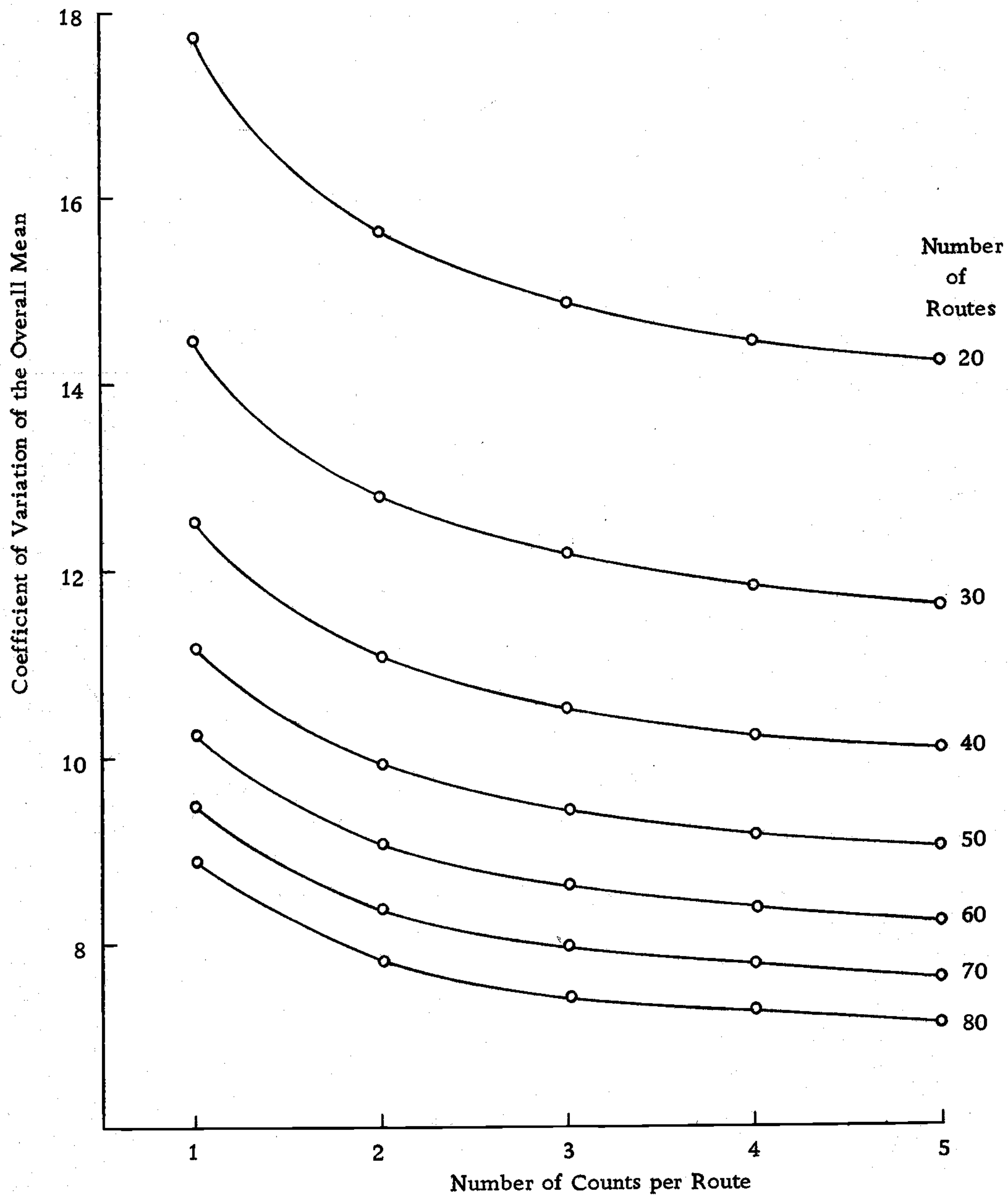

Figure 10. Estimated coefficients of variation of the overall mean number of calls heard per call-count as a function of sample size and arrangement, based on 31 counts conducted on seven routes in western Oregon in 1966.

SUMMARY AND DISCUSSION

Vocalizations of band-tailed pigeons observed in the present study included "perch-calls," "chirping," "crowding grunts," and a "nest call." With exception of the perch-call, these vocalizations were of very low intensity. During observations of captive band-tails, calling was usually restricted to adult males. However, an adult female was observed calling during one morning observation period, suggesting that female band-tails are able to call. The perch-call was the only vocalization heard which was considered sufficiently audible for use in an audio-census.

Development of an audio-census technique requires knowledge of seasonal and diurnal trends in production of the sound on which the technique is based. Mourning dove coo-counts are conducted during the "peak-season plateau" (May 20 to June 10) each year (McGowan 1953, p. 439). Coo-counts are started 1/2 hour before sunrise and end approximately 1 1/2 hours after sunrise. Thus, mourning dove coo-counts are designed to coincide with seasonal and diurnal peaks in cooing activity.

The seasonal trend in calling of free-living band-tails was determined except for the period between May 18 and June 10. Because band-tails apparently began to call during this period, the earliest date on which a call-count could be conducted was not established. However, it appeared that counts conducted between June 15 and July 1 would be adequate for determining year-to-year trends in abundance. Distributions of frequencies of calling in mornings indicated that call-counts made in western Oregon should begin 1/2 hour before sunrise and end approximately 1 1/2 hours after sunrise. The relatively brief peak in morning frequencies of calling suggested that all call-counts should begin at the same time in relation to sunrise to eliminate variation resulting from diurnal changes in calling activity.

Although the exact audible range of the perch-call was not determined, my observations indicated a maximum range of approximately 1/4 mile. The time required to conduct a call-count on a route having 20 stops at 1/2-mile intervals was approximately 2 hours. The time required to conduct a count on a route having 20 stops at 1-mile intervals was approximately 2 1/2 hours. Because of these factors, it is suggested that listening stops on band-tail census routes should be spaced at 1/2-mile intervals.

Glover (1953) suggested that early morning fog may have caused band-tails to call later in the morning in northwestern California. It is suggested that call-counts should be conducted only on clear mornings. However, through future research, it may be possible to establish a uniform time to begin counts based on the density of fog.

Several workers have investigated effects of weather on variation in calling or other sounds used in audio-censuses. McClure (1939, p. 325) reporting on mourning doves stated that "more birds cooed during clear weather than at other times." He also suggested that cooing decreased with increasing wind velocity. During early investigations of the use of mourning dove coo-counts, cooperators were instructed not to conduct counts in rainy weather or when wind velocity exceeded Beaufort 3 (U. S. Fish and Wildlife Service 1952, p. 4). In an intensive study of cooing of captive male mourning doves, Frankel and Baskett (1961) tested linear correlations between cooing and individual weather factors: temperature, relative humidity, barometric pressure, wind, and cloud cover. They found no consistent significant ($P < 0.05$) relationships and concluded that no generalizations could be made about effects of weather on cooing. In addition, the latter authors (1961, p. 382) suggested that "possibly cooing behavior is governed by environmental extremes, between which the small daily changes have little effect." Kimball (1949, p. 120) investigating use of crowing counts for censusing ring-necked pheasants, reported that "weather factors, with exception of wind above 8 miles per hour, and heavy precipitation, apparently seldom affect crowing counts." Duke (1966) tested linear correlations between some individual weather factors and the peenting activity of woodcocks. He found two significant ($P < 0.05$) correlations which he attributed to differences in human efficiency and concluded no correlation between peenting and weather. Williams (1961, p. 126) conducted a multiple correlation analysis between several physical and biological factors and the rally calling of chukars and concluded that "factors of the physical environment do not affect calling in the chukar partridge." Gullion (1966, p. 721) reporting on drumming behavior of ruffed grouse, stated: "low or high temperature is apparently the most important environmental influence discouraging daily drumming, except for moderate to heavy rainfall." My results indicated that variations in individual weather factors recorded did not bear significant linear relationships to corresponding variations in calling activity of band-tailed pigeons observed. It is possible that calling of band-tails is affected by extremes in individual climatic factors, or by combinations of factors. Non-linear relationships may also exist. Further study will be needed before effects of weather on calling of band-tailed pigeons can be completely evaluated.

Breeding status was found to be the most important factor influencing cooing of male mourning doves. Frankel and Baskett (1961) reported that three captive male doves they observed cooed ten times more frequently while unmated than while mated. Jackson and Baskett (1964, p. 295) reported that "unmated males cooed more than 13 times as often per three-minute period as did mated males" during observations of marked free-living doves. The relationship between breeding status and calling of captive band-tails I observed (Tables 4 and 5) was similar to that for penned doves (Frankel and Baskett 1961) and for free-living doves (Jackson and Baskett 1964). It is interesting to note that free-living band-tails heard on the MacDonald Forest census route called throughout the nesting season (Figure 3). This suggested that there were unmated free-living male band-tails present in MacDonald Forest during the nesting season, or that mated free-living male band-tails call more frequently than mated captive males. Although the probability of hearing a free-living band-tail call could not be determined, the mean rate of calling of free-living band-tails heard during call-counts was significantly higher than that of captive unmated males. Mackey (1965) observed a mated male mourning dove engaged in territorial conflict which cooed as often as unmated males observed by Jackson and Baskett (1964). It is suggested that a similar relationship may have existed during observations of band-tails in the present study. Pen conditions undoubtedly suppressed territorial behavior. If calling serves a territorial display function for free-living band-tails, mated free-living male band-tails may call more often than mated captive male band-tails. Frankel and Baskett (1961) and Jackson and Baskett (1964) suggested that precise interpretation of mourning dove coo-count data would require information on the ratio of mated to unmated male doves being censused. However, Wight (1964) used hypothetical models to demonstrate that changes in matedness of mourning doves, where sex ratios of adults approach equality, would not affect results of the coo-call census significantly. According to the latter author estimates of biases in the mourning dove coo-count resulting from changes in matedness ratios would require: (1) an estimate of the ratio of mated to unmated males in the population, and (2) a measurement of changes in the ratio that may occur from year to year. It is suggested that similar information will be required before effects of matedness on band-tailed pigeon call-counts can be evaluated. Also, it will be necessary to establish the relationship between calling and matedness in free-living pigeons.

No quantitative data were collected on factors affecting the audible range of the perch-call in the present study. Factors such as wind (U. S. Fish and Wildlife Service 1952, p. 5), noise of automobiles (Duke 1966), hearing abilities of observers (Duke 1966), and experience of observers (Carney and Petrides 1957) have been found to influence audio-censuses of various species. Wind velocity exceeding Beaufort 3 seemed to reduce ability to hear band-tails during call-counts. Also, noise from streams, railroad trains, and logging operations seemed to reduce ability to hear pigeons. I did not investigate effects of differences in hearing abilities of observers on band-tail call-counts. Because differences in abilities of observers to hear band-tails could cause unrepresentative call-counts, it is suggested that criteria be established for hearing abilities of personnel making counts.

The primary use of audio-censuses has been to estimate changes in abundance of species on an annual basis. Such estimates are based on increases or decreases in numbers of animals heard or sounds heard. The assumption is that the same proportion of the total population is tabulated each sampling period when the same technique is used under similar field conditions with the same species (Davis 1963). The ability of an audio-census to detect a change in abundance depends on its precision. Precision is related to sample size and variance. Information on the relative abundance of mourning doves gained from dove coo-counts is based on large sample sizes. Foote _et al_. (1958, p. 402) reporting on mourning doves stated: "extensive data gathered by cooperators in recent years from 600-700 routes in 44 states annually have been used for management information." The U. S. Fish and Wildlife Service (1952, p. 33) reported that 36 coo-counts were necessary on any one of three routes censused to detect a change of 15 percent or more in abundance of calling doves. If all three of these routes were considered as a unit, 12 trips on each were needed to reflect a 15 percent change. For band-tails, estimated coefficients of variation of overall mean numbers of birds heard and calls heard (Tables 7 and 8) indicated that one count on each of 40 routes was necessary to detect a 25 percent change in numbers of birds present. However, using numbers of pigeons seen for the same sample size and arrangement the minimum detectable change was 42 percent. The U. S. Fish and Wildlife Service (1952, p. 42) and Foote et al. (1958) reported more variation in doves seen than doves heard during mourning dove coo-counts. It is suggested that watching for pigeons while driving may be hazardous, especially on routes passing through mountainous terrain. Furthermore, watching for pigeons may produce a distraction for observers listening for band-tails. For these reasons, it is suggested that only numbers of pigeons calling, and numbers of calls be recorded during band-tail call-counts. Having observers close their eyes while listening may reduce visual distraction during call-counts.

It should be pointed out that estimates of precision of band-tail call-counts presented in this report are based on the first organized attempt to census pigeons by this method. Although observers were instructed to begin band-tail call-counts at sunrise in 1966, actual starting times varied from 1/2 hour before sunrise to 1/2 hour after sunrise. This variation in starting time may have contributed to variance in call-counts analysed in this report. Precision of band-tail call-counts may be increased by elimination of this source of variance. Therefore, it is suggested that future research on band-tail call-counts include investigations to determine sources of variation in this census.

Many of the census routes first used for mourning dove coo-counts were selected because they were known to pass through good dove habitat. Data from these routes were used primarily to detect changes in abundance of calling doves on the same routes from year to year (Foote *et al*. 1958). The latter authors proposed an improved sampling design for dove coo-counts, based on stratified random selection of routes by ecological zones, which would allow comparisons on the basis of area as well as on the basis of time. Further development of the band-tail call-count should include research to determine if random selection of routes would permit similar comparisons.

Results of the present study suggested that call-counts have potential value as a technique for censusing band-tailed pigeons during the breeding season. Findings presented in this report are preliminary, and are intended to form a basis for further research. Assuming that calling of band-tailed pigeons heard during this study was representative, the recommended procedure for sampling is as follows: (1) routes should be established on lightly traveled roads, preferably not passing near any sources of interfering noise, such as fast moving streams or rivers, (2) counts should be conducted between June 15 and July 1, (3) counts should start 1/2 hour before local official sunrise, and only those counts starting within 10 minutes of the correct starting time should be used in analysis of data, (4) counts should consist of 20 3-minute observations at stops spaced 1/2 mile apart, (5) numbers of band-tails calling and numbers of calls heard should be recorded at each stop, and (6) counts should not be conducted when wind velocity exceeds 5 miles per hour, or during heavy rain or fog.

BIBLIOGRAPHY

Bent, A. C. 1932. Life histories of North American gallinaceous birds. Washington, D. C. 490 p. (U. S. National Museum. Bulletin 162)

Carney, S. M. and G. A. Petrides. 1957. Analysis of variation among participants in pheasant cock crowing censuses. Journal of Wildlife Management 21:392-397.

Davis, D. E. 1963. Estimating the numbers of game populations. In: Wildlife investigational techniques, ed. by H. S. Mosby. 2d ed. Blacksburg, Va., The Wildlife Society, 1963. p. 89-118.

Duke, G. E. 1966. Reliability of census of singing male woodcocks. Journal of Wildlife Management 30:697-706.

Foote, L. E., H. S. Peters and A. L. Finkner. 1958. Design tests for mourning dove call-count sampling in seven southeastern states. Journal of Wildlife Management 22:402-408.

Frankel, A. I. and T. S. Baskett. 1961. The effect of pairing on cooing of penned mourning doves. Journal of Wildlife Management 25:372-384.

Glover, F. A. 1953. A nesting study of the band-tailed pigeon (Columba f. fasciata) in northwestern California. California Fish and Game 39:397-407.

Gullion, G. W. 1966. The use of drumming behavior in ruffed grouse population studies. Journal of Wildlife Management 30:717-729.

Houston, D. B. 1963. A contribution to the ecology of the band-tailed pigeon, Columba fasciata, Say. Master's thesis. Laramie, University of Wyoming.

Jackson, G. L. and T. S. Baskett. 1964. Perch-cooing and other aspects of breeding behavior of mourning doves. Journal of Wildlife Management 28:293-307.

Kimball, J. W. 1949. The crowing count pheasant census. Journal of Wildlife Management 13:101-120.

Lowe, J. I. 1956. Breeding density and productivity of mourning doves on a county-wide basis in Georgia. Journal of Wildlife Management 20:428-433.

McClure, H. E. 1939. Cooing activity and censusing of the mourning dove. Journal of Wildlife Management 3:323-328.

McGowan, T. A. 1953. The call-count as a census method for breeding mourning doves in Georgia. Journal of Wildlife Management 17:437-445.

Mackey, J. P. 1965. Cooing frequency and permanence of pairing of mourning doves. Journal of Wildlife Management 29:824-829.

Morse, W. B. 1949. The band-tailed pigeon. Oregon State Game Commission Bulletin 4(7):1, 5, 7.

________________. 1950. Observations on the band-tailed pigeon in Oregon. In: Proceedings of the Thirtieth Annual Conference of the Western Association of State Game and Fish Commissioners, Portland, Oregon, August 14-16, 1950. Portland, Oregon. p. 102-104.

Neff, J. A. 1947. Habits, food, and economic status of the band-tailed pigeon. Washington, D. C. 76 p. (U. S. Fish and Wildlife Service. North American Fauna 58)

Neff, J. A. and R. J. Niedrach. 1946. Nesting of the band-tailed pigeon in Colorado. Condor 48:72-74.

Peeters, H. J. 1962. Nuptial behavior of the band-tailed pigeon in the San Francisco Bay area. Condor 64:445-470.

Petraborg, W. H., E. G. Wellein, and V. E. Gunvalson. 1953. Roadside drumming counts, a spring census method for ruffed grouse. Journal of Wildlife Management 17:292-295.

Pitelka, F. A. 1943. Territoriality, display, and certain ecological relations of the American woodcock. Wilson Bulletin 55:88-114.

Quick, H. F. 1963. Animal population analysis. In: Wildlife investigational techniques, ed. by H. S. Mosby. 2d ed. Blacksburg, Va., The Wildlife Society, 1963. p. 190-228.

Rogers, G. E. 1963. Blue grouse census and harvest in the United States and Canada. Journal of Wildlife Management 27:579-585.

Rosene, W., Jr. 1957. A summer whistling cock count of bobwhite quail as an index to wintering populations. Journal of Wildlife Management 21:153-158.

Smith, R. H. and S. Gallizioli. 1965. Predicting hunter success by means of a spring call count of Gambel quail. Journal of Wildlife Management 29:806-813.

Steel, R. G. D. and J. H. Torrie. 1960. Principles and procedures of statistics with special reference to the biological sciences. New York, McGraw-Hill. 481 p.

U. S. Fish and Wildlife Service. 1952. Investigations of methods of appraising the abundance of mourning doves. Washington, D. C. 53 p. (Special Scientific Report, Wildlife no. 17)

Wales, J. H. 1926. The coo of the band-tailed pigeon. Condor 28:42.

Wight, H. M. 1964. Matedness in the mourning dove and its effect on the nationwide dove-call census. Transactions of the North American Wildlife and Natural Resources Conference 29:270-281.

Wight, H. M., R. U. Mace and W. M. Batterson. 1967. Mortality estimates of an adult band-tailed pigeon population in Oregon. Journal of Wildlife Management. (In press)

Williams, H. W. 1961. The influence of physical and biological factors on the rally call of the chukar partridge (Alectoris graeca) with regard to use of the call as a census method. In: Proceedings of the Forty-first Annual Conference of the Western Association of State Game and Fish Commissioners, Santa Fe, New Mexico, June 12-14, 1961. Santa Fe, New Mexico. p. 117-129.

APPENDIX

APPENDIX A

Table A. 1. Arrangement of captive band-tailed pigeons in the Oak Creek pen study area during observations in 1965.

Male	Female	Pen	Date
1	A	I	June 11 to August 15
2	*	IV	June 11 to August 15
3	C	III	June 11 to August 15
4	*	IV	June 11 to August 15
5	B	II	June 11 to August 15
6	F	VI	June 11 to August 15
7	D and E **	V	June 11 to August 15

*Observations not made of individual pigeons in pen IV.

**Both present at the same time.

Table A. 2. Arrangement of captive band-tailed pigeons in the Oak Creek pen study area during observations in 1966.

Male	Female	Pen	Date
1	A	I	January 13 to August 16
2	none	V	January 13 to April 2
	none	II	April 3 to August 16
3	**	**	**
4	E	III	January 13 to August 16
5	B	II	January 13 to April 2
	B	V	April 3 to August 16
6	none	VI	January 13 to July 2
	F	VI	July 3 to July 14
	G	VI	July 15 to August 16
7	*	IV	January 13 to August 16

*Observations not made on individual pigeons in pen IV.

**Male 3 died September 10, 1965.

Table A. 3. Names, locations, and lengths of band-tailed pigeon census routes established in western Oregon, and numbers and dates of call-counts conducted on these routes in 1966.

Name of Route	County	Length of Route in Miles	Number of Counts	Date
MacDonald Forest	Benton	5	19	April 27 to August 12
Burnt Woods	Lincoln	10	6	June 30 to August 13
Sugar Loaf Mtn.	Clatsop	20	3	June 3 to June 25
Patterson Creek	Tillamook	20	3	June 6 to June 29
Mary's Peak	Benton	20	3	June 6 to June 27
North Beaver Cr.	Lincoln	20	3	June 22 to June 29
Elk Creek	Douglas	20	3	June 9 to June 27
Salmon Creek	Lincoln	10	2	June 23 and June 25
Cedar Flat	Josephine	20	2	June 9 and June 18
Table Mtn.	Lincoln	20	1	June 7
Walker Creek	Lane	10	1	June 16
Millicoma	Coos	20	1	June 24
Banks-Manning	Washington	20	1	June 12