AN ABSTRACT OF THE THESIS OF

Michael Forrest Passmore for the degree of Master of Science

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Title: UTILIZATION OF MINERAL SITES BY BAND-TAILED PIGEONS

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Robert L. Jarvis

The occurrence of band-tailed pigeons (Columba fasciata) at three mineral sites in Western Oregon was studied during the summers of 1974-1976. Objectives of the study were to: determine seasonal patterns of utilization of mineral sites by pigeons of different sex and age classes; determine productivity of pigeon populations associated with mineral sites; determine fidelity of pigeons to mineral sites; and determine sizes of pigeon populations utilizing mineral sites. Study sites included two sites (Long Tom and Nashville) where pigeons were hunted during the Oregon band-tailed pigeon hunting season and one site where hunting was prohibited (Finley). Observations of pigeons marked with patagial wing tags provided information on daily and seasonal patterns, fidelity of pigeons to mineral sites, and sizes of pigeon populations using the mineral sites. Productivity was determined from counts of adult and immature pigeons recorded at 15 min intervals. Observations

occurred daily between sunrise and 1200 h at each site during 2 of the 3 years. Band-tailed pigeons were associated with mineral sites from May to September, coinciding with the breeding season. The most intensive period of use of mineral was during August when the majority of immatures fledged. Males and females frequented mineral sites during different time periods and males were associated with mineral for longer seasonal periods than were females. Cloudy and wet weather had adverse affects on the numbers of pigeons visiting the sites. Adult pigeons had high fidelity to mineral sites, both among years and during each breeding season. Interchange was frequently observed between two closely adjacent sites. Estimates of sizes of populations indicated that between 1800 and 2500 pigeons were associated with the three sites in 1976. Patterns of nesting and productivity varied among the sites. Pigeons associated with the site where hunting was prohibited (Finley) had approximately twice the amount of production as did pigeons at the two sites where hunting occurred. Most pigeons associated with the Finley site and probably the Nashville site were involved in multiple nestings, but the majority of the birds associated with the Long Tom site nested only once per season. Patterns of utilization of mineral and productivity displayed by pigeons associated with the Nashville site were probably representative of the reproductive activities of the majority of band-tailed pigeons which bred in Oregon.

Utilization of Mineral Sites by Band-Tailed Pigeons

by

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INTRODUCTION

The Pacific coast subspecies of the band-tailed pigeon (Columba fasciata monilis Vigors) occurs in the western portions of British Columbia, Washington, Oregon, California and Baja California. Pigeons breeding in the northern areas (Northern California-British Columbia) winter mainly in Southern California. Although nesting occurs nearly year-round in resident flocks in Southern California (MacGregor and Smith 1955), the breeding season for most migrant pigeons is from April to September (Ziegler 1971, Glover 1953, March and Sadleir 1970). Nesting in many areas is apparently stimulated by availability of certain food sources (Gutiérrez et al. 1975, March and Sadleir 1972).

Use of mineral water and mineralized soil by band-tailed pigeons during the fall was reported by Neff (1947), Smith (1968) and March and Sadleir (1972). Calcium was suggested by March and Sadleir (1972) as the element required by pigeons due to loss of calcium from egg laying and crop milk production (March and Sadleir 1975). March and Sadleir (1970, 1975) reported use of mineral sites by pigeons in British Columbia occurred from April to September, with peak numbers of birds at mineral sites corresponding to timing

of breeding activities in that area. Morse (1950) suggested mineral sites may be used as focal points for breeding by pigeons in Oregon.

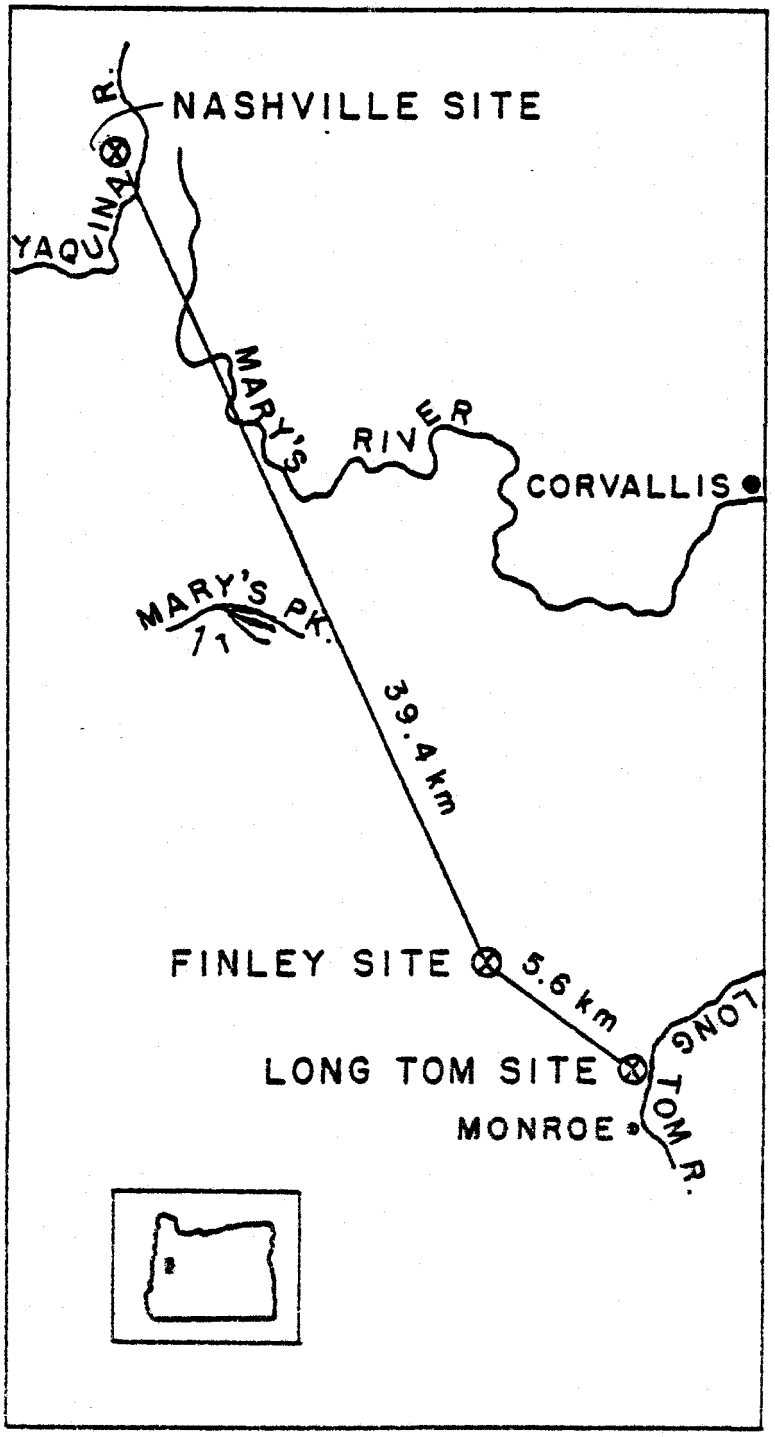
Hunting of band-tailed pigeons occurs during September in Oregon with much of the hunting centered around mineral sites where pigeons are concentrated. Although counts of band-tailed pigeons present at several mineral sites in Western Oregon during August, reported annually since 1956 by the Oregon Department of Fish and Wildlife, have shown a substantial reduction in the numbers of pigeons at most sites in recent years, information concerning daily and seasonal associations between band-tailed pigeons and mineral sites was not available.

This study was designed to determine the patterns of utilization of mineral sites by band-tailed pigeons. Specific objectives were to: (1) determine seasonal patterns of use of mineral sites by age and sex classes of band-tailed pigeons; (2) determine productivity of band-tailed pigeon populations using specific mineral sites; (3) determine fidelity of band-tailed pigeons to specific mineral sites during the reproductive period; (4) determine sizes of local populations of band-tailed pigeons associated with individual mineral sites.

STUDY SITES

My research was conducted at three mineral sites in central Western Oregon (Figure 1). The Long Tom study site, approximately 27 km south of Corvallis, included a mineral outcropping on a gravel bar in the Long Tom River. The Finley study site was located on the William L. Finley National Wildlife Refuge, approximately 5.6 km northwest of the Long Tom study site and included three areas of exposed soil which were used by pigeons. The Nashville study site was located approximately 45 km northwest of the Long Tom site and included an artesian mineral spring on the west bank of the Yaquina River. The Long Tom and Finley mineral sites, frequently referred to collectively as the Valley sites, were similar in elevation (approximately 61 m) and vegetation; dominant tree species at both sites were Oregon white oak (Quercus garryana), big-leaf maple (Acer macrofolium), hawthorne (Crataegus oxyacantha) and Cascara (Rhamnus purshiana). In contrast to the Valley sites, the Nashville site was higher in elevation (approximately 183 m) and differed in the type of dominant tree species, Douglas fir (Pseudotsuga menziesii) and red alder (Alnus rubra). Hunting of pigeons occurred between 1-30 September at the Long Tom and Nashville mineral sites; hunting at the Finley site was prohibited in 1970.

Figure 1. Locations of study sites in Western Oregon.


NASHVILLE SITE
YAQUINA R.
MARY'S RIVER
CORVALLIS
MARY'S PK.
1 1
39.4 km
FINLEY SITE
5.6 km
LONG TOM R.
LONG TOM SITE
MONROE

METHODS

Wing Marking Program

Band-tailed pigeons were trapped once a week at each mineral site when possible. Trapping periods were 7 July to 31 August 1974, 23 June to 31 August 1975 and 9 July to 18 August 1976. Rocket nets (6 x 9 m and 12 x 18 m) were used to capture nearly all pigeons trapped during this study. Mist nets (10.2 cm mesh) were used during 1974 with limited success. Pigeons were trapped as they were consuming mineral resources. Age class (adult or immature) of most pigeons captured was determined by the presence (adult) or absence (immature) of a white nape stripe (Grinnell et al. 1918), and by wing plumage (Silovsky et al. 1968). Pigeons classed as second-year birds (yearlings) in 1975 and 1976 had complete white nape stripes, white-tipped upper wing converts, had molted at least six juvenile primaries, and had some but not all juvenile secondaries. Since some yearling pigeons could not be correctly identified due to advanced stages of molt, I used the numbers of yearlings only as minimal values for comparisons among sites and years. The sex of all adult pigeons captured was determined by plumage coloration (Gabrielson and Jewett 1940) or cloacal characters (Miller and Wagner 1955). All pigeons were marked with two 2.8 cm x 11.3 cm patagial tags made from a plasticized nylon fabric (Day-Glo Saflag,

Safety Flag Company of America; and Herculite 20, Vaughn Bros.). Tags were attached to the patagia with 1.2 cm nylon double-T-end tabs (Buttoneer, Dennison Manufacturing Co.). Stainless steel pins were also used for attachment of tags in 1975 and 1976 because of the high rate of loss of tags attached only with nylon tabs. All tags had a one letter-one numeral code to allow identification of individual pigeons. A U.S. Fish and Wildlife Service metal leg band was attached to each tagged pigeon.

Observations of pigeons at the mineral sites began on 8 July 1974, 23 June 1975 and 16 June 1976 and continued through September at the Finley site. The hunting season for band-tailed pigeons began 1 September forcing termination of observations at the Long Tom and Nashville sites. Observations occurred at approximately 3 day intervals at each site in 1974, but were conducted daily at each site in 1975 and 1976. Observations occurred continuously between sunrise and 1200 h except when trapping disturbed the routine. Observations were limited to the morning hours as preliminary data collected during all diurnal periods indicated nearly all pigeons which visited mineral sites each day initially arrived at the sites prior to 1200 h.

Data recorded throughout each observation period included: times of arrival and departure of pigeons at the sites, number of pigeons in each group arriving or leaving the sites, time of initial sightings of tagged birds, timing of consumption of mineral resources,

and miscellaneous activities (sunning or bathing behavior, feeding behavior, response to predators and courtship behavior). Temperature, estimation of wind velocity and cloud cover, number of pigeons present, and numbers of pigeons engaged in various states of behavior (preening, resting, feeding, using mineral and courtship behavior) were recorded at one-half hour intervals during the observation periods in 1975 and 1976. Numbers of adult and immature pigeons were recorded at 15 min intervals during observation periods in 1975 and 1976. The presence or absence of the white nape stripe was used to determine age of pigeons for quarter-hour counts and only pigeons for which the nape of the neck could be clearly seen were included in those counts. All observations were made with binoculars (7-10X) or spotting scopes (20-80X).

Estimation of Percent Immature

The percentages of the total numbers of pigeons visiting the mineral sites each day which were immature were weighted averages derived from the quarter-hour counts of adults and immatures. Weekly estimates of percent immature at each site were calculated as unweighted means of the seven daily estimates. Hatching dates of immatures captured were determined from the sequence of molt of primary feathers (White 1973).

Estimation of Sizes of Populations Associated with Mineral Sites

Estimates of sizes of pigeon populations associated with each mineral site in 1976 were derived using two methods: A modified Lincoln Index technique (Overton 1969) and a Probability of Occurrence Index. The Lincoln Index formula used was:

$$P_{xi} = \frac{M_x n_{xi}}{m_{xi}},$$

where P_{xi} = estimated population size at site x during week i; M_x = total number of birds tagged in 1974 or 1975 which visited site x at least once in 1976; n_{xi} = mean daily number of adults visiting site x during week i; and m_{xi} = mean daily number of tagged pigeons observed at site x during week i.

Population estimates were also determined by:

$$P_{xi} = \frac{n_{xi}}{O_x},$$

where P_{xi} and n_{xi} were the same as previously described; and O_x = probability of occurrence of pigeons at site x. Probabilities of occurrence (O_x) were calculated for tagged pigeons using the mineral sites by:

$$O_{xi} = \frac{D_{xi}}{A_{xi}} \quad \text{and} \quad O_x = \sum_{n=1}^{i} O_{xi} ,$$

where O_{xi} = the probability that the ith pigeon visited site x on any given day between 16 June and 31 August 1976; D_{xi} = number of days the ith individual was sighted at mineral site x; and A_{xi} = number of days that were available for the ith tagged pigeon to be observed at mineral site x. Sizes of the populations of pigeons associated with the mineral sites during the entire season were calculated as the mean of the weekly population estimates for each site.

RESULTS

During the 3 year period 745 band-tailed pigeons were tagged in 67 days of trapping (Table 1). A total of 571 days of observations at the mineral sites produced 1,945 sightings of 416 different tagged pigeons during the study.

Table 1. Numbers of band-tailed pigeons tagged with patagial markers and observations of tagged pigeons during 1974-1976 at three mineral sites in Western Oregon.

	1974	1975	1976
Number of days trapping occurred	30	31	6
Number of pigeons tagged	259	415	71
Total observation days	78	233	260
Number of different tagged pigeons sighted	66	203	147
Total sightings of tagged pigeons	163	855	927

Pigeons were frequenting the mineral sites when observations began each year. Infrequent observations during late May and early June indicated less than 10 pigeons per day visited each site prior to mid June. The mean daily number of adult pigeons on days with no precipitation (see weather effects) during the period 23 June to 31 August was significantly higher ($t = 7.9$, 9 d.f., $p \leq .05$) in 1976 (51.9) than 1975 (45.4) at the Finley site, significantly lower ($t = 7.7$, 9 d.f., $p \leq .05$) in 1976 (33.8) than 1975 (40.9) at the Long Tom site and not significantly different ($t = 1.45$, 9 d.f., $p \leq .05$) between 1976

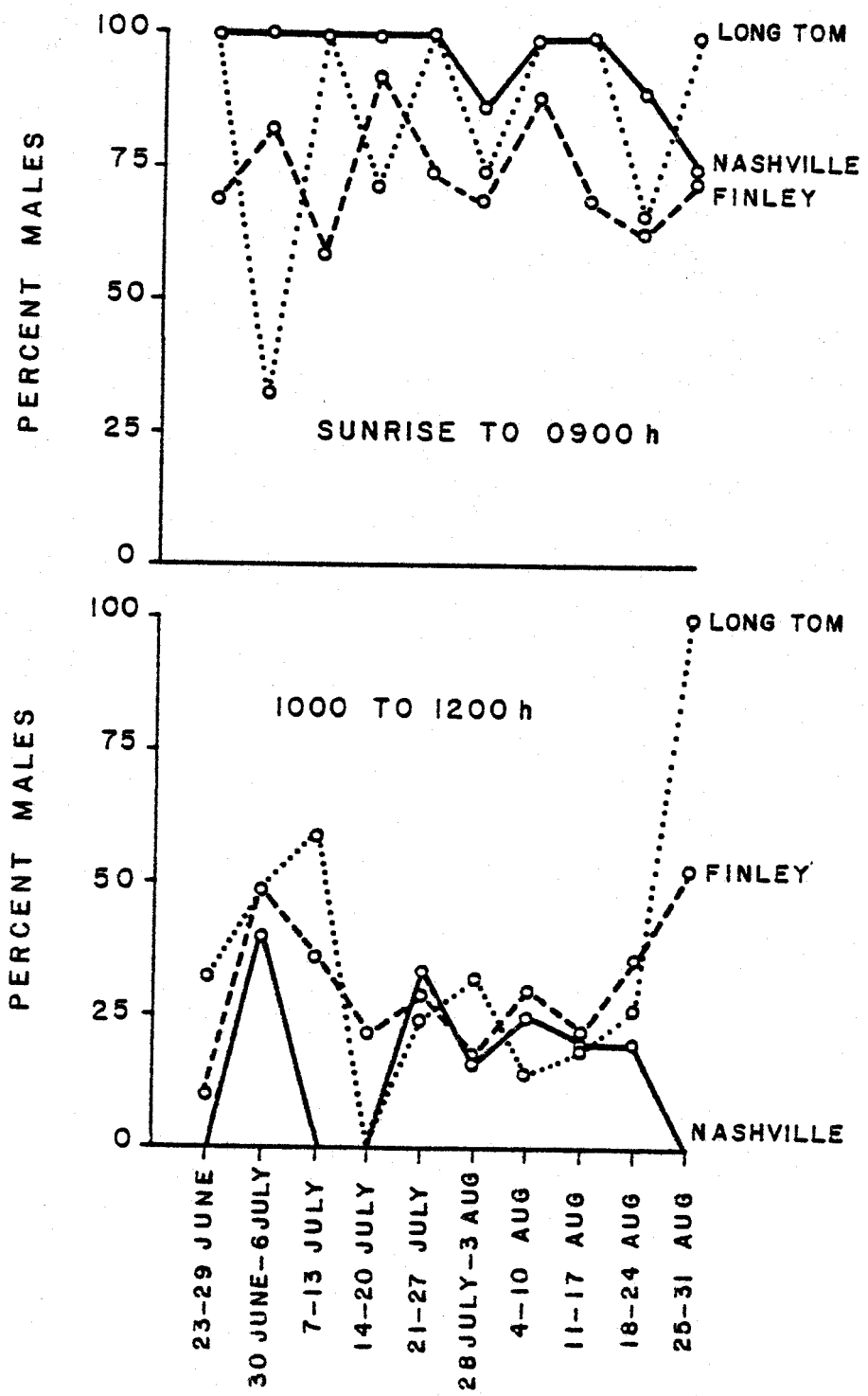
(59.7) and 1975 (57.8) at the Nashville site.

Males arrived at the sites beginning approximately at sunrise (later on cloudy mornings) and comprised about 75 percent of the adult pigeons which arrived prior to 0900 h (Figure 2). Nearly all males left the sites prior to 1000 h. Females comprised about 70 percent of the adults which arrived at the sites between 1000 to 1200 h.

When present at mineral sites, pigeons usually spent 2-3 h in the trees near the mineral resource engaged in various forms of behavior. Most of their time at mineral sites was spent preening or loafing with occasional periods of feeding or social behavior. Normally pigeons used the mineral resources as a flock. Utilization of mineral usually occurred one to five times during a morning period. Duration of mineral consumption lasted from 45 sec to 45 min, averaging 4-5 min. Presence of a pigeon at a mineral site was not synonymous with utilization of mineral as some pigeons visited the sites but did not consume mineral.

Regression analysis of date (day number) and percent of immatures (ARCSIN $\sqrt{\text{percent immature}}$ transformation; Snedecor and Cochran 1967) indicated there was no significant differences between 1975 and 1976 in the rates of increase of immatures at the different mineral sites. The rate of increase of percent immatures at the Long Tom site was significantly higher ($F = 3.63$; d.f. = 8; $p < .05$) than the rate of increase of percent immatures at the

Figure 2. Percentages of males in sightings of tagged band-tailed pigeons during the early morning period (sunrise to 0900 h) and late morning period (1000 to 1200 h) at three mineral sites in Western Oregon during 23 June-31 August 1976.


PERCENT MALES
100
75
50
25
0
LONG TOM
NASHVILLE
FINLEY
SUNRISE TO 0900 h
PERCENT MALES
100
75
50
25
0
1000 TO 1200 h
LONG TOM
FINLEY
NASHVILLE
23-29 JUNE
30 JUNE-6 JULY
7-13 JULY
14-20 JULY
21-27 JULY
28 JULY-3 AUG
4-10 AUG
11-17 AUG
18-24 AUG
25-31 AUG

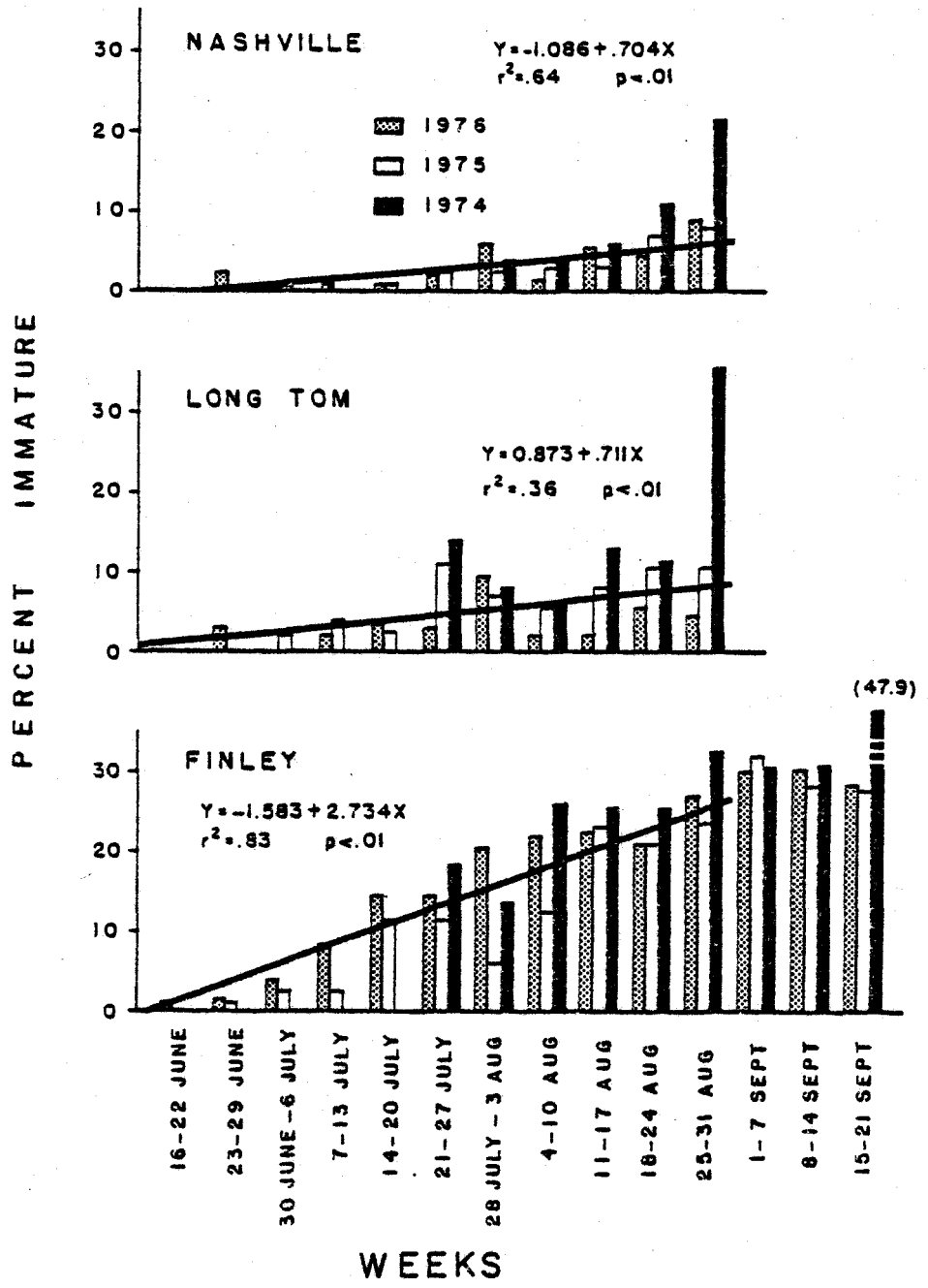
Nashville site, but significantly lower ($F = 6.01$; d.f. = 8; $p < .05$) than the rate of increase of percent immatures at the Finley site (Figure 3).

Effects of Weather

Precipitation significantly reduced the numbers of adults observed at all sites during 1975 and 1976 (Table 2). The effect of rain was even stronger than the analysis suggested, due to the behavior of the birds. Precipitation dramatically reduced the numbers of pigeons observed at the sites, often to zero. However, if pigeons were prevented from obtaining mineral for two consecutive days, a third day of rain had little effect on the numbers of adults visiting the sites. The numbers of adults visiting a site during a third consecutive day of rain often nearly equaled the numbers recorded at that site prior to the rainy days. Thus the desire of these birds for mineral was obviously a strong physiological force in directing their behavioral patterns.

The number of adults visiting a mineral site on a given day was inversely related to the mean percent cloud cover and directly related to the daily high temperature (Table 2). The daily low temperature had a significant adverse affect on numbers of adults only at the Nashville site. Linear correlation coefficients showed the effect of low temperature was minor, however. Barometric pressure and

Figure 3. Percentages of immatures in counts of band-tailed pigeons recorded at three mineral sites in Western Oregon during 1974-1976. Linear regression models include data only from 1975 and 1976. In the regression models, y = estimated percent immatures; x = week of observation.


NASHVILLE
Y=-1.086+.704X
r²=.64 p<.01
1976
1975
1974
LONG TOM
Y=0.873+.711X
r²=.36 p<.01
FINLEY
Y=-1.583+2.734X
r²=.83 p<.01
(47.9)
PERCENT IMMATURE
0
10
20
30
16-22 JUNE
23-29 JUNE
30 JUNE-6 JULY
7-13 JULY
14-20 JULY
21-27 JULY
28 JULY-3 AUG
4-10 AUG
11-17 AUG
18-24 AUG
25-31 AUG
1-7 SEPT
8-14 SEPT
15-21 SEPT
WEEKS

wind velocity had no significant affects on the numbers of adults visiting the mineral sites.

Table 2. Regression coefficients of linear regression models indicating relationships between daily number of adult band-tailed pigeons visiting mineral sites and weather factors during the period 23 June to 31 August. Affect of precipitation on numbers of adults was determined by Student's t-test.

	Location and Year					
	Finley		Long Tom		Nashville	
Weather Factor	1975	1976	1975	1976	1975	1976
High temperature	.52*	.36*	.65*	.18	.36*	.41*
Low temperature	.01	.16	.19	-.09	-.26*	.25*
Mean percent cloud cover	-.39*	-.27*	-.43*	-.30*	-.39*	-.28*
Precipitation (t values)	2.93**	3.61**	4.80**	3.35**	6.05**	3.88**

*F value significant at $p \leq .05$ (1975 d.f. = 1,68; 1976 d.f. = 1,75).
**t value significant at $p \leq .05$.

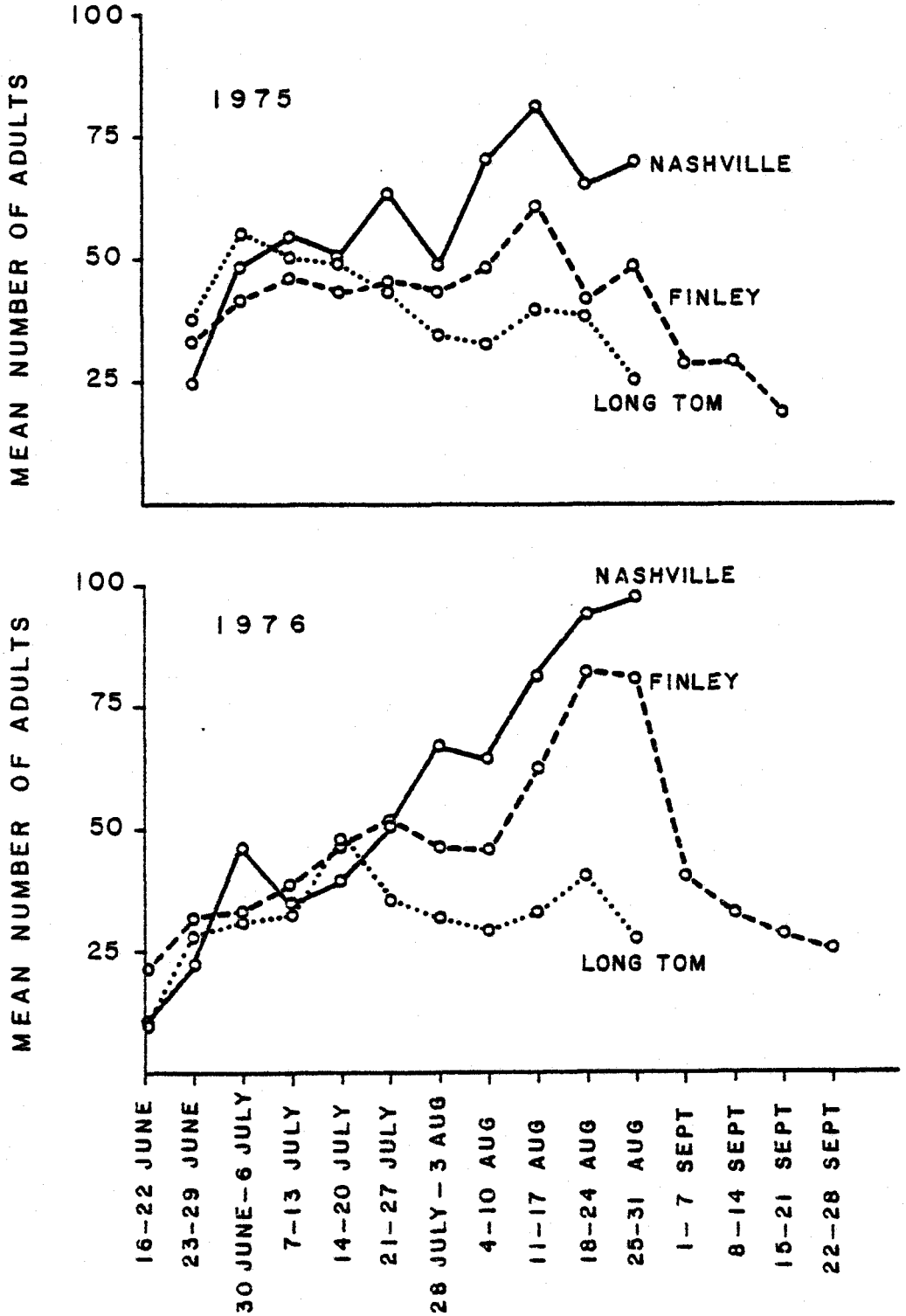
Timing of Reproduction and Productivity

Two major periods of nesting during 1975 and 1976 by pigeons at all mineral sites were indicated by several parameters. However, the chronology of nesting and the resulting productivity varied among sites.

Finley

The mean daily number of adults observed at the Finley site in 1976 peaked during 21-27 July and 18-31 August (Figure 4).

Figure 4. Weekly mean numbers of adult band-tailed pigeons which visited three mineral sites in Western Oregon during 16 June-28 September 1975 and 1976. Values include data only from days during which no precipitation was recorded.


MEAN NUMBER OF ADULTS
100
75
50
25
1975
NASHVILLE
FINLEY
LONG TOM
MEAN NUMBER OF ADULTS
100
75
50
25
1976
NASHVILLE
FINLEY
LONG TOM
16-22 JUNE
23-29 JUNE
30 JUNE-6 JULY
7-13 JULY
14-20 JULY
21-27 JULY
28 JULY-3 AUG
4-10 AUG
11-17 AUG
18-24 AUG
25-31 AUG
1-7 SEPT
8-14 SEPT
15-21 SEPT
22-28 SEPT

Similarly, the percentages of the tagged population observed at the Finley site in 1976 showed peaks during 21-27 July and 18-24 August (Table 3). Occurrence of adults during the 1975 season was relatively constant (mean daily numbers about 45) during 30 June to 4-10 August with an influx of adults during 11-17 August. Declines in the mean daily numbers of adults during the last 2 weeks of August 1975 at all sites probably reflected the affects of 7 days of precipitation during those 14 days; most of the 7 days without rain had high percentages of cloud cover.

Males incubate and brood during the mid-morning to late afternoon period with females at the nest during the remainder of the day (Neff and Neidrach 1947). Thus males and females involved with incubation or brooding were free to visit mineral sites during the early morning and late morning periods, respectively. I assumed males present at mineral sites during 1000 to 1200 h and females present between sunrise and 0900 h were not actively engaged in incubating or brooding of young. Thus percentages of weekly sightings of tagged males during the early morning period and percentages of weekly sightings of tagged females during the late morning period provided an indication of the portion of the population involved in a typical nesting regime. The percentages of pigeons involved with nest duties, as determined by the timing of mineral site visitations, were considered to be maximum estimates as the presence of a bird during

Table 3. Percentages of tagged band-tailed pigeons, tagged in 1974 or 1975 and sighted in 1976, which occurred at three mineral sites in Western Oregon in 1976.

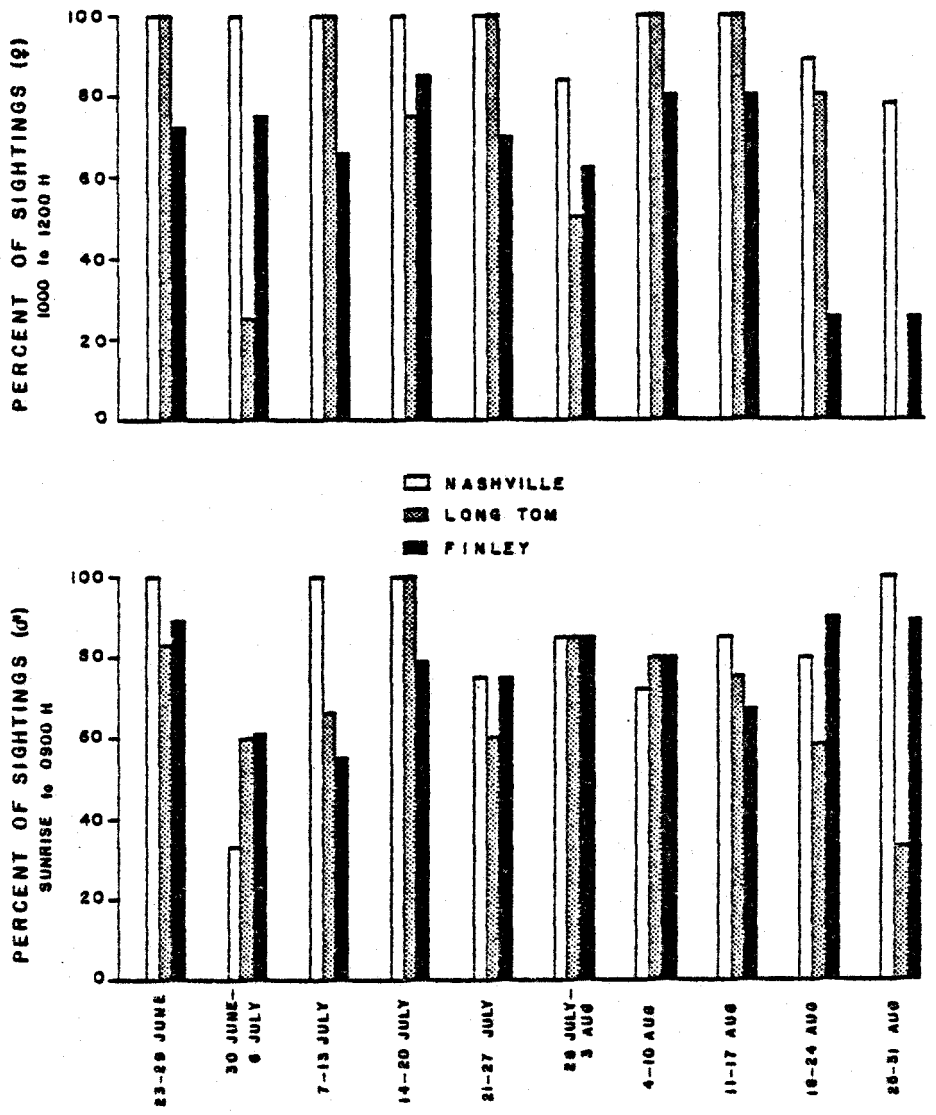
Location	23-29 June	30 June -6 July	7-13 July	14-20 July	21-27 July	28 July -3 Aug	4-10 Aug	11-17 Aug	18-24 Aug	25-31 Aug
Finley (n = 69)	20.3	23.2	21.7	29.0	37.7	30.4	29.0	27.5	40.6	30.4
Long Tom (n = 37)	18.9	21.6	24.3	32.4	21.6	24.3	27.0	27.0	40.5	8.1
Nashville (n = 46)	8.7	19.6	17.4	15.2	34.8	34.8	28.3	26.1	41.3	30.4

a "normal" time period was not necessarily evidence of nesting.

Approximately 25 percent of the tagged birds in the late morning period during mid July to mid August were males; males comprised about 50 percent of the tagged birds in the late morning period during early July and late August (Figure 2). Males not actively engaged with nesting duties, present in late August, likely had completed breeding while males not actively engaged in nesting during July were either between broods or had not begun their initial nesting of the year. Patterns of occurrence of individual males provided evidence of both cases. Some males were sighted in the early morning period during June and subsequently sighted in the late morning period during early July indicating an end of brooding activities. Other males were initially observed during early July, occurring in the late morning period, which indicated some birds associated with mineral sites prior to breeding. Sightings of tagged females also indicated that a few pigeons associated with mineral sites prior to nesting. However, since some pigeons utilized the sites prior to initiation of observations, it was possible that those individuals which appeared to associate with mineral sites prior to nesting had actually completed a nesting attempt.

Approximately 70 percent of the sightings of tagged females were recorded during the late morning period from June through mid August (Figure 5). However, only 25 percent of the females were

Figure 5. Percentages of sightings of tagged female band-tailed pigeons recorded during the late morning period (1000 to 1200 h) and percentages of sightings of tagged male band-tailed pigeons recorded during the early morning (sunrise to 0900 h) period during 23 June-31 August 1976 at three mineral sites in Western Oregon.


PERCENT OF SIGHTINGS (♀)
1000 to 1200 H
100
80
60
40
20
0
NASHVILLE
LONG TOM
FINLEY
PERCENT OF SIGHTINGS (♂)
SUNRISE to 0900 H
100
80
60
40
20
0
23-29 JUNE
30 JUNE-6 JULY
7-13 JULY
14-20 JULY
21-27 JULY
28 JULY-3 AUG
4-10 AUG
11-17 AUG
18-24 AUG
25-31 AUG

present in the late morning period in late August indicating few females were still actively incubating or nesting.

Use of the Finley site by pigeons continued into September; approximately 25 percent of all tagged adults which visited that site during 16 June-31 August 1976 were sighted in September. Of the tagged birds seen at the Finley site during August, 51 percent continued to visit that site in September.

Pigeons which occurred at mineral sites longer than 50 days were assumed to have been involved with multiple nestings, since the length of a typical breeding cycle of band-tailed pigeons was 50 days (Fitzhugh 1974). Approximately 63 percent of the tagged pigeons associated with the Finley site in 1976 had lengths of sighting periods over 50 days, indicating a majority of the adults at that site attempted more than one brood. Possibly an even higher percentage of the Finley population produced multiple broods since some pigeons were frequenting the site prior to 16 June when observations began.

Productivity of pigeons associated with the Finley site was relatively high with large influxes of young occurring during mid July and late August (Figure 3). Immatures comprised 23 percent (1975) and 27 percent (1976) of the birds visiting the site during 25-31 August. However, immatures comprised approximately 30 percent of the pigeons at Finley during the first 3 weeks of September, which indicated some immatures fledged during September.

Long Tom

Pigeons associated with the Long Tom site tended to display evidence of only one nesting during the season compared to two nestings by most adults at the other sites. The mean daily number of adults visiting the Long Tom site was highest during late June (1975) or mid July (1976), decreasing throughout the remainder of the season (Figure 4). Minor increases in daily numbers of adults occurred during mid August in both years, which suggested a small portion of the pigeons at Long Tom may have had two broods. However, numbers of adults frequenting the Long Tom site were lowest during the last week of August, which indicated few pigeons completed two broods.

Percentages of sightings of males and females in the early and late morning periods were similar to that recorded at the two other sites until August (Figure 5). The percentages of sightings of males not engaged in nesting (occurring in late morning period) increased steadily throughout the last 3 weeks of August, which suggested termination of nesting activities by the majority of the male segment of the population. Sightings of tagged females at the Long Tom site also indicated little brooding of young occurred in late August, as there were no sightings of tagged females at the Long Tom site after 24 August.

The occurrence of immatures at the Long Tom site indicated that the majority of the production occurred during the initial nesting period in May. The percentages of immatures were highest during late July in both 1975 (11 percent) and 1976 (9 percent). Increases in the percentages of immatures also occurred in late August but did not equal the percentages recorded in July. Of immatures captured at the Long Tom site during August 1974 and 1975 (Figure 6) only 25 percent hatched during July, compared to 62 percent and 57 percent of the immatures captured in August at the Finley and Nashville sites, respectively. The mean hatching date for immatures captured during August at the Long Tom site was 9 June which was two weeks earlier than mean hatching dates of immatures captured during August at Finley (25 June) and Nashville (26 June).

Nashville

Pigeons associated with the Nashville mineral site were quite variable in their chronology of breeding compared to Valley populations. Initial sightings of some tagged birds occurred at Nashville during all but the last week (25-31 August) of the study period (Figure 7). The mean daily numbers of adults at the Nashville site (Figure 4) also suggested a relatively steady increase in the numbers of breeding pigeons throughout the season. The increase in the mean daily numbers of adults observed at the Nashville site during the last 3 or 4

Figure 6. Percent distribution of estimated hatching dates of immature band-tailed pigeons captured during August at three mineral sites in Western Oregon in 1974 and 1975.

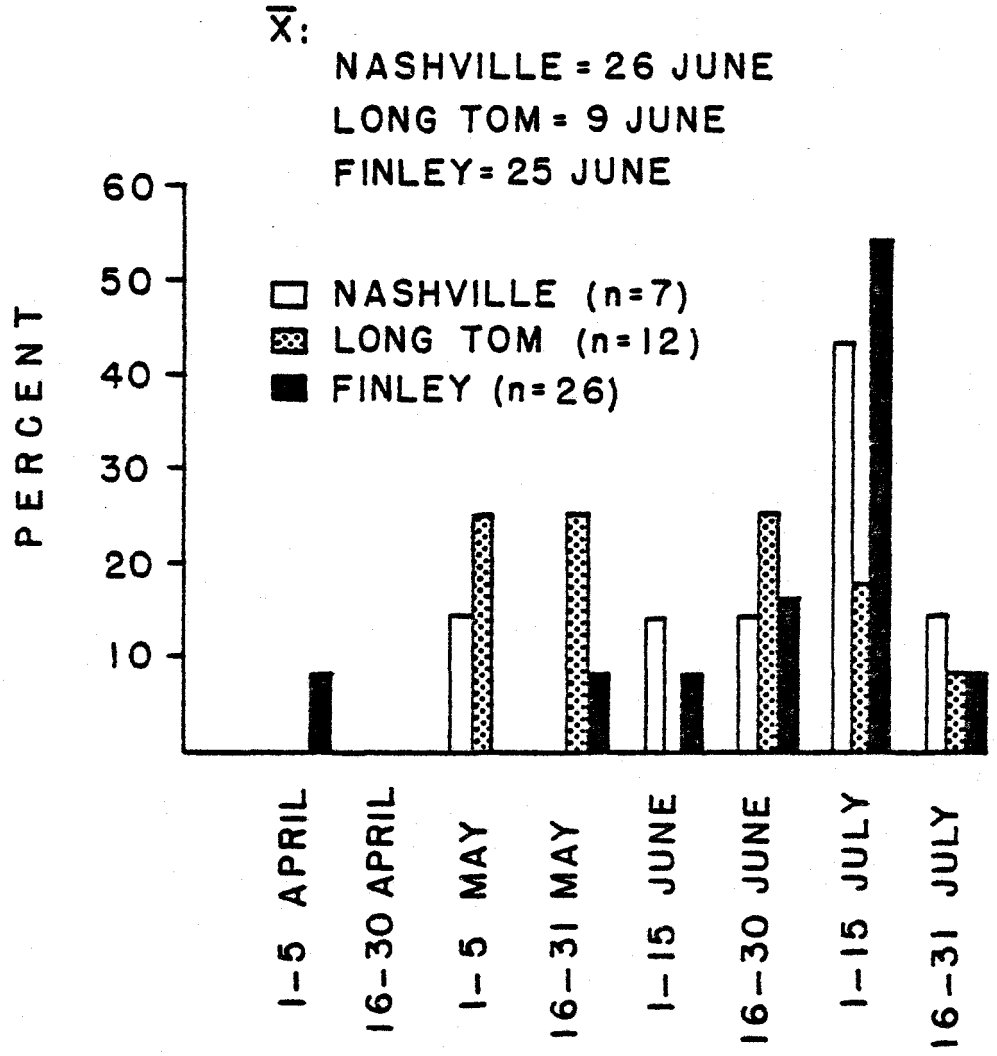
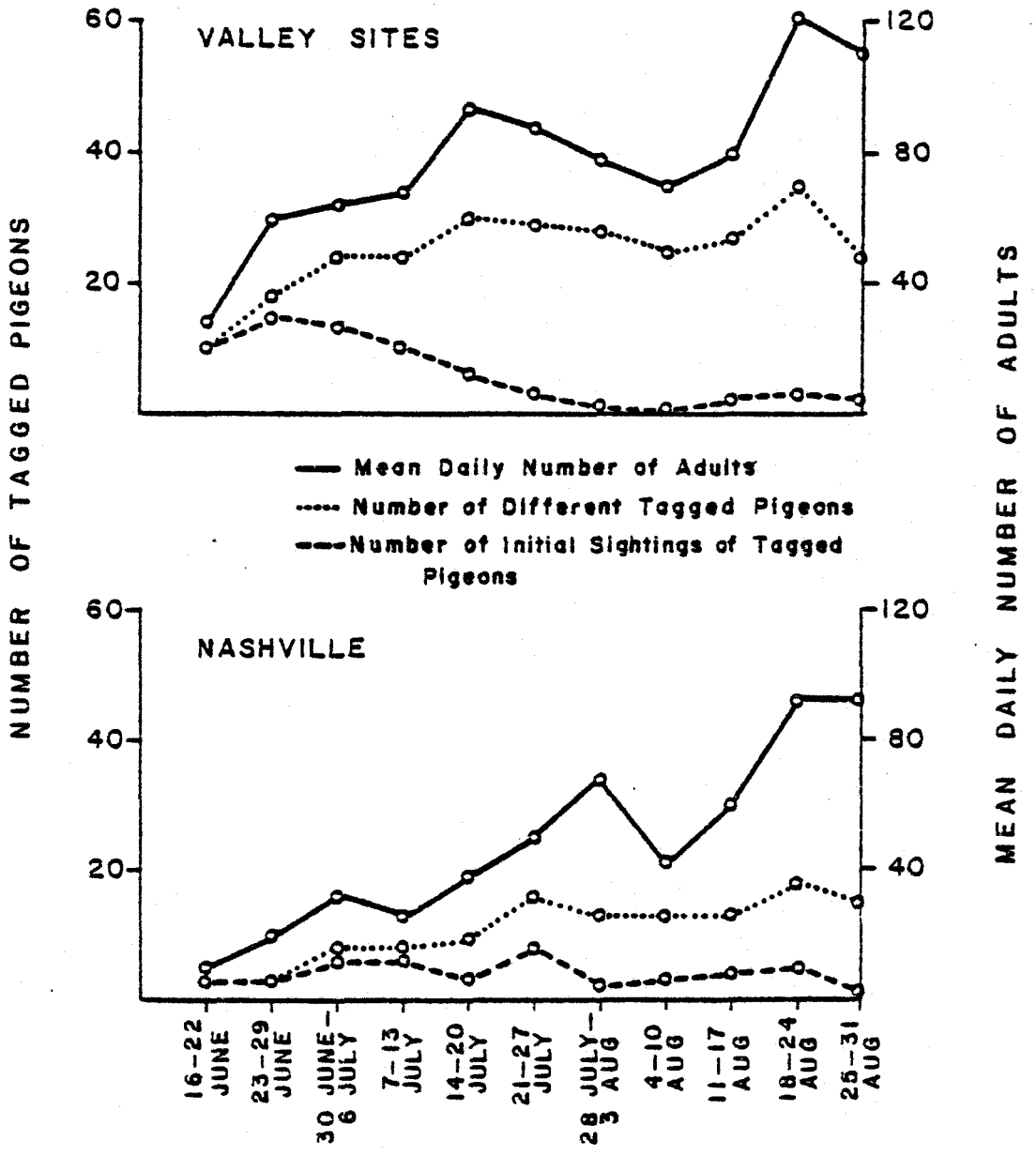

X̄:
NASHVILLE = 26 JUNE
LONG TOM = 9 JUNE
FINLEY = 25 JUNE
NASHVILLE (n=7)
LONG TOM (n=12)
FINLEY (n=26)
PERCENT
60
50
40
30
20
10
1-5 APRIL
16-30 APRIL
1-5 MAY
16-31 MAY
1-15 JUNE
16-30 JUNE
1-15 JULY
16-31 JULY

Figure 7. Weekly numbers of different tagged band-tailed pigeons visiting mineral sites, numbers of initial sightings of tagged pigeons, and mean daily numbers of adult band-tailed pigeons at the Valley (Finley and Long Tom combined) sites and the Nashville site during 1976.


VALLEY SITES
NASHVILLE
NUMBER OF TAGGED PIGEONS
MEAN DAILY NUMBER OF ADULTS
60
40
20
120
80
40
Mean Daily Number of Adults
Number of Different Tagged Pigeons
Number of Initial Sightings of Tagged Pigeons
16–22 JUNE
23–29 JUNE
30 JUNE–6 JULY
7–13 JULY
14–20 JULY
21–27 JULY
28 JULY–3 AUG
4–10 AUG
11–17 AUG
18–24 AUG
25–31 AUG

weeks of August (Figure 4) may have been at least partially due to the nesting of the yearling segment of the population. Pigeons were not classed as yearlings during 1974 and relatively few pigeons were trapped in 1976. Yearlings initially visited the Nashville site during 14-20 July and comprised from 13 to 15 percent of the birds visiting the site during late July to mid August 1975 (Table 4). Yearlings thus tended to nest later than many, if not most, adults in the Nashville population. Fitzhugh (1974) reported yearlings generally nested later than adults and yearling attempted only a single nesting.

Cessation of nesting duties by some adults was evident during late July and early August (Figure 5). Females showed a more uniform adherence to the normal time periods than did males. Although the percentages of females sighted in the late morning period declined during the last 2 weeks of August (Figure 5), the highest percentage of tagged females sighted in the early morning period (those females not engaged in nesting) reached only 22 percent in 25-31 August. Thus, nearly 80 percent of the females at Nashville may have been incubating or brooding young when the hunting season began on 1 September.

Recruitment of young into the pigeon population at Nashville, as suggested by the mean daily percentages of immatures visiting the site each week (Figure 3), proceeded in a pattern similar to the occurrence of adults. Few young were seen at Nashville until late

Table 4. Percentages of yearling band-tailed pigeons in weekly groups of pigeons (excluding immatures) trapped during 23 June to 31 August 1975 at three mineral sites in Western Oregon.

Location	23-29 June	30 June -6 July	7-13 July	14-20 July	21-27 July	28 July -3 Aug	4-10 Aug	11-17 Aug	18-24 Aug	25-31 Aug	Seasonal Mean
Finley	0	0	10.5	44.44	12.5		3.6	8.7	8.6		9.6
Long Tom	7.7	4.5	23.1	9.5	0		0		0		6.7
Nashville		0	0	6.9	13.0		14.0	15.4	6.3	5.3	10.8
Mean	4.0	3.4	13.9	13.5	10.8		7.8	12.2	6.5	5.3	9.3

July, followed by a gradual increase throughout August with maximum percentages of immatures seen during 25-31 August. An initial peak in percent immatures was recorded during 28 July to 3 August 1976, the same week in which the first tagged females appeared during the early morning period (Figure 5). Much courtship activity was observed at the Nashville site during early August, suggesting remating prior to initiation of the second nesting by some pigeons. Persons living near the Nashville site reported influxes of pigeons occurred during late September which indicated nesting during August by an unknown portion of the pigeon population. If large numbers of pigeons associated with the Nashville site did in fact begin broods during August, percentages of immatures may have increased substantially during September. The highest mean daily percent of immatures was recorded during the last week of August in 1975 (8 percent) and 1976 (9 percent).

Sexual Differences in Seasonal Utilization of Mineral Sites

Differences in the seasonal patterns of utilization of mineral sites by tagged male and female band-tailed pigeons were detected during 1976. Sex ratios of tagged adults observed during June through September 1976 (Table 5) showed an increase in males during the season at the Finley site but no patterns were evident at the Long Tom or Nashville sites. Only 2 of 19 tagged adult pigeons observed

at the Finley site in September 1976 were females; one visited the site for 6 days, arriving each day before 0900 h and the other female visited the site only once in September, arriving at 0932 h.

Table 5. Sex ratios (female:male) of tagged band-tailed pigeons observed at three mineral sites in Western Oregon during 16 June-28 September 1976.

Location	June[a]	July	August	September	June-August Mean
Finley	1.5:1	0.9:1	0.7:1	0.2:1	0.9:1
Long Tom	0.3:1	1.3:1	1.1:1		0.9:1
Nashville	0.7:1	1.2:1	0.9:1		1.0:1
Means	1.0:1	1.1:1	0.9:1		1.0:1

[a]Observations recorded during 16-30 June.

Sex ratios (females:males) observed during the last week of August were 0:1, 0.4:1, and 1.1:1 at the Long Tom, Finley and Nashville sites, respectively, which indicated many females had ceased use of mineral at the Valley sites by late August, probably due to termination of brooding. However, males and females occurred in similar numbers at the Nashville site in late August, which provided additional evidence of relatively later nesting by pigeons in the Nashville area compared to birds in the Valley area.

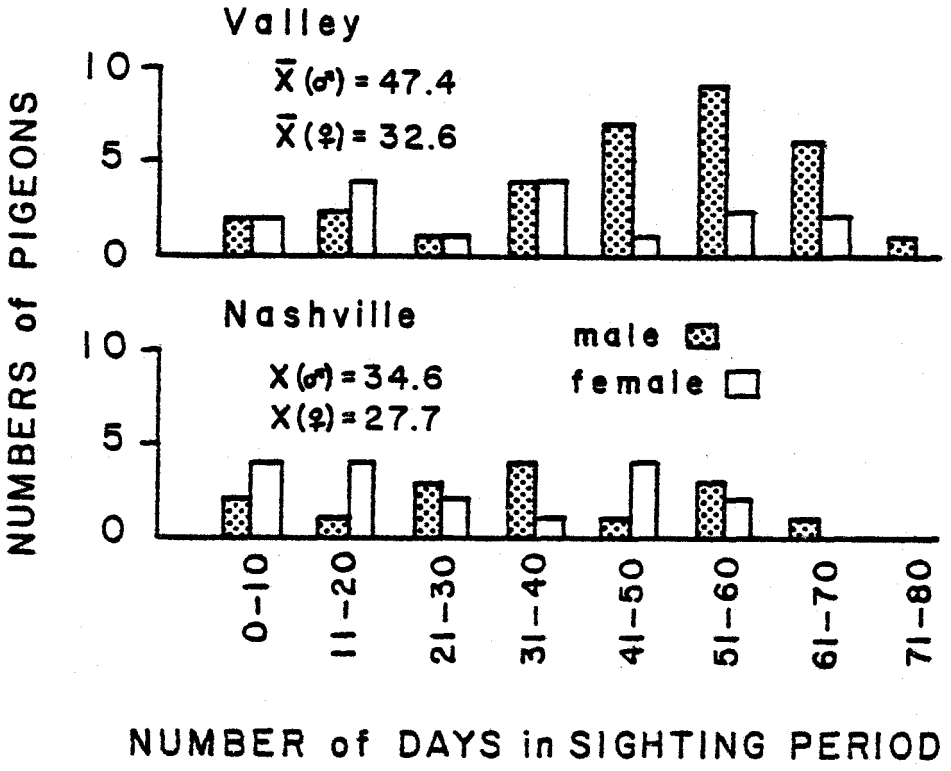
Females at all sites apparently terminated mineral use earlier than males, indicated by the low percentage of sightings of tagged females in the 1000 to 1200 h period during late August (Figure 5). The percentages of males sighted during the late morning period

(indicating termination of nesting) remained low (less than 26 percent) at the Nashville and Finley sites, which suggested at least some males continued to have a requirement for mineral during early September. However, the percentages of males not actively engaged in nesting in the Long Tom population increased throughout August (Figure 5). The increase of males which had ceased nesting duties during August in conjunction with the decrease in numbers of adults during August provided additional evidence of the tendency of the pigeon population associated with the Long Tom site to produce only one brood per season.

The lengths of sighting periods also indicated sexual differences in mineral utilization as the mean lengths of sighting periods for males at the Valley and Nashville sites were 47.4 days and 34.6 days, respectively; females at the Valley and Nashville sites had sighting periods of only 32.6 days and 27.7 days, respectively (Figure 8). Mean sighting periods for males (n = 25) and females (n = 10) associated with the Finley site in 1976 were 61.2 days (± 26.5 days) and 41.9 days (± 32.6 days) respectively, when sightings during September were included. Thus, males exhibited a more prolonged attachment to the mineral resources, often lasting well into September, at least at the Finley site.

Differences in the lengths of sighting periods of pigeons at the Nashville and Valley sites may have been due to later nesting of the

Figure 8. Lengths of sighting periods of tagged band-tailed pigeons (tagged in 1974 or 1975) observed at three mineral sites in Western Oregon during 16 June-31 August 1976.


Valley
$\bar{X}$ (♂) = 47.4
$\bar{X}$ (♀) = 32.6
Nashville
X (♂) = 34.6
X (♀) = 27.7
male
female
10
5
0
NUMBERS of PIGEONS
0-10
11-20
21-30
31-40
41-50
51-60
61-70
71-80
NUMBER of DAYS in SIGHTING PERIOD

Nashville birds. Occurrence of pigeons at the Nashville site in September may have increased the mean lengths of sighting periods to levels approximating those obtained by Valley pigeons, although I had no data to indicate such increases.

Fidelity to Specific Mineral Sites

The use of multiple mineral sites by individual pigeons was analyzed to determine fidelity to mineral sites where the birds were originally encountered. The percentage of pigeons tagged at the Long Tom site which were sighted at the Finley site (interchange) was consistently higher each year than the percentage of pigeons tagged at the Finley site and sighted at the Long Tom site (Table 6). An average of 59 percent of the pigeons tagged at the Long Tom site (which were sighted after being tagged) occurred at least once during the same year at the Finley site. Only 33 percent of the pigeons tagged at the Finley site were sighted at the Long Tom site. Sightings of individual tagged pigeons closely associated with the Long Tom site during 1976 were analyzed for movements of Long Tom pigeons to the Finley site during late August which would have indicated a change in preference of mineral sites rather than termination of mineral requirements. Inspection of the patterns of occurrence of 12 males and 3 females (Table 7) failed to provide evidence of a substantial movement of pigeons from the Long Tom site to the Finley site during late August.

Because pigeons generally did not leave the Long Tom site in favor of the Finley site, I assumed the decline in the numbers of adults at the Long Tom site during August was due to the failure of most birds of that population to initiate second nestings.

Immatures had both the lowest amount of interchange (Finley, 1974; 16.7 percent) and the highest (Long Tom, 1974; 100 percent). However, immatures had the lowest combined percentage of interchange during the 3 year period (47.6 percent). The average percent of interchange for all tagged pigeons at the two Valley sites during the 3 year period was 51.3 percent.

Table 6. Percentages of band-tailed pigeons tagged at the Long Tom and Finley mineral sites (resighted subsequent to tagging) which were sighted at the site at which they had not been tagged, at least once during the year of tagging.

	Year					
Location of Tagging	(N)	1974	(N)	1975	(N)	1976
Long Tom						
Male	(10)	60.0	(34)	61.8	(21)	42.9
Female	(4)	100.0	(13)	53.8	(5)	80.0
Immature	(2)	100.0	(2)	50.0	(2)	50.0
All Classes	(16)	75.0	(49)	59.2	(28)	50.0
Finley						
Male	(21)	23.8	(44)	36.4		
Female	(10)	20.0	(24)	50.0		
Immature	(6)	16.7	(9)	22.2		
All Classes	(37)	21.6	(77)	39.0		

Table 7. Patterns of sightings of tagged band-tailed pigeons closely associated[a] with the Long Tom site during 23 June-31 August 1976.

Individual Code	Sex	Weeks of Period									
		1	2	3	4	5	6	7	8	9	10
Green R-6	M		W[b]				L[c]	L		LW	L
Green T-1	F				L	L		L		W	
Green T-9	M			L	L	LW	L	W		L	
Green X-2	F				L				L		
Black J-9	M				L		L				
Black J-0	M	L	W	L	W			LW	L		
Black P-2	M	L						L		LW	LW
Black S-8	M	L		L	L	L			L	L	
Blue J-2	F	LW			L				L	L	
Blue P-4	M		L						L	L	LW
Blue R-5	M			L		L	L			L	
Blue T-0	M			L	W		L				L
Blue X-1	M	LW	L	L	L		L	W	L		
Red S-4	M	L		L							
Red E-0	M			L	L	L	L	L		W	W

[a]Pigeons "closely associated with the Long Tom site" were those birds sighted at least three days in 1976 with the majority of sightings recorded at the Long Tom site.

[b]Sightings of pigeons at the Finley site were indicated with "W".

[c]Sightings of pigeons at the Long Tom site were indicated with "L".

Multiple Interchange

A few individuals during 1975 (n = 8) and 1976 (n = 9) visited both the Long Tom and Finley sites during a single morning period. Multiple sightings of individuals comprised only 1.0 percent and 1.5 percent in 1975 and 1976, respectively, of the total sightings of tagged pigeons at the Valley sites. One adult female, tagged at Finley in 1975, had 5 days of multiple sightings in 1976.

Changes from Original Site Among Years

It was difficult to determine changes in "home" mineral sites between years for tagged birds using the Valley sites because of the high rates of interchange. However, three adult females tagged at the Nashville site in 1975 were consistently sighted at the Finley site during 1976. No pigeons were observed to have moved from the Nashville site to the Valley sites between 1974 and 1975, although a female tagged during 1974 at the Finley site was sighted once at Nashville in 1975. Some pigeons apparently had different "home" mineral sites during different breeding seasons. One male pigeon, tagged as a yearling in 1974 at the Long Tom site and sighted twice at the Long Tom site in 1974, was observed during May, September and October 1976 at a feeding station in Kent, Washington (personal communication, Fred Martinson). An adult female, tagged in 1975 at the

Nashville site, was sighted near Salem, Oregon during June 1976 but was not sighted at any study area in 1976.

Estimated Percent Returns

Return of pigeons in successive years to their original sites was quite high (Table 8). The percent returns in later years of birds tagged in 1974 and 1975 were calculated using:

$$F = \frac{O_{ix}}{p_x s r_a},$$

where F = percent return; p_x = number of tagged pigeons known to remain in the population subsequent to tagging during base year x; s = annual adult survival (70 percent; Wight et al. 1967); r_a = estimated percent retention of patagial tags for 1 and 2 year periods (a); and O_{ix} = number of band-tailed pigeons encountered (by trapping or observation) during year i which were previously tagged in base year x. The estimated percent tag retention between 1974-1975, 1974-1976 and 1975-1976 was 68 percent, 41 percent and 75 percent, respectively.

Females tended to display greater fidelity to mineral sites among years than males (Table 8). Estimations of the number of females available during successive years were obviously low. The differences in the percent returns of males and females tagged in 1974

and sighted in 1976 were likely due to a small sample size (only four pigeons tagged in 1974 were sighted in 1976).

Table 8. Percent of tagged band-tailed pigeons estimated to have survived 1 or 2 years after tagging, which were encountered at the mineral site(s) where tagging had originally occurred.

Year and Location Where Tagged	(N)[a]	Percent Returning in: 1975 Male	1975 Female	1976 Male	1976 Female
1974					
Valley	52	69	86	60	100
Nashville	26	60	133	25	300
1975					
Valley	145			74	81
Nashville	74			95	111

[a]Number of tagged band-tailed pigeons which were encountered at least once after tagging.

Estimates of Sizes of Populations

Although the estimates of sizes of pigeon populations associated with the study sites in 1976 were higher when derived from the Probability Indices than when estimated by the Lincoln Index method, the estimates of population sizes were approximately in the same relative proportions among sites with both methods of estimation (Table 9).

Table 9. Estimates of sizes of band-tailed pigeon populations associated with three mineral sites in Western Oregon in 1976.

Location	Method of Estimation		95% Confidence Interval
	Probability Index	Lincoln Index	
Finley	501	370	306 - 434
Long Tom	892	543	402 - 684
Nashville	1107	868	675-1061

DISCUSSION

Seasonal Patterns

Numbers of adult band-tailed pigeons visiting mineral sites varied throughout the summer and were apparently related to nesting activities. Numbers of immature pigeons corresponded to the numbers of adults at each site, increasing throughout the summer at the Nashville and Finley sites but was highest during July at the Long Tom site.

Sex ratios of tagged pigeons visiting mineral sites during this study indicated approximately equal numbers of males and females visited the sites during June through August. However, males used mineral resources for longer periods than females and many males continued to frequent mineral sites after most females had discontinued use of mineral. The apparent difference in mineral requirements between males and females may be related to the ability of females to store calcium as medullary bone prior to the breeding season (Keyes and Potter 1934). Loss of calcium through production of eggs and crop milk by females may be replenished from absorbtion of medullary bone supplemented by terrestrial sources, whereas males apparently rely totally upon mineral sites to compensate for loss of calcium through production of crop milk. March and Sadleir (1975) reported a continuous decrease in the ratio of females to males in

pigeon populations frequenting mineral sites in British Columbia from May (5.8 females:1 male) through September (0.6:1). However, their data were apparently derived from collections of pigeons visiting mineral sites between 1000 and 1200 h (March and McKeown 1973), a time period predominated by females until September. Thus sex ratios reported for May through August (March and Sadleir 1975) likely represented only males which had completed brooding or were between nestings; the September sex ratio probably was additionally influenced by the disappearance of females from the mineral sites.

Productivity

Productivity, as depicted by age ratios recorded during the last week of August, was higher for birds using the Finley site (0.33 young per adult) than for pigeons associated with the Nashville (0.11 young per adult) or Long Tom (0.11 young per adult) sites. Results indicated most pigeons associated with the Finley site attempted two nestings during the summer with most males and some females still using mineral during late August. Most pigeons associated with the Long Tom site probably nested only once during the season and adult pigeons were nearly absent from that site by late August. A large portion of the population of pigeons associated with the Nashville site may have begun broods during mid August, resulting in substantial numbers of immatures fledged during September but not observed

at the mineral site because of disturbance from hunting activities. Multiple nestings by band-tailed pigeons were reported in British Columbia (March and Sadleir 1970), California (MacGregor and Smith 1955) and Arizona (Fitzhugh 1974), although Glover (1953) reported most pigeons in northwestern California nested only once per season.

Continued association of females with the Nashville site through late August and increasing daily numbers of both adults and immatures in late August (Table 10) supported the conclusion that many pigeons in the Nashville population were involved with nesting activities during early September. I assumed a direct relationship existed between the percentage of sightings of tagged females which occurred in the late morning period during 25-31 August (25 percent at Finley) and the percent increase in percent immatures recorded during September (20 percent at Finley). Since 78 percent of the sightings of tagged females at the Nashville site during 25-31 August occurred during the late morning period a 62 percent increase (25:20 = 78:62) in the percent immatures may have occurred at the Nashville site during September. Total productivity by pigeons at Nashville may have been 15 percent immature, since immatures comprised 9 percent of the population present in the last week of August (1.62 x 9). Thus approximately 38 percent of the immatures produced by pigeons at the Nashville site may have been fledged during September.

Table 10. Summary of comparative aspects of band-tailed pigeon populations associated with three mineral sites in Western Oregon during 1976.

Aspects of Mineral Site Utilization	Finley	Long Tom	Nashville
Weekly period of peak numbers of adults	18-24 Aug	14-20 July	25-31 Aug
Percent of peak numbers of adults which occurred during 25-31 August	98	57	100
Sex ratios (female:male) during 16 June-31 August	0.9:1	0.9:1	1.0:1
Sex ratios (female:male) during 25-31 August	0.4:1	0:1	1.1:1
Percent of sightings of tagged females which occurred in 1000-1200 h period during 25-31 August	25	0[a]	78
Weekly period of initial peak of percent immature and mean daily number of young present ( )	14-20 July (6)	28 July-3 Aug (3)	28 July-3 Aug (4)
Weekly period of second peak of percent immature and mean daily number of young present ( )	25-31 Aug (22)	18-24 Aug (3)	25-31 Aug (8)

[a]No tagged females were sighted at the Long Tom site during 25-31 August 1976.

Late nesting of pigeons associated with the Nashville site was indirectly indicated by the occurrence of yearlings at that site. Yearlings comprised a higher proportion of the breeding population during mid August at the Nashville site as compared to the Finley site, although the mean hatching dates of immatures captured at the two sites during August were nearly identical. If a substantial proportion of immatures fledged during September then the bulk of the yearlings at Nashville would likely breed somewhat later than yearlings at the Finley site. Occurrence of yearlings at the Long Tom site reflected breeding patterns of pigeons associated with that site. Since the majority of immatures produced by pigeons at the Long Tom site were fledged during late July, most yearlings occurred earlier than at the Nashville or Finley sites.

Although breeding of pigeons associated with the Valley sites was nearly completed by the end of August, estimated hatching dates of immatures collected throughout Western Oregon indicated large numbers of birds were probably utilizing mineral sites during early September. The average hatching dates of immatures harvested throughout Western Oregon in 1974 and 1975 (n = 168) was 2 July (unpublished data). However, the mean hatching date for immatures harvested in the South Valley region (which included the Finley and Long Tom mineral sites) was 21 June. Since the mean hatching data of all immatures harvested in Oregon during September was

approximately 11 days later than that of immatures harvested in the South Valley region, a high percentage of pigeons breeding in Oregon probably required mineral for nearly 2 weeks longer than did pigeons associated with the Finley site. Pigeons at the Finley site showed a strong affinity for mineral during late August, indicating most pigeons breeding in Oregon would have been physiologically attached to mineral sites during the first 2 weeks of September. Therefore, productivity of band-tailed pigeons using the Nashville site, as described in this paper, may be most representative of band-tailed pigeons breeding in Oregon.

Fidelity

Mineral sites attracted reasonably well defined populations of band-tailed pigeons during the breeding season (June-September). High fidelity of adults to mineral sites among years and within years was determined from observations of tagged pigeons during this study. Sexual differences in fidelity were noted, although the results may have been influenced by the small sample sizes. High affinity of adults to breeding areas was reported by Edminster (1954) and MacGregor and Smith (1955). Braun (1972) reported a return rate of 92 percent among years for adult pigeons breeding in Colorado; immatures reportedly had high fidelity to natal areas.

Sizes of Populations

Sizes of band-tailed pigeons populations ranged from 370 ± 64 at the Finley site to 868 ± 193 at the Nashville site. Mean daily numbers of pigeons visiting the sites during 1975 and 1976 showed a decrease in the population at the Long Tom site, an increase in the size of the population at the Finley site and no change in the Nashville population between years.

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