bridge Univ. Press, Cambridge. (Colored copies only)

GRINNELL, J., AND T. I. STORER. 1924. Animal life in the Yosemite. Univ. California Press, Berkeley.

MICHENER, H., AND J. R. MICHENER. 1928. What color is the eye of a Bush-tit? Condor 30:133–135.

PHILLIPS, A. R. 1958. Las peculiaridades del sastrecito (*Psaltriparus*, Familia *Paridae*) y su incubacion. An. Inst. de Biol. 29:355–360.

PHILLIPS, A. R., J. MARSHALL, AND G. MONSON. 1964. The birds of Arizona, Univ. of Arizona Press, Tucson.

RAITT, R. J. 1967. Relationships between black-eared and plain-eared forms of Bushtits (*Psaltriparus*). Auk 84:503–528.

SWARTH, H. S. 1929. The faunal areas of Southern Arizona: A study in animal distribution. Proc. California Acad. Sci. 18:267–383.

VAN ROSSEM, A. J. 1935. A note on the color of the eye of the Bush-Tit. Condor 37:254.

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CLUTCH SIZE OF THE SPRUCE GROUSE, *CANACHITES CANADENSIS FRANKLINII*, IN SOUTHWEST ALBERTA

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There has been very little documentation of clutch size of Spruce Grouse (*Canachites canadensis*). Rand (1947) summarized the early clutch size information for *Canachites*; however, some of the data presented were of questionable value. Johnsgard (1973) recently reviewed clutch-size data and the paucity of information is apparent. The report by Tufts (1961) for 39 nests of *C. c. canace* located during 1922–40 is the most extensive set of data for a single locality. Information for *C. c. franklinii* has been particularly lacking; I know of four published accounts for a total of only five nests (Dawson 1897; Bent 1932; Reed 1965; McCourt et al. 1973).

This note reports on clutch size of *C. c. franklinii* from nests located during a population study in 1970–73. All nests were found in predominantly lodgepole pine (*Pinus contorta*) forest within an 8 km radius of the R. B. Miller Biological Station (50° 39′ N, 114° 39′ W), approximately 27 km W of Turner Valley, Alberta. Most nests were found by trained English pointer dogs.

Clutch size for 21 nests is presented in table 1. These nests were considered complete because the number of eggs remained constant between two or more counts (18 nests) or because clocker droppings (enlarged fecal droppings that result from infrequent defecation by an incubating hen) were present in the vicinity of the nest (three nests). Counts of eggs in the above 18 nests were made at least 3 days apart for 15 nests; for the remaining three nests the counts were only 1–2 days apart, but the female exhibited a very strong behavioral attachment to the nest. For all nests the count of egg shells after hatch or nest destruction did not exceed the number earlier recorded for complete clutch. The range in clutch size (table 1) was two to six eggs, with a mean of 4.9 for adults and yearlings combined. A clutch of five was found most frequently. Data of all years have been pooled to compare clutch size of adults (2 or more years old) and yearlings (1 year old). Clutches averaged 5.0 and 4.6 eggs for adults and yearlings, respectively, and this difference was not statistically significant ($P > 0.05$). The number of clutches was not sufficient to test for differences between years.

An additional nine nests provided clutch-size data. The number of eggs recorded for these nests was not, however, used to represent full clutch for a variety of reasons, principally because of the known, earlier destruction of at least one egg and insufficient counts of eggs. Caution was needed in recording a clutch as complete because females have been observed to continue incubating after their clutch was partially destroyed. Field evidence suggested that all nine nests were beyond the early stages of laying when found, and the range of clutch size, four to six with a mean of 4.8, was within the range for completed clutches (table 1).

Clutches from renestings are included in table 1. The two-egg clutch of an adult was possibly a renest; this female was known to have laid five eggs the previous year. Two adults laid clutches of four eggs, and I believe one was the result of renesting because of the very late hatch date (25 July). The other four-egg clutch by an adult was a known renest. The original nest of this female, with one egg, was located on 6 June 1972; on 9 June the nest was found to be destroyed. Her new nest was located on 10 June with one egg, and four eggs were eventually laid. The short time span within which the two nests were initiated indicates that any sample of nests may include some clutches of renests. A clutch may result from renesting yet fit within the normal distribution of hatch dates.

Rand (1947) suggested that brood size should give a minimal estimate of clutch size. More than 100 different broods were sighted during this study, and of these there were five broods in which seven or more chicks were seen in a single sighting. However, mixing of chicks between broods is known to occur in *C. c. franklinii* (Keppie, unpubl. data), and such mixing accounted for the large chick counts in three of the above broods and the possibility exists for the other two. Juveniles that changed broods were at least 11 days of age, and perhaps counts of younger chicks would be free of this bias. Movements between broods may be infrequent, but such changes may alter the accuracy of estimates of clutch size from brood size and these estimates should be used with caution.

Although the maximum clutch recorded in this study was six eggs, there is other evidence that larger

TABLE 1. Clutch size of *C. c. franklinii* in southwest Alberta, 1970–73. Clutches recorded were known to be complete.

Age of female	Clutch size 2	3	4	5	6	N	Mean	Standard deviation
Adult	1	0	2	4	5	12	5.0	1.20
Yearling	0	1	2	4	1	8	4.6	0.93
Age unknown	0	0	0	1	0	1	5.0	—
Total	1	1	4	9	6	21	4.9	1.06

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clutches may be laid. D. A. Boag (pers. comm.) reported that a yearling female in captivity laid a clutch of seven eggs. Single clutches recorded by Dawson (1897) and Reed (1965) contained seven eggs. In this study 15 broods of six chicks each were sighted. Of these, two hens had a known clutch of six eggs and four broods were known to have chicks from other broods. For the remaining nine broods of six chicks each, there was no evidence that the chicks originated from other broods. In four of these broods the first count of chicks was made at an early age, thus the opportunity for mixing prior to the count was minimal and it was possible these hens had a clutch greater than six eggs. The truncation of clutch-size data in table 1 does indeed suggest that clutches of seven or more eggs are possible in the wild.

Data collected in this study provide the largest known sample for this subspecies of Spruce Grouse. Clutches presented here are similar to those reported earlier for this grouse: two clutches of seven eggs, one each in Washington (Dawson 1897) and British Columbia (Reed 1965); one clutch of six eggs from Montana (Bent 1932); and two clutches of three and five eggs from the same locality as the present study (McCourt et al. 1973). Unfortunately, in the first three citations above clutch size was merely mentioned in passing; and in all except the five-egg clutch there was no real indication that numbers of eggs recorded were full clutches.

Rand (1947) compiled a listing of 67 clutches, with 2–13 eggs each, from throughout the distribution range of *Canachites*. These data were taken from 19 different sources or locations and all collections but one (Tufts 1961) were of four clutches or less. Using the data provided by Tufts ($N = 39$), I calculated a mean clutch size of 5.8 (range of 4–10 although 38 clutches were between 4 and 7). Tufts' data for *C. c. canace* and those reported here ($N = 21$) for *C. c. franklinii* are significantly different ($P < 0.01$). The only other sizeable sample is for *C. c. osgoodi* by Ellison (1974) in Alaska; he gave a mean of 7.5 eggs (range 4–9) for 26 nests, significantly greater ($P < 0.001$) than the Alberta data.

In view of the most recent findings in Nova Scotia, Alaska, and Alberta, it is difficult to comprehend the clutches listed in Rand (1947) that were greater than 10 eggs. Rather large clutch sizes are often attributed to *Canachites* in the early regional listings of bird species, yet accurate, descriptive data were rarely provided. Further, some clutches listed by Rand were from captive birds, and some eggs were removed after being laid, and so direct comparisons are not really possible. Rand commented that there was little evidence for geographical variation in clutch size. The comparative data now available indicate otherwise, and results for Alaska and southwestern Alberta seem to be an example of increased reproductive potential with increasing latitude.

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LITERATURE CITED

BENT, A. C. 1932. Life histories of North American gallinaceous birds. U.S. Natl. Mus. Bull. 162.

DAWSON, W. L. 1897. A preliminary list of the birds of Okanogan County, Washington. Auk 14: 168–182.

ELLISON, L. N. 1974. Population characteristics of Alaskan Spruce Grouse. J. Wildl. Manage. 38: 383–395.

JOHNSGARD, P. A. 1973. Grouse and quails of North America. Univ. Nebraska Press, Lincoln. 553 p.

MCCOURT, K. H., D. A. BOAG, AND D. M. KEPPIE. 1973. Female Spruce Grouse activities during laying and incubation. Auk 90:619–623.

RAND, A. L. 1947. Clutch size in the Spruce Grouse and theoretical considerations of some factors affecting clutch size. Can. Field Nat. 61:127–130.

REED, C. A. 1965. North American birds' eggs. Dover, New York (Revised ed.). 372 p.

TUFTS, R. W. 1961. The birds of Nova Scotia. Nova Scotia Museum, Halifax. 481 p.

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QUANTIFICATION OF NOCTURNAL PASSERINE MIGRATION WITH A PORTABLE CEILOMETER

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Students of nocturnal bird migration have long sought reliable methods of determining the magnitude of migration. Several techniques are now available. The oldest is the moon-watching method described by Lowery (1951). While accurate results can be obtained with this technique, its use is limited to a few nights each month and is highly weather-dependent. Migration volume can also be measured with long-range surveillance radars (Nisbet 1963a; Gauthreaux 1970) and low-power tracking units (Bruderer 1971), but such sophisticated equipment is available to only a small fraction of those who might wish to know something about the quantity of migration occurring at night.

Gauthreaux (1969) described an inexpensive portable ceilometer unit that can be used to observe the passage of low-altitude nocturnal migration. The narrow beam of light is directed vertically and observations are made with binoculars or a telescope pointed up the cone of light. The briefly illuminated birds can be counted as they pass through the field of observation and their flight directions noted.

Counts of birds during a known time interval can be converted to birds per hour or some other convenient *relative* measure of migration density (e.g., see the temporal patterns presented by Gauthreaux 1969). However, it is preferable to generate measures of migration volume in more absolute terms. Thus, we have worked out methods of quantifying nocturnal migration with the portable ceilometer which yield a measure of migration magnitude in units of birds per