Nesting and brood-rearing characteristics of Chukars in west central Idaho

Andrew J. Lindbloom  
*University of Idaho, Moscow*

Kerry P. Reese  
*University of Idaho, Moscow*

Peter Zager  
*Idaho Department of Fish and Game, Lewiston, Idaho*

Follow this and additional works at: https://scholarsarchive.byu.edu/wnan

**Recommended Citation**  

This Article is brought to you for free and open access by the Western North American Naturalist Publications at BYU ScholarsArchive. It has been accepted for inclusion in Western North American Naturalist by an authorized editor of BYU ScholarsArchive. For more information, please contact scholarsarchive@byu.edu, ellen_amatangelo@byu.edu.
NESTING AND BROOD-REARING CHARACTERISTICS OF CHUKARS IN WEST CENTRAL IDAHO

Andrew J. Lindbloom1,2, Kerry P. Reese1, and Peter Zager3

ABSTRACT.—We analyzed attributes from 23 nests (10 renests) and 46 brood locations of radio-marked Chukars (Alectoris chukar) in the lower Salmon River canyon of west central Idaho in 1995 and 1996. Nesting effort was 100%, apparent nest success was 45%, and estimated time from destruction or abandonment of a nest to initiation of laying a subsequent nest averaged 13 ± 5 days. Average clutch size for 1st nests (14.5 ± 1.0) was greater (P = 0.017) than renests (10.4 ± 1.1). Cover types used by nesting Chukars included grass/forb (48% of nests), rock (43%), and shrub (9%), whereas the most common structure used for nests was rock outcrop (57%). Chukars did not use yellow starthistle (Centaurea solstitialis) habitats differently from what was expected (P = 0.08) for nesting, but birds with broods selected areas with less starthistle (P < 0.001). Chukar broods, which averaged 12.0 ± 1.1 chicks, used shrub and grass/forb cover types approximately equally (43% and 47% of locations, respectively) but rock habitats infrequently (11%).

Key words: Chukar, Alectoris chukar, reproduction, nest, brood, habitat, yellow starthistle, Centaurea solstitialis, Idaho.

Limited research has been conducted on nest site characteristics of Chukars, possibly resulting from the difficulty of finding nests in the wild (Garbleth and Moreland 1953, Christensen 1970). In Nevada, Christensen (1970) found 3 inactive nests, 1 beneath a sagebrush at the base of a hill and 2 hidden among rocks and brush. Harper et al. (1958) found no preference for aspect or cover type in 16 nests in California. In contrast, Garbleth and Moreland (1953) reported nest preference for south-facing slopes in Washington. Mackie and Buechner (1963) observed 24 nests in Washington, but only 4 were complete clutches; no habitat data were reported.

Macro- and microhabitat characteristics, such as slope, cover type, nesting structure, and overhead canopy cover, have not been quantified for Chukar nest sites. Understanding such characteristics, in addition to knowledge of Chukar productivity, would provide biologists with fundamental data to manage local populations and their habitats. Although average clutch and brood size estimates, and dates of laying, incubation, and hatching, exist for Chukars in many western states (e.g., Garbleth and Moreland 1953, Harper et al. 1958, Christensen 1970), data specific to Chukar populations in Idaho have not been reported.

Nest success and renesting of Chukars are poorly documented. Christensen (1970) stated that no convincing data are available to dispute the possibility that Chukars renest. Most reports of Chukar renesting are supported only by the preponderance of late-hatch chicks in the fall, often occurring after an unusually wet spring. Based on evidence of incubation patches present on birds during May, June, and July, Mackie and Buechner (1963) concluded that Chukars do renest.

Data concerning habitats used by Chukar broods are also lacking. Garbleth and Moreland (1953) observed that young Chukars up to the age of 4 weeks do not use rocky terrain for escape as do older birds. Details concerning brood success, brood size, and habitat use during brood-rearing have not been evaluated.

The impacts of invading yellow starthistle in Chukar habitats require immediate attention. An introduced annual knapweed from Eurasia, yellow starthistle has infested approximately 1,215,000 ha in Idaho, California, and Washington, and continues to spread rapidly throughout the Chukar’s range (Callihan et al. 1989).

We conducted a 2-year research project using radio telemetry to address many of the poorly known aspects of Chukar reproduction. We recorded descriptive data important to

1Department of Fish and Wildlife Resources, University of Idaho, Moscow, ID 83844-1136.
2Present address: South Dakota Department of Game, Fish, and Parks, 20541 SD Hwy 1806, Ft. Pierre, SD 57532.
3Idaho Department of Fish and Game, 1540 Warner Avenue, Lewiston, ID 83501.
managers such as nesting chronology, clutch size, nest success, renesting efforts, nest structures, cover types used for nesting and brood-rearing, and physical/vegetal characteristics of nest sites. We analyzed data collected from radioed Chukars to assess whether differences exist between (1) ground cover at nest sites and immediate surrounding areas, (2) physical characteristics (slope and elevation) of nest sites and brood sites, and (3) cover types used by nesting Chukars and by brood-rearing Chukars. We also examined nesting and brood-rearing use of areas heavily infested by yellow starthistle in proportion to availability. Qualitative analyses were completed to assess differences in nest success between years, nesting attempts, nesting structures, and nesting cover types. In addition, the use of habitats for nesting and brood-rearing was compared with habitat availability.

STUDY AREA

Our research was conducted in the canyon grasslands of the lower Salmon River in west central Idaho (45°55'N, 116°22'W), approximately 14 km south of Cottonwood. Boundaries of the 2036-ha study area were delineated by Chukar movements and natural physiographic barriers (Lindbloom 1998). The general climate of the lower Salmon River region is semiarid, characterized by hot, dry summers and mild winters with little snow in the valley bottoms (Tisdale 1986). Elevations range from 402 m to 1108 m, with slopes of 45% to 75% (Tisdale 1986). Numerous vertical cliffs and talus slopes of Columbia River basalt are present, and intermittent springs, creeks, and livestock watering ponds are interspersed throughout the area.

Land ownership along the canyon and plateau portions of the study area is primarily private, but most riparian habitats of the lower Salmon River are administered by the Bureau of Land Management. Livestock grazing is the principal land use of the study area. The plains area above the river canyons adjacent to the study area is extensively planted to wheat (Triticum sp.).

Natural vegetation of the study area developed from the Pacific Northwest region flora and is strongly dominated by bunchgrasses (Horton 1972). Tisdale (1986) reported that plant communities characterized by bluebunch wheatgrass (Agropyron spicatum), Idaho fescue (Festuca idahoensis), and hood sedge (Carex hoodii) occupy most of the grassland area in west central Idaho. Sand dropseed (Sporobolus cryptandrus) and red threeawn (Aristida longiseta) occur at low elevations. Small inclusions of shrub-grass types are dominated by stiff sagebrush (Artemisia rigida), common snowberry (Symphoricarpos albus), smooth sumac (Rhus glabra), curreleaf mountain-mahogany (Cercocarpus ledifolius), and netleaf hackberry ( Celtis reticulata; Tisdale 1986). Invasion of exotic annuals like cheatgrass (Bromus tectorum) and perennial forbs such as yellow starthistle has modified the historical natural vegetation composition on many areas in the lower Salmon River canyon.

METHODS

Data Collection

Fifty-one Chukars (30 males, 21 females) were captured with baited walk-in traps (Christensen 1970) and were radio-tagged between late January and early May. Because sexes are alike, we used shank length (Woodard et al. 1986) and several other measurements to determine gender (Lindbloom 1998). Necklace-mounted transmitters, weighing an average 10.8 g, were attached to 22 birds in 1995. Backpack-mounted transmitters, weighing an average 14 g, were used for 29 birds in 1996. Radio-marked Chukars were located approximately weekly from April to August 1995 and 1996. Each locale of use consisted of the area within a 10-m-radius circle centered at the bird location. Chukars that were located consecutively in the same location were assumed to be nesting, and each bird was observed during the subsequent survey. Because most birds were reluctant to flush from the nest, we located birds on nests by walking concentric circles, decreasing in size, around the nest location until the bird was visible.

Efforts were made to measure clutch size and stage of incubation (Westerkov 1950) while the bird was feeding off the nest. After nesting efforts ceased, we determined nest fate and number of eggs successfully hatched by analyzing egg membrane condition (Rearden 1951). A nest was considered successful if at least 1 egg hatched.

Initiation of incubation was determined by backdating 24 days from estimated date of hatch or from stage of incubation. If a nest was
destroyed prior to hatch or to measurement of incubation stage, we examined weekly movements to approximate the most likely initiation of incubation.

Initiation of laying was determined by backdating from the beginning of incubation. Number of eggs multiplied by 1.3 days per egg (Woodard et al. 1973) was used to assess number of days to backdate. If clutch size was unknown, 15 × 1.3 was used. The time period between completion of laying and initiation of incubation was assumed to be 0 days.

Nest success was considered the probability that a nesting attempt, whether 1st nest or renest, would result in a successful nest. Apparent nest success was calculated by dividing the number of successful nests by total number of nests (Klett et al. 1986). Estimated nest success was calculated similarly to apparent nest success, but with 2 additional nests added to the total number of nests; these were from 2 radio-tagged birds that were documented only on nests during the renesting period, but we believe the 1st nesting attempts were missed.

Hen success, the probability of a hen having a successful nest, was calculated by dividing the number of successful nests by the number of nesting hens. Breeding success was considered the probability of all hens having a successful nest, whether or not they nested. We calculated breeding success by dividing the number of successful nests by the number of radio-marked hens. Hatch success was considered the proportion of eggs laid only in successful nests that produced chicks; it was calculated by dividing the number of hatched eggs by the total number of eggs in successful nests.

Nest site characteristics were measured the week following determination of nest fate. Nest site macrohabitat variables included cover type, slope, aspect, and elevation. We grouped nest sites into the following cover type categories: (1) rock (talus, outcrop, cliff), (2) shrub, (3) grass/forb, and (4) agriculture.

Because most bird and nest locations contained more than a single vegetative and/or physical characteristic, we determined cover type based on the percentage of cover types present inside the 10-m-radius circle. These percentages were determined using 10-m line intercepts (Canfield 1941) extending in cardinal directions from the nest or flush site, or from visual estimation of the nest or flush site location. We measured 22 sites using these line intercepts, completing these measurements throughout the field seasons (late winter through midsummer) to sample plants in various phenological stages and provide checks on the accuracy of visual estimations.

Agricultural cover types were characterized as areas containing ≥50% agricultural crop, whereas shrub cover types contained ≥20% shrubs. Areas containing ≥20% rock cover but <20% shrub characterized rock cover types. Grass/forb cover types were characterized by areas containing <20% rock or shrub, with grass and forbs making up the highest percentage of cover for the location.

Microhabitat characteristics of nests we measured included nesting structure, overhead canopy cover, visual obstruction, and ground cover. Nesting structure was defined as the immediate physical or vegetal structure (e.g., rock or shrub) used for nesting. To measure overhead canopy cover, we used a coverboard (Jones 1968) positioned over the nest. A Robel pole, centered in the nest bowl and read from a height of 1 m and a distance of 4 m (Robel et al. 1970) in all cardinal directions, was used to assess visual obstruction. Ground cover by forb species, grass species, litter, rock, and bare ground was measured using 20 × 50-cm quadrats (Daubenmire 1959) that were placed at 2.5-m intervals (2 per line) along a 5-m tape running from the nest site in cardinal directions. In addition, ground cover for a 40 × 50-cm area centered at the nest was measured using 2 quadrats placed directly over the nest. Ground cover by shrubs was determined using visual estimation or 10-m line intercepts (Canfield 1941) extended in cardinal directions from the nest.

Most brood locations gathered within the first few weeks after hatch were obtained by circling the telemetered bird. Often we flagged these sites and later sampled them to prevent disruption of the young brood. Once chicks reached flight capability (after approximately 2 weeks), we flushed hens and broods with a Labrador retriever to obtain accurate brood counts. Slope, aspect, elevation, cover type, percent of each cover type, common vegetative species, and percent of yellow starthistle ground cover were recorded at brood locations.

To quantify cover type availability at the study-area level, we delineated all cover types onto 7.5-minute-series orthophotoquads from
interpretation of aerial photographs. Cover type availability was measured by overlaying the orthophotoquads with 100-dots-per-square-inch grids.

The availability of areas with yellow starthistle was determined during peak bloom (late July) by measuring 2 categories of ground cover: (1) starthistle ≤5% and (2) starthistle >5%. Category 1 areas contained no starthistle or only sparse densities and were easily discernible from category 2 areas. We delineated these categories on aerial photographs after walking and driving the study area and using a spotting scope. Data were later transferred to orthophotoquads and area per category of starthistle ground cover was measured using dot grids. Approximately 41% of the study area was classified as category 1 (815 ha), 59% as category 2 (1169 ha).

Statistical Analyses

Because of the relatively large number of continuous variables (11 nest measurements) and small sample sizes (17 complete nesting data sets), statistical analyses could not be conducted to assess whether macro- and micro-habitat data differed between nesting attempt and nest success.

We used the general linear models procedure (PROC GLM; SAS Institute, Inc. 1990), repeated measures analysis of variance (ANOVA), to detect differences in ground cover at nest site and immediate surrounding areas. The assumptions of ANOVA were investigated using graphic and descriptive statistical output from PROC UNIVARIATE (SAS Institute, Inc. 1990). Parametric ANOVAs (repeated measures) were conducted on transformed variables (Conover and Iman 1981) to assess differences between ground cover at nest sites and at distances of 2.5 m and 5.0 m. If significant differences were detected, we examined contrast comparisons within ANOVAs for differences between (1) nest measurements vs. average of measurements taken from 2.5 m and 5.0 m away, and (2) measurements of 2.5 m vs. 5.0 m away.

Exploratory data analysis (EDA) was conducted on individual continuous variables using boxplots (SAS Institute, Inc. 1990). Relationships between habitat variables and nesting attempt, as well as habitat variables and nest success, were graphically examined. We also investigated the effects of cover type and nesting structure on nest success, differences in nesting attempts on nest success, and use of cover types and nesting structures on nesting attempts.

Due to the circular nature of aspect data, we categorized measurements of aspect into 4 quadrants: (1) northeast (0°–90°), (2) southeast (91°–180°), (3) southwest (181°–270°), or (4) northwest (271°–360°). Aspect data were qualitatively examined for differences between successful and unsuccessful nests and 1st and 2nd nesting attempts. Aspects of slopes used for nesting and brood-rearing were also compared. In addition, t tests were used to test for differences in physical characteristics (slope and elevation) between nest and brood sites.

Using chi-square tests of homogeneity, we evaluated use of habitats by broods compared with use by nesting birds. If significant differences existed, we conducted binomial proportions Z-tests to assess which cover types were used differently. Use of cover types for brood and nest sites was graphically compared with availability. Furthermore, using chi-square goodness-of-fit tests (Neu et al. 1974) and Bailey’s confidence intervals (Bailey 1980, Cherry 1996), we tested the null hypothesis that nesting and brood-rearing Chukars use areas with different ground cover of yellow starthistle in proportion to availability.

RESULTS

Data Collection

Grass/forb cover type was the most abundant habitat in the study area (77.5%). Rock composed 11.3% of the study area, shrubs 6.3%, and agricultural fields 4.9%. Two cover types, trees and Conservation Reserve Program (CRP) fields, accounted for minor proportions (0.5% and 2.1%, respectively). Since birds did not use either cover type, we did not include them in statistical analyses.

Nesting data were measured for 23 nests, 10 of which were renests. Birds were known to be renesting only after being followed through unsuccessful 1st nesting attempts. Assumed 1st nesting attempts of 2 birds were not observed. These birds were found on nests for the 1st time when all other radio-marked birds were renesting, suggesting that their 1st nests were missed. This was probable because radio-locations were obtained infrequently on these birds.
The nesting (including renesting) period for Chukars in west central Idaho was slightly longer than 4 months, from approximately 16 April to 20 August (Table 1). Initiation of laying and incubation could be determined for 17 nests; hatching dates could be determined for 9 nests. Laying of 1st nests began 16 April; 50% of birds completed laying by 14 May, 75% by 26 May, and 100% by 4 June. Incubation of 1st nests began 7 May; 50% of birds completed incubation by 31 May and 100% by 7 June. The 1st clutch hatched on 31 May for 1st nests and the last on 7 June. Peak (maximum number of radio-marked birds) laying, incubating, and hatching occurred 1-10 May, 21-31 May, and 1-10 June, respectively.

For renests, laying began 27 May; 50% of birds completed laying by 24 June, 75% by 7 July, and 100% by 27 July (Table 1). Incubation for 2nd nests began 9 June, with 50% of birds completing incubation by 31 July and 100% by 20 August. The 1st clutch of 2nd nests to hatch was on 18 July, the last on 20 August. Peak laying, incubating, and hatching occurred 11 June–10 July, 1-31 July, and 1-10 August, respectively.

Estimated time from destruction or abandonment of nest to initiation of laying of subsequent nest averaged 13 days and ranged from 1 to 37 days ($n = 7$, $s_x = 5$). Distances between nesting attempts ranged from 152 m to 386 m and averaged 294 m ($n = 7$, $s_x = 31$); 1 bird that moved 3065 m between nesting attempts was considered an outlier and not included in the previous summary statistics.

Three nests were excluded from nest success analyses because of possible observer influence. However, we included these birds in hen success analysis because 2 of 3 had successful nests. Apparent nest success for both years pooled was 45% (Table 2), while 45% of nests were lost to predation and 10% were abandoned (reasons unknown). Of 9 nests lost to predation, 3 were depredated by avian and 3 by mammalian predators; the remaining 3 nests were indirectly affected by predation after depredation of the incubating hen. Overall estimated nest success was 41% (Table 2). Hen success for both years pooled was 64%. Because all available radio-collared birds nested (100% nesting effort), breeding success was the same as hen success.

Average clutch size for 16 nests (the number of nests in which clutch size could be accurately determined) was $12.4 \pm 0.9$ eggs (Table 2). Average clutch size for 1st nests ($14.5 \pm 1.0$) was greater ($P = 0.017$, $t = 2.14$, df = 14) than renests ($10.4 \pm 1.1$). Hatch success...
was 91% \((n = 7\) nests in which clutch size and number of eggs hatched could be determined with certainty).

Cover types used by nesting Chukars included rocks (43%), shrubs (9%), and grass/forbs (48%). Average slope and elevation for 23 nest sites were 58\% \((\text{range } 28^\circ - 77^\circ, s_x = 2)\) and 905 m \((\text{range } 710 - 1043, s_x = 22)\), respectively. Eighty-seven percent of nests were on southern-exposed slopes (30\% = SE, 57\% = SW), while 13\% were northern-exposed (4\% = NE, 9\% = NW; Fig. 1).

Physical and/or vegetal structures used directly for nest sites included rock outcrops, low shrubs, and grass/forbs. Thirteen nests (57\%) were located in rock outcrops, with the nests usually completely concealed from 3 sides. Four nests (17\%) were located in low shrubs (2 in cudweed sagewort \([Artemisia ludoviciana]\) and 2 in common snowberry), and 6 nests (26\%) were located in grass/forbs (2 in arrowleaf balsamroot \([Balsamorhiza sagittata]\), 2 in yellow starthistle, 1 in purple vetch \([Vicia villosa]\), and 1 in bluebunch wheatgrass). Visual obstruction averaged 3.9 dm \((n = 20, \text{range } 1.6 - 9.9, s_x = 0.5)\). Overhead canopy cover averaged 63\% \((n = 20, \text{range } 0 - 100, s_x = 9)\), and total ground cover averaged 93\% \((n = 20, \text{range } 47 - 153, s_x = 5)\).

We obtained brood data from locations of radio-marked birds \((n = 38)\) and incidental unmarked broods \((n = 9)\). Small sample sizes prevented statistical analyses of data between marked and unmarked broods (Dixon and Massey 1969), but our qualitative examination suggested data sets were similar; hence, data were pooled. Brood sizes averaged 12.0 chicks \((n = 31, s_x = 1.1)\), with a minimum of 3 and maximum of 30 (>1 adult present). The actual number of chicks per adult was lower, averaging 6.2 \((n = 22, s_x = 4.1)\). We gathered limited data on brood success. In 1995 two radio-collared Chukars had broods; 1 bird slipped the transmitter off, and the transmitter on the other bird failed. In 1996 radios failed on 2 of 7 hens with broods. Of the remaining 5 hens, 3 had broods survive to flight stage (60\% brood success).

Shrub and grass/forb habitats were used approximately equally (43\% and 47\%) by Chukar broods, with rock habitats used infrequently (11\%). Average slope and elevation for brood locations were 59\% \((n = 46, \text{range } 20 - 90, s_x = 3)\) and 875 m \((\text{range } 576 - 1064, s_x = 21)\), respectively. Aspect ranged from 32\° to 355\°, with 55\% of locations on southern-exposed slopes (48\% = SW, 7\% = SE) and 45\% on northern-exposed slopes (41\% = NW, 4\% = NE; Fig. 1).

Shrub species most abundant in use locations of Chukar broods included cudweed sagewort (23\% of locations), syringa \([Philadelphus lewissii]\; 19\%), common snowberry (17\%), and blackberry \([Rubus spp.; 17]\%). Grass species frequently most abundant were brome spp. (77\%), bluebunch wheatgrass (57\%), and Sandberg’s bluegrass \([Poa sandbergii; 28\%]\); forb species included western yarrow \([Achillea lanulosa; 66\%]\), yellow starthistle (57\%), Dalmatian toadflax \([Linaria dalmatica; 47\%]\), arrowleaf balsamroot (43\%), and lupine \([Lupinus spp.; 30\%]\).

Statistical Analyses

No differences were found for ground cover measurements between nest site and distances of 2.5 m and 5.0 m for grasses \((F_{2,38} = 0.80, P = 0.43)\), forbs \((F_{2,38} = 2.96, P = 0.08)\), debris \((F_{2,38} = 0.88, P = 0.42)\), and total ground cover \((F_{2,38} = 0.88, P = 0.42)\), but differences were found for rock \((F_{2,38} = 3.87, P = 0.037)\) and bare ground \((F_{2,38} = 3.73, P = 0.047)\). Contrast comparisons within ANOVAs.
revealed that rock ground cover was greater \((P = 0.033)\) at nest sites \((\bar{x} = 46\%)\) than at immediate habitat surrounding the nest \((\bar{x} = 26\%)\). Averages of 2.5 m and 5.0 m measurements and bare ground \((\bar{x} = 4\% \text{ vs. } 8\%)\) was less \((P = 0.023)\).

EDA on continuous nest variables suggested that overhead canopy cover was greater for both successful nests \((85\% \text{ canopy cover vs. } 51\% \text{ for unsuccessful nests})\) and renesting attempts \((81\% \text{ vs. } 55\% \text{ for 1st nests})\). All other continuous nest variables did not appear to differ between nesting attempt and nest success. Nests were more successful in rock structures \((55\%)\) than in shrub \((33\%)\) and grass/forb \((33\%)\) structures, but differences in nest success between cover types were not apparent. Estimated nest success was higher for renesting attempts \((63\%)\) than for initial nesting attempts \((29\%)\). The use of cover types between nesting attempts did not appear to differ, but the use of nesting structures did; 78\% of renests were in rock structures vs. 43\% of 1st nests.

Aspect did not differ with nest success, but use of northern-facing slopes was greater for broods \((45\%)\) than for nests \((13\%)\). Measurements of both slope and elevation were not different \((P = 0.40, \ P = 0.21, \text{ respectively})\) between nests and broods.

Chukars used different cover types for nesting than for brood-rearing \((\chi^2 = 13.4, \df = 2, \ P < 0.001)\). Binomial-proportions Z-tests revealed that Chukars used rock cover types more \((P = 0.001)\) for nest sites \((43\%)\) than for brood sites \((11\%)\); however, shrub cover types were used less \((P = 0.003)\) by Chukars for nesting \((9\%)\) than for brood-rearing \((42\%)\). No differences in grass/forb cover type use were detected \((P = 0.218)\). Although selection of cover types could not be assessed statistically, it appears that rock cover types were selected by nesting Chukars, whereas shrub cover types were selected by brood-rearing Chukars (Fig. 2).

Chukar use of yellow starthistle was proportional to the expected frequency for nesting birds \((\chi^2 = 3.04, \df = 1, \ P = 0.08)\) but not for brood-rearing birds \((\chi^2 = 21.8, \df = 1, \ P < 0.001)\). Chukars with broods used habitats with <5\% ground cover of yellow starthistle (observed use = 0.745; Bailey's CI = 0.566, 0.868) more \((P < 0.05)\) than expected (0.411), whereas broods used habitats with >5\% ground cover of yellow starthistle (observed use = 0.255; CI = 0.122, 0.419) less \((P < 0.05)\) than expected (0.589).

**DISCUSSION**

Nesting chronology of Chukars in west central Idaho, extending approximately 4 months from 16 April to 20 August, was similar to reports from other western states. Galbreath...
and Moreland (1953) reported the season extended from 3 April to mid-August in Washington. Christensen (1970) reported egg-laying commenced in Nevada in April and hatch occurred in late May and June, and Harper et al. (1958) recorded that the nesting season in California extended from late April to the 1st week in August. These dates are comparable to data for Chukars in Idaho. Mackie and Buechner (1963), however, reported earlier dates of Chukar nesting in Washington, with laying beginning in early March and hatching ending mid-August. Our data suggest Chukars in Idaho began laying and incubating about 1 month later than birds studied by Mackie and Buechner (1963) in Washington.

Clutch sizes of 16 Chukar nests in Idaho averaged 12.4 eggs. Alcorn and Richardson (1951) reported average clutch size of 14 nests in Nevada to be 9 eggs. Williams (1950) suggested that 10–12 eggs was average in New Zealand. Mackie and Buechner (1963) recorded an average clutch size of 15.5 eggs from 4 nests in Washington and suggested renests may have smaller clutches. Our data indicate that clutches from renest attempts are significantly smaller than those of initial nests.

Nest success for Chukars had not been previously quantified. An estimated nest success of 41% for Chukars in the lower Salmon River, however, is comparable with success reports of other Galliformes: 26% for Ring-necked Pheasants (Phasianus colchicus; Johnsgard 1986), 33% for Bobwhite Quail (Colinus virginianus; Roseberry and Klimstra 1984), 56% for Sharp-tailed Grouse (Tympanuchus phasianellus; Marks and Marks 1987), and 37% for Gray Partridge (Perdix perdix; Hupp et al. 1980).

As stated by Christensen (1970), Chukars are indeed persistent nesters. He reported that renesting has not been well studied but is of importance when the peak of the hatch occurs during prolonged periods of inclement weather, which may result in severe chick loss. Our data confirm that Chukars renest. For both 1995 and 1996, a 100% nesting and renesting effort occurred. Two birds made 3rd nesting attempts, and the time it took for a bird to mate, select a new nest site, and begin laying after destruction of its 1st clutch averaged only 13 days.

Forty-five percent of nests in our study were lost to predation. This is less than reported elsewhere. Mackie and Buechner (1963) reported 75% of 24 observed nests were destroyed by predators, and Harper et al. (1958) reported that nest predation was a decimating factor of Chukar populations. Whether predator populations of those previous studies and our study were similar is unknown, but differences in nest predation between studies could also be attributable to differences in habitats. Greater nest predation (Harper et al. 1958, Mackie and Buechner 1963) occurred in predominantly shrub habitats, whereas our study area was a grassland habitat. Regardless, given the reported nestling and renesting effort, clutch size, hatch success, and hen success, it seems unlikely that nest predation is limiting Chukar productivity in west central Idaho.

Overhead canopy cover was greater for both successful nests and renesting attempts than for unsuccessful and 1st nesting attempts. Similarly, 78% of Chukar renests were in rock structures, and nest success in rock structures was higher (55%) than in shrub and grass/forb structures (33%). We hypothesize that rock nesting structures are used most often because the more extensive canopy cover associated with them provides greater nest success.

As stated by Christensen (1970), Chukars are indeed persistent nesters. He reported that renesting has not been well studied but is of importance when the peak of the hatch occurs during prolonged periods of inclement weather, which may result in severe chick loss. Our data confirm that Chukars renest. For both 1995 and 1996, a 100% nesting and renesting effort occurred. Two birds made 3rd nesting attempts, and the time it took for a bird to mate, select a new nest site, and begin laying after destruction of its 1st clutch averaged only 13 days.

Despite the apparent importance of rock for nest sites, shrubs and grass/forb vegetation were also used. Two previous nesting studies reported differing results concerning nesting habitats. Harper et al. (1958) located Chukar nests in shrubs, grasses, and forbs and reported
that preference for nesting cover was not limited to any specific vegetation in California. Only 1 nest was found in rock; however, rock outcrops were uncommon. Galbreath and Moreland (1953) found nests in Washington under low-growing scabland sage (*Artemisia rigida*), bluebunch wheatgrass, common yellow mustard (*Brassica campestris*), and salt bush (*Atriplex* spp.). Rock was not reportedly used, perhaps because of preference for large shrub species such as sagebrush and salt bush that were abundant in that shrub-steppe habitat. Our study was conducted in a canyon grassland that does not contain such an abundance of shrubs; most shrubs were restricted to narrow riparian areas and occasionally within talus slopes.

Galbreath and Moreland (1953) reported Chukar preference for nesting on south-facing slopes, while Harper et al. (1958) reported no slope preference for nest sites. Our study suggests Chukar nest sites occur mostly on south-facing slopes (aspect = 90°–270°). Perhaps this is due to warmer temperatures, less dense vegetation, or seemingly rockier habitats found on southern slopes. Whether these observations are a result of slope and/or nesting habitat availability needs further investigation.

Whereas rock cover appears to be important nesting habitat for Chukars, it is not for brood-rearing. Galbreath and Moreland (1953) reported that up to the age of 4 weeks, Chukars do not use rocky terrain to escape as do older birds. Our results are similar in that only 11% of brood locations were in rock cover types. In a related study (Lindbloom 1998), 31% of locations of Chukars without broods (*n* = 112 locations) were in rock cover types; thus, it appears that Chukars with broods use rock cover types less than those without broods. We hypothesize that Chukar broods avoid open rock areas because they encounter greater predation pressure, increased difficulty of movement, and/or decreased quantities of food (invertebrates) in rock cover.

Brood sizes of Chukars in Washington averaged 13.5–14.5 chicks (Galbreath and Moreland 1953). Christensen (1970) reported brood sizes per county averaged 3.5–13.3 chicks in Nevada, and mean brood size was approximately 9 (*n* = 243) in California (Harper et al. 1958). Broods are reportedly cared for by both adults (Christensen 1970), and brood integrity is questionable after 3 weeks. Brood sizes of Chukars in west central Idaho at 12.0 chicks per brood were comparable to observations in other states, but it is unknown whether this estimate was inflated because of brood mixing. Our calculation of 6.2 chicks per adult likely underestimates actual brood size in cases where both adults were tending to a single brood.

The male role during nesting has been greatly debated. Goodwin (1953) concluded that it is probably normal for Red-legged Partridges (*Alectoris rufa*) to lay 2 clutches, the 1st being incubated by the male. Christensen (1970) stated there has been no authenticated record of a male Chukar incubating in the wild: Observations of Chukars double-clutching were not made during this research; however, a male Chukar was observed incubating a nest in May and June 1996. Although no sexing measurement of live Chukars is 100% accurate, multiple measurements increase the likelihood of being correct. The following measurements of this bird were taken on 27 April at the time of capture: shank length 63.9 mm, weight 675 g, spur-tarsus diameter 11.7 mm (spurs on both legs), and middle toe length 43 mm. Woodard et al. (1986) classified all Chukars with shank length measurements of ≥61 mm as male (93.3% accuracy). Christensen (1954) reported the weights of 20 adult wild female Chukars to range from 462 g to 550 g and males from 536 g to 729 g. Cunningham (1959) reported the diameter of spur-tarsus in males was 7.5–11 mm, and females 6–9 mm. He also reported a middle toe length of 37–46 mm for males and 34–43 mm for females. All of these measurements strongly suggest the incubating Chukar was male. Unfortunately, this bird was preyed upon while attending the brood and internal sexing for positive verification was not possible; whereabouts of its mate were also unknown.

The above results are not conclusive evidence that male Chukars incubate nests; rather, they suggest that a low percentage of males in a population may incubate nests given certain circumstances. One radio-collared female that was trapped 530 m from the male nest site was found depredated the same week the male was discovered incubating. In addition, this study population is considered to be at record low levels of abundance. We hypothesized that male incubation is the result of nest abandonment by, or death of, the female and may occur only when populations are very low.
MANAGEMENT IMPLICATIONS

Nest success is a component amenable to management, varying according to predator abundance and habitat quality (Johnson 1994). Nest success in our study was comparable with other Galliformes, and thus current management practices may sustain adequate nesting habitat for Chukars.

Results from this study indicate Chukars in canyon grasslands prefer nesting on southern exposures with an average slope of 58%. Rock outcrops are the most used structure for nesting. Nest placement by Chukars is not affected by yellow starthistle; Chukars exhibited no avoidance of areas with greater ground cover by starthistle. Perhaps Chukars nested in these areas as a predator-evasion technique.

Avoidance of yellow starthistle, however, was observed for Chukars with broods. Reduction of yellow starthistle may increase brood-rearing habitat and overall productivity. Management of brood-rearing habitat should also consider shrub and grass/forb densities; Chukars with broods most often used habitats with 37% average shrub coverage or 20% and 39% average grass and forb coverage, respectively. Fire management and grazing practices could possibly be used to meet these approximate densities.

Whether nest site habitat characteristics affect nest success of Chukars in canyon grasslands still remains unknown. Nest densities and brood success within particular habitats were not assessed. Habitat use by broods was not adequately addressed in this study and needs further investigation.

ACKNOWLEDGMENTS

This research was approved by the Animal Care and Use Committee of the University of Idaho. Funding was provided by the Bureau of Land Management and the Idaho Department of Fish and Game. Gratitude goes to the cooperative private landowners from Idaho County. We thank S.C. Bunting and R.C. Wright for critical reviews, C. Johnson for assistance with logistics and fieldwork, and W.R. Hundrup for assistance with collection of field data. Numerous personnel at the BLM Cottonwood Resource Area also provided essential support to this project. Statistical analyses were greatly facilitated by consultations with C. Williams. This is a contribution from Idaho Federal Aid in Wildlife Restoration Project W-160-R-24, Subproject 43, and Contribution 960 of the University of Idaho, College of Forestry, Wildlife, and Range Experiment Station.

LITERATURE CITED


Received 4 February 2002
Accepted 13 September 2002