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Natural history and ecology of the Chukar (*Alectoris chukar*) in the northern Great Basin

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INTRODUCTION

The Chukar (*Alectoris chukar*) has thrived in much of the western United States since its introduction and establishment earlier this century. The first documented introduction of Chukars from Asia to North America occurred in Illinois in 1893 (Cottam et al. 1940); however, widespread releases began in the 1930s (Aldrich 1947). Chukars now inhabit a large portion of the Great Basin and are popular game birds in many parts of this range, but understanding of reproductive ecology, survival rates, daily movements, and territory size of the Chukar remains poor (Christensen 1996).

A recent radio-tracking study in Idaho reported results of movements and nesting that in some cases did not agree with past estimates (Lindbloom 1998). This article reports nesting, brood habitat use, and spring-summer home ranges of Chukars derived from a radio-tracking study conducted in Succor Creek State Park, Malheur County, Oregon during 1997-1998. These two studies, both Master's thesis projects at the University of Idaho, are believed to be the only research involving radio-tracking of wild-caught Chukars in North America. Consequently, this report presents information in an attempt to shed light on some aspects of Chukar ecology and management, but also to encourage and perhaps guide future investigations into these unique residents of the Great Basin.

METHODS

Data Collection. We trapped and equipped adult Chukars with radio transmitters from 15 February until the first week of May in 1997 and 1998. Tagged individuals were monitored from 12 April to 10 August in 1997 and from 28 February to 6 August in 1998. Data also were collected during visits to the study area during the fall hunting season in 1996-1999. Individual Chukars often were located daily between 07:00 and 20:00, but observations usually were 24 hours or more apart. Status of nests was recorded every 24 to 48 hours. Parameters recorded at each location included UTM coordinates, cover type, date, time, and covey composition. The cover types identified were annual grass, bunchgrass, riparian, shrub, and rock.

Analyses. Locations and contents of nests were recorded in each year. Aspect of nests was tested for randomness using Rayleigh's Z Test (Zar 1996). Nest success was calculated using the Mayfield method (Mayfield 1961, 1975), which reduces bias and generation of inflated nest success rates by calculating nest survival based on the number of exposure days after discovery. All general pairwise comparisons between observations were performed using the Mann-Whitney U test (Zar 1996).

The frequency of occurrence in cover types between adults and broods was compared with a Chi-square test of independence (Zar 1996). Brood locations were obtained from coveys in which a majority of the individuals were young of the year. Adult locations were defined as those obtained from coveys with no young of the year as members or from lone adult Chukars. Differences in proportion of locations within cover types were tested with 2-tailed z-tests (Zar 1996).

Only Chukars with data from ≥ 25 locations were included in homerange estimation. A quantitative and objective test for autocorrelation of locations was used to assess whether the time between consecutive locations assured independence (Swihart and Slade 1985b). All locations analyzed were from coveys with a majority of adults, but locations from coveys with some juveniles were included. Hen locations while nesting and within 3 weeks after hatching of nests were excluded to eliminate brood effects.

We used three estimators to calculate Chukar home ranges with the program CALHOME (Kie et al. 1996): minimum convex polygon (MCP) (Mohr 1947), bivariate normal ellipse (BVN) (Jennrich and Turner 1969), and adaptive kernel (ADK) (Worten 1989). Estimates of 100% and 90% MCP, 85% BVN, and 70% ADK estimates were calculated.

We also calculated straightline distances between consecutive locations of adult Chukar coveys with >15 locations using the Pythagorean theorem. Because individuals usually were located every 1-3 days, consecutive locations were considered representative of daily movements. Consecutive locations over 5 days apart, however, were excluded.

RESULTS

Nesting. A total of 23 nests were located during the study: 12 (7 first nests, 2 renests, 3 incidentals) in 1997 and 11 (6 first nests, 2 renests, 3 incidentals) in 1998. Incubation of successful nests in 1997 averaged 23.3 days (SE = 0.5, range = 23-25, n = 6) and 25.8 days (SE = 3.4, range = 23-30, n = 4) in 1998, but the two years were not different (P = 0.476). Reliable clutch sizes were obtained from 16 nests (8 in 1997, 5 in 1998, 3 incidentals). Mean clutch size of radioed hens was 13.3 (SE = 1.9, range = 10-16, n = 8) in 1997 and 12.0 (SE = 1.2, range = 9-16, n = 5) in 1998, and they were not different (P = 0.268). Clutch size of renests was 16 and 12 in 1997, and 8 and 10 in 1998. Clutch sizes of incidental nests were 8, 16, and 16, but the specific year they were active could not be determined.

Nests of radioed hens were not randomly distributed with respect to aspect (Rayleigh's z_{17} = 4.91, P < 0.01). Nests tended to face southeast with a mean aspect of 101° (95% CI = 66-136°, range = 52-192°, n = 9) in 1997, and 156° (95% CI = 124-188°, range = 105-279°, n = 8) in 1998. Nesting aspect did not differ between years (Watson-Williams test for 2 samples: $F_{1,15}$ = 4.37, P = 0.090). The mean aspect of all nests was 125° (95% CI = 81-142°, range = 6-330°, n = 23).

Nest site characteristics were examined at all 23 nests (17 nests of radioed birds, 6 incidental nests). Cover types used for nesting were bunchgrass (n = 10), rock (n = 9), shrub (n = 2) and annual grass (n = 2) (Table 2). Nests were placed on the ground under rocks (n = 10), bluebunch wheatgrass (*Agropyron spicatum*) (n = 8), basin wildrye (*Elymus cinereus*) (n = 3), and broom snakeweed (*Gutierrezia sarothrae*)(n = 2). Although nest success rates in each cover type differed, small sample sizes precluded statistical analyses.

The apparent nest success rate was 67% in 1997, and the nest success rate calculated with the Mayfield method was 60% (95% CI = 36-100%, n = 9) (Mayfield 1973). In 1998, the apparent nest success rate was 50% with a calculated Mayfield success rate of 37% (95% CI = 17-97%, n = 8). The daily nest survival rate during incubation was 0.9811 and 0.9649 during 1997 and 1998, respectively, which did not differ (z = 0.913, P = 0.181). The combined 1997-98 daily nest survival rate and nest success rate were 0.9744 and 51% (95% CI = 32-84%, n = 17), respectively.

Brood Habitat. Broods and adults appeared to utilize habitat differently. Cover type at locations of adults (n = 139) and broods (n = 129) was not independent in 1997 (χ^2_4 = 15.44, P < 0.005) or 1998 (χ^2_4 = 17.50, P < 0.005). Broods used shrub cover types more than adults (P < 0.04) and rock cover types less than adults (P < 0.006) in both years (Figure 1).

Home Range Size. Data from 13 Chukars consisted of 25 or more locations and were used in home range estimation: 4 females and 3 males in 1997, and 6 males in 1998. Home range estimates of males and females in 1997 were not different (P = 0.634) and the sexes were pooled.

Home range estimates using the 100% MCP averaged 61.7 ha and 51.0 ha in 1997 and 1998, respectively, and did not differ between years (P = 0.568) (Table 1). Mean 90% MCP estimates were 21.6 ha and 25.2 ha in 1997 and 1998, respectively, and also did not differ (P = 0.886) (Table 1). A qualitative examination of locations indicated that Chukars may not use areas uniformly, concentrating use in specific parts of their home range.

Mean 85% BVN estimates were 48.1 ha in 1997 and 55.9 ha in 1998, and did not differ (P = 0.568) (Table 1). The assumption of bivariate normality in the BVN method was difficult to evaluate by a qualitative examination of locations. Some Chukars favored areas near the center of their coordinate plane while others did not.

The 70% ADK estimates averaged 16.5 ha in 1997 and 18.9 ha in 1998

(Table 1). ADK estimates did not differ between years (P = 0.568). Some ADK estimates consisted of multiple polygons, excluding areas between clusters of locations, indicating Chukars may concentrate use around specific features of the landscape.

Adult Movements. Mean daily movement of radio-tagged Chukars was 282 m (SE = 11.2, range = 181-415, n = 17). Range of all movements was 9 to 3,871 m, but 71% of daily movements (n = 527) were less than 250 m. The longest daily movement observed (3,871 m) was by a hen that renested in a new area after her first nest was depredated.

Locations from three Chukars that survived from 1997 to 1998 indicated there was no movement of adult birds out of the study area. One male monitored in 1997 was recaptured and radioed in 1998, and shifted home range center approximately 2 km between years. The 2 other birds could not be recaptured and their signals were lost in March 1998, probably due to low battery power. During the 1997-99 hunting seasons, a total of six tagged Chukars were harvested in areas they had used throughout the spring and summer of the same or previous years.

DISCUSSION

Nesting. The two-year combined nest success rate of 51% for Chukars in Oregon is similar to the 41% success rate reported for Chukars in Idaho (Lindbloom 1998). Nest success was 25% for 16 nests in California (Harper et al. 1958). Nest success of Oregon Chukars in both years was also within the range reported for other Galliformes (20-70%), although reports vary by location and year (Johnsgard 1973). Nest success in Chukars is sure to vary annually, and a range (37-60%) such as the one observed during the two years of our study seems normal.

The mean clutch size, including renests, of 13.0 is close to the 12.4 eggs per nest reported in Idaho (Lindbloom 1998), but less than the average of 15.5 reported in Washington (Mackie and Buechner 1963). The Washington estimate, however, was calculated from four incidental nests, and detection may have been influenced by clutch size. Although not statistically significant, smaller clutch sizes of re-nests are consistent with observations in Idaho (Lindbloom 1998).

Bunchgrasses and rocks appear to be important nest sites for Chukars. Chukars nested in vegetation, especially bunchgrasses or shrubs, more than rocks. Availability of rock cover types in the study area was not assessed, but use of rocks was disproportionately high based on observations. Chukars intentionally selected rocks for nesting in west-central Idaho (Lindbloom 1998). Perennial vegetation and rocky areas should be considered suitable components used by Chukars for nesting. Harper et al. (1958) observed successful Chukar nesting in areas where few rocks were present, and a preference for rocks was not established in Washington (Galbreath and Moreland 1953). Nest success in rocks and vegetation did not appear different because sample sizes in each group were small and the power to detect a difference was undoubtedly low, but future investigations should address this possibility.

Chukars favored southeast slopes for nesting. Use of southeast slopes was also reported in Washington (Galbreath and Moreland 1953) and Idaho (Lindbloom 1998). Nests on south-east slopes may benefit from increased solar radiation or different vegetation and moisture regimes. Hens may consider the forage quality of habitats in which they choose to nest in order to maximize the efficiency of their foraging bouts during incubation or brood rearing.

Broods. Broods used cover types differently than adults. Broods used substantially more shrub cover types and less rock cover types than adult coveys in both years. Similar patterns of use of rock and shrubs by broods were noted in central Idaho as well (Lindbloom 1998), and an aversion to rocky areas in the first four weeks of life was noted in Washington (Galbreath and Moreland 1953). While adult Chukars typically are associated with rocky areas and annual grasses, shrub vegetation types may be beneficial, if not essential, to broods.

Broods and adults may use different cover types because of differences in predator avoidance strategies. Broods may not venture into areas with low concealment value, such as rocks, because they can not escape, through flight, as well as adults if predators approach. In almost every case when broods were visually located, the hen and chicks were hiding under the leeward side of bunchgrasses or shrubs. Annual and rock cover types did not provide this kind of hiding cover.

Another possible explanation for the difference in cover type use is that shrubs cover types provide more food items than rock cover types, especially insects essential for growing chicks (Christensen 1970). Partridge broods have been reported to prefer areas with higher food densities (Green 1984). It appears that rock cover types, including talus slopes and rimrock bluffs, are more important to adults than to broods. The importance of shrub cover types to broods in this study and the Idaho study (Lindbloom 1998) suggests that shrub stands might be a favorable addition to Chukar brood habitat in areas where they are lacking.

While the dominant shrub in this study area was broom snakeweed, a significant amount of Chukar range contains patches of sagebrush. Range management practices that reduce bunchgrass and sagebrush, or other shrub cover, may be detrimental to Chukar reproduction by decreasing available nesting sites or brood habitats. Heavy grazing that reduces the height and diversity of vegetation structure may affect nesting and brood-rearing habitats used by Chukars. It is unknown if light grazing in our study area affected Chukars, but steep and rocky areas, often used by Chukars for nesting, appeared to be used infrequently by cattle.

Home Range. Behavior of radioed Chukars with regard to movements or space-use did not appear affected by research activities because Chukars were located in the same areas repeatedly. A 24-hour period between locations appeared sufficient to maintain statistical and biological independence, but this may not be true for all populations. As in most home range and movement studies, the number of locations per individual should be maximized to improve estimates.

All home range estimation methods generated different results. When data do not clearly indicate which specific method is best, a choice should be made considering the species' biology (Ackerman et al. 1990). However, it also is appropriate to present results of numerous home range estimators to allow valid comparisons between studies (Lawson and Rodgers 1997). Of the four methods, we believe the 90% MCP and 70% ADK generated the best estimates of Chukar spring-summer home range. Based on observations and field experiences, both methods consistently generated the most realistic home ranges, and they disregarded exploratory locations that were considered outliers because Chukars did not return to these remote locations. The pooled 100% MCP estimate of 56.8 ha (SE = 9.5, range = 18.9-92.0, n=13) reported by this study is larger than the 100% MCP estimate of 39.8 ha (SE = 5.0, range 6.0-78.8, n = 20) reported in central Idaho during 1995-96 (Lindbloom 1998).

The mean daily movement estimate of 282 m in eastern Oregon is almost identical to the 280 m (SE = 44.5, range = 32-686, n = 19) reported in central Idaho (Lindbloom 1998). Neither agrees with previous observations that Chukars moved 1.6-4.8 km daily (Bump 1951, Phelps 1955, Christensen 1970). Daily movements of 280 m and 282 m also concur with the mean home range size arrived at in this study (17-25 ha).

During our study, a hen made a movement of 3,871 m after her nest was depredated and then re-nested. In central Idaho, a hen moved >3,000 m from her depredated nest and re-nested (Lindbloom 1998). It is possible that some hens exhibit extreme movements in response to destruction of their nests.

A male Chukar tracked both years exhibited a 2-km shift in home range. Many locations of this male were while he was paired with unmarked females, and the behavior or movements of the females may have caused some of the spatial differences between years. Agonistic interactions with other resident males may also have caused the observed shift in home range (Green 1983). Three Chukars showed no shift in home range between years in Idaho (Lindbloom 1998). Fidelity of Chukars to annual home ranges needs further research, as does the dependence between male and female ranges, especially their relationship during pairing and nesting.

MANAGEMENT IMPLICATIONS

The small home range size of Chukars is an important factor to consider when implementing management activities. Habitat management or improvement projects may affect only a small local population of Chukars. Conversely, a small amount of improved or protected habitat (1 km^2) can support several coveys of Chukars during spring-fall, but they may need additional areas in the winter. Habitat improvements or watering sites should be placed in areas Chukars are known to occupy because of their apparent site fidelity and short daily movements.

Population surveys should recognize the short movements and small home ranges of Chukars. Large areas should be sampled quickly to find areas of Chukar activity that subsequently can be sampled thoroughly. The likelihood that Chukars will move closer to water sources in the summer also should be considered. Movement to water can make counting Chukars easier by concentrating them, but it adds the confounding factor of annual variations in seasonal water availability and distribution.

Roadside brood counts in the late summer are a chief method used to sample Chukar populations and estimate production. Roads, however, often are built along waterways, and these counts may not represent population trends, but rather local moisture conditions and the response of Chukars to them. Helicopter counts may be more effective at quickly surveying larger areas and locating areas of high Chukar density, but this method costs more.

Chukars provide hunting opportunities in rangeland settings where the status of some native game birds may be declining. Within specific management areas, the impacts of factors such as heavy grazing, intense fire, and changes in plant community structure should be evaluated. The Chukar's success is related to the availability of cheatgrass (Christensen 1996), but the spread and domination of vast tracks of rangeland by exotic grasses and weeds could ultimately affect the Chukar, perhaps by limiting bunchgrass or shrub availability during the vital nesting and brood rearing periods.

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Table 1. Covertypes used for nesting by radio-marked Chukars in eastern Oregon in 1997 and 1998, and apparent nest success within each.

Covertype	1997	1998	Incidental Nests	Total Nests	Apparent Nest Success[a] (*n*)[b]
Bunchgrass	5	3	2	10	62% (8)
Rock	3	4	2	9	43% (7)
Shrub	1	0	1	2	100% (1)
Annual grass	0	1	1	2	100% (1)
Riparian	0	0	0	0	

[a] the proportion of successful nests to total nesting attempts

[b] incidental nests were not included in these estimates because they were not considered random samples.

Table 2. Home range estimates for Chukars in eastern Oregon computed from radio-tracking data collected April-August 1997 and 1998.

Estimation Method	1997 (0 ± SE, n = 7)	Range (ha)	1998 (0 ± SE, n = 6)	Range (ha)
100% MCP[a]	61.7 ± 9.3	20.7 – 92.0	51.0 ± 10.4	18.9 – 87.7
90% MCP[a]	21.6 ± 2.1	13.9 – 30.8	25.2 ± 5.2	11.9 – 41.2
85% BVN[b]	48.1 ± 5.9	17.4 – 61.6	55.9 ± 11.8	21.6 – 102.3
70% ADK[c]	16.5 ± 5.9	7.0 – 23.1	18.9 ± 3.9	8.9 – 30.0

[a] MCP = minimum convex polygon.
[b] BVN = bivariate normal ellipse.
[c] ADK = adaptive kernel.

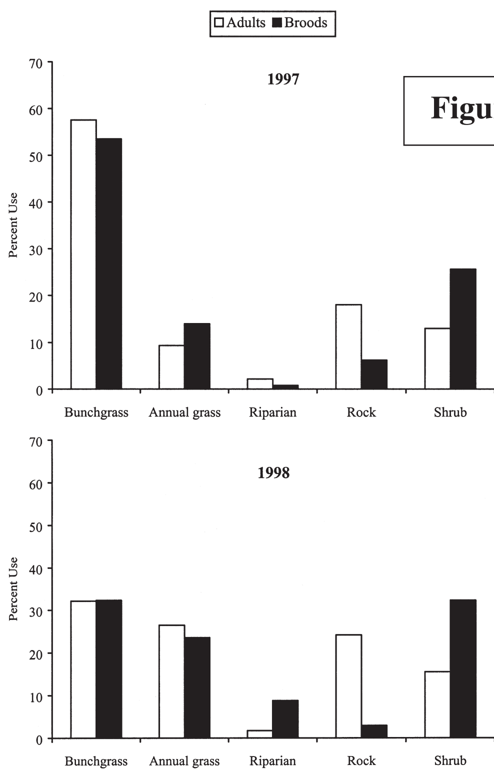

Figure 1.