



A Study of the Chukar (*Alectoris chukar*) in the Thompson River Valley of South-central British Columbia¹

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Editor's Note: The following undergraduate thesis (Figure 1) was written by Raymond A. Demarchi and submitted in April, 1962 to the Faculty of Agriculture, Department of Plant Science, at the University of British Columbia in Vancouver, British Columbia, in partial requirements for a Bachelor of Science in Agriculture degree. Shortly after publication in *Wildlife Afield*, the full article will be available for download at www.wildlifebc.org.

In the mid-1970s, Ray Demarchi's original unpublished thesis was given to Wayne Campbell for inclusion in the bibliographies of British Columbia ornithology and *The Birds of British Columbia* project. Ray's research was the first quantitative analysis of food habits of the Chukar (*Alectoris chukar*) in British Columbia and is still one of the few studies focused on the species' seasonal biology in North America (Figure 2). Prior to 1962, most diet information for the province was incidental and was obtained from the stomachs of specimens. Ray's research during the summer, autumn, and winter of 1961-1962 in the Big Sagebrush/ Bunchgrass Steppe of the Thompson River Valley mainly involved stomach analysis by volumetric analysis and field observations for Chukar. He did, however, bring in additional information in his thesis from census data gathered along the Canadian Pacific Railroad right-of-way by his father, William Demarchi. This additional collection is unique for this species.

Fifty-five years have lapsed since Ray's pioneering study. There have been changes in the species' taxonomy, Chukar populations have

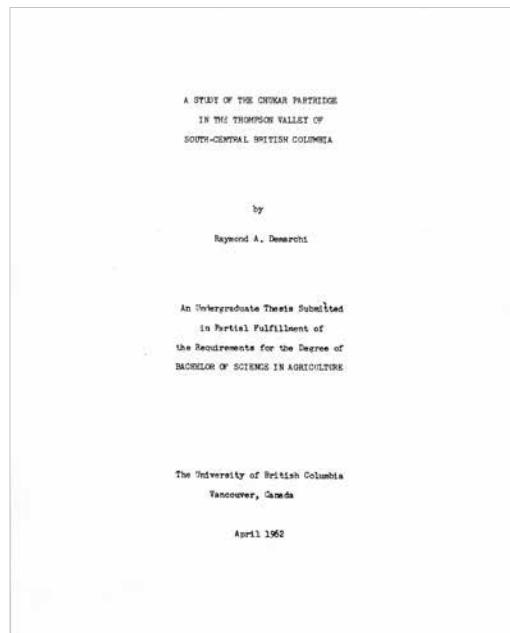


Figure 1. Undergraduate bachelor's theses provide students an opportunity to work independently to develop a research topic, apply methodologies, process data, and incorporate relevant literature into a document that is reviewed by the student's academic committee. They also provide a good opportunity for the student to determine whether he or she is interested in continuing research and study in the future. Most universities do not retain copies of Bachelor's theses even though some, like Ray's, contain significant findings.



Figure 2. Chukar, a boldly patterned Eurasian upland gamebird, was introduced to the sagebrush grasslands of south-central British Columbia in the early 1950s by the provincial government and private groups. Photo by Alan D. Wilson.

fluctuated, habitats have been altered or lost, and available food resources may have changed or been altered. Most of Raymond's original text has been retained but some components are updated to make it more relevant to current conditions and knowledge.

It should be noted that during the 1960s, after completion of Raymond's study, the topography of his study area has been changed by a gravel extraction operation, but the surrounding rocky hill sides are still being used by Chukars.

Abstract

The nesting biology and ecology of Chukar (*Alectoris chukar*), an introduced gamebird in British Columbia, was studied from May, 1961 to January, 1962 in the Thompson River Valley. Between 1950 and 1955, at least 2,600 birds were released at seven locations in the big sagebrush/bunchgrass steppe of south-central British Columbia where the species is now present year-round.

Nesting begins in late March and early April and continues into June. Egg-laying commences in the

first week of April and hatching peaks in early June. Re-nesting may occur with small broods reported into late August. Post-nesting brood sizes, predation, weights, chick development and maturation, internal parasites, and ecological requirements and associations are also discussed.

Principal food items were determined for each season. In spring, green leafage and flowers of the common dandelion were chief items; in summer, the seeds of cheatgrass and alfalfa leaves were primary foods; in autumn, leaves of Sandberg's bluegrass and cheatgrass were the main food items; and in winter, seeds of Russian thistle and cheatgrass comprised most of the diet.

Post-nesting coveys begin forming in mid-June when males and unsuccessful females band together in small groups. The average covey size ranged from 5.4 to 8.5 birds per covey from July, 1961 to January, 1962.

Unfavourable weather in December and January is one of the causes of Chukar mortality in British Columbia.

Introduction

The Chukar (*Alectoris graeca*) [now *A. chukar*] population in the Thompson River Valley in south-central British Columbia is the most northerly self-sustaining population in North America. Since the first hunting season in 1955, Chukar has become one of British Columbia's most popular upland game birds. It has filled an ecological niche and provides game in an area where it was scarce (Figure 3). There is considerable literature on Chukar in North America and several recent studies have been completed that add much to the understanding the species' ecology. However, data in British Columbia are limited and a general study of its life-history in the province has not previously been attempted.



Figure 3. In British Columbia, the introduced Chukar occurs in rocky, sagebrush-dominated grassland habitat in extreme south-central British Columbia and succeeds best where there is no agriculture. Photo by Dennis A. Demarchi, near Tranquille, BC, May 28, 2017.

World Distribution

Chukars are native to India, Mongolia, northern China, Persia, Arabian Asia Minor, and Southern Europe. It has been introduced with varying success to many lands such as New Zealand, Russia, Australia, and Hawaii as well as North America.^{15,24}

In the United States, Chukar is found in most western states from New Mexico to Washington. Introductions have also been attempted, unsuccessfully, in several of the Atlantic states. In Canada, it has been most successfully introduced into British Columbia, but has also been attempted on the Canadian Prairies and even Ontario. It has survived best in the semi-arid and arid regions of the above states and provinces.

Taxonomy

Chukar (Order Galliformes; Family Perdicidae) is in the genus *Alectoris*, which contains four species of red-legged partridges. Chukar, one of these species, is classified as *A. graeca* [now classified as *A. chukar*].

Prior to the 1950s, 31 sub-species of Chukar were recognized in Asia, three of which have been used for introductions to North America.³ These include two sub-species of the Turkish Chukar (*A. g. cyriotes* and *A. g. kleini*) and one of the Indian Chukar (*A. g. chukar* [*A. c. chukar*]). The latter is the subspecies believed to have been introduced into British Columbia.

The present taxonomy of Chukar still remains a confusing group of “red-legged partridges.” Several plumage variations and size differences within the widespread native distribution of Chukar have been recently described.^{15,39} In the past, the Chukar group was included with the Rock Partridge (also known as the Greek Partridge). The species from Turkey and farther east was subsequently separated from *A. graeca* of Greece and Bulgaria and western Europe.^{13,23}

The most recent treatment of the Chukar (1965) recognized 14 subspecies.³⁹ It is still believed that birds originally introduced into North America were taken from the range of the nominate *A. c. chukar*, the Indian Chukar, which occurs from eastern Afghanistan east through northern India to western Nepal and is the darkest race of Chukar.¹⁴

History of Chukar Releases

North American Introductions

Chukars were first released in North America from Karachi India (now Pakistan) in 1893. Between 1931 and 1970 roughly 795,000 birds were released in 41 United States and an additional 10,600 were released in six Canadian provinces.¹⁴ The Canadian introductions outside of British Columbia and releases outside of the western states and Hawaii were all unsuccessful (Figure 4).

British Columbia Introductions

Chukars were first introduced into British Columbia by game farm operator, A.D. Hitch of Whonock, which is located on the north side of the Fraser River west of the mouth of Stave River in southeastern Maple Ridge. Hitch supplied live birds to both private interests and the British Columbia Game Commission. The first Chukars actually released in the province were at Alkali Lake and Dog Creek in the Cariboo in 1940 but the introductions were unsuccessful.^{9,20} Between 1950 and 1955, about

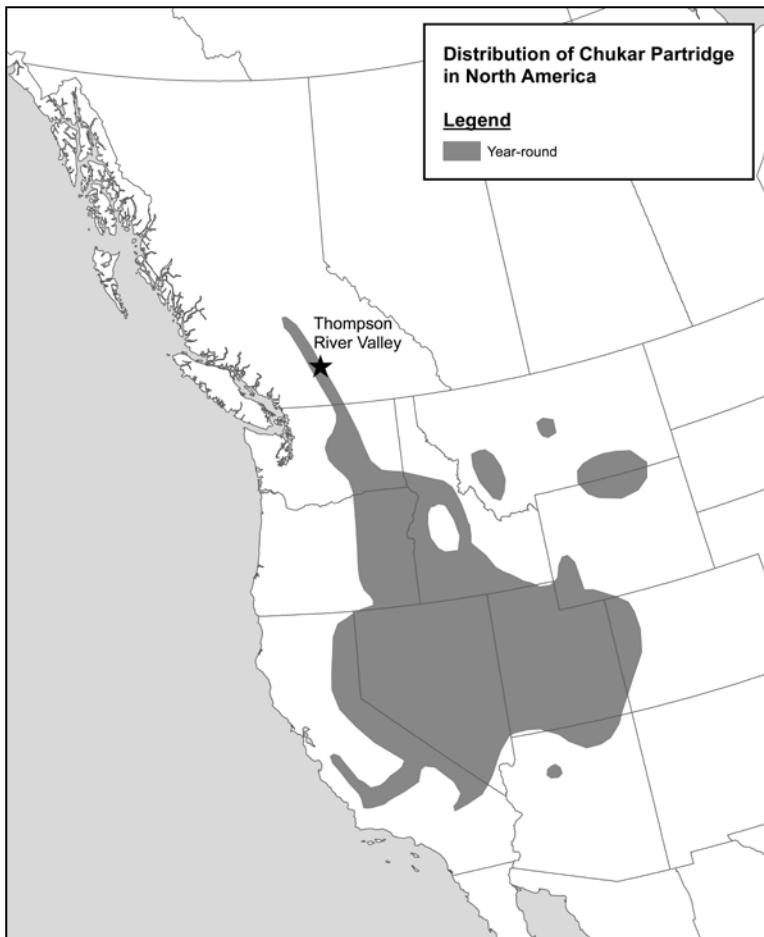


Figure 4. Current distribution of the introduced Chukar in North America. The species still remains a popular upland game bird and in some western states where Chukars are still being released.¹⁴

2,600 Chukars were released in at least 12 sites in south-central BC. These included 878 birds at seven sites in the Thompson River Valley from Spences Bridge (Figure 5) to Pritchard (Figure 6).^{29,30} Two of

the releases (map reference numbers 1 and 2) were sponsored by an independent group, the Lower Mainland Hungarian Partridge Committee. Details for the Chukar releases are given in Table 1.



Figure 5. Small numbers of Chukars were released in the Bunchgrass Zone Biogeoclimatic Zone at Spences Bridge in 1954 by sportsmen with the Lower Mainland Hungarian Partridge Committee. *Photo by R. Wayne Campbell, Spences Bridge, BC, March 28, 1996.*

Table 1. Dates and number of Chukars released at seven locations in the Thompson River Valley, south-central British Columbia, 1950-1955.²⁹

Date of Release ¹	Release Location	Map No. ²	No. of Birds
Oct 6, 1950	Harper Ranch (east of Kamloops)	6	17
Aug 8, 1951	Deadman Creek	4	80
Sep 14, 1951	Harper Ranch (east of Kamloops)	6	52
Mar 11, 1952	Tranquille Creek	5	108
Aug 25, 1952	Ashcroft	3	200
Oct 2, 1953	Deadman Creek	4	150
Apr 25, 1954	Spences Bridge ³	1	72
Apr 25, 1954	Oregon Jack Creek ³	2	71
Apr 12, 1955	Pritchard	7	128
Total Birds			878

¹Listed chronologically.

²See Figure 6.

³Releases at these sites sponsored by the Lower Mainland Hungarian Partridge Committee.

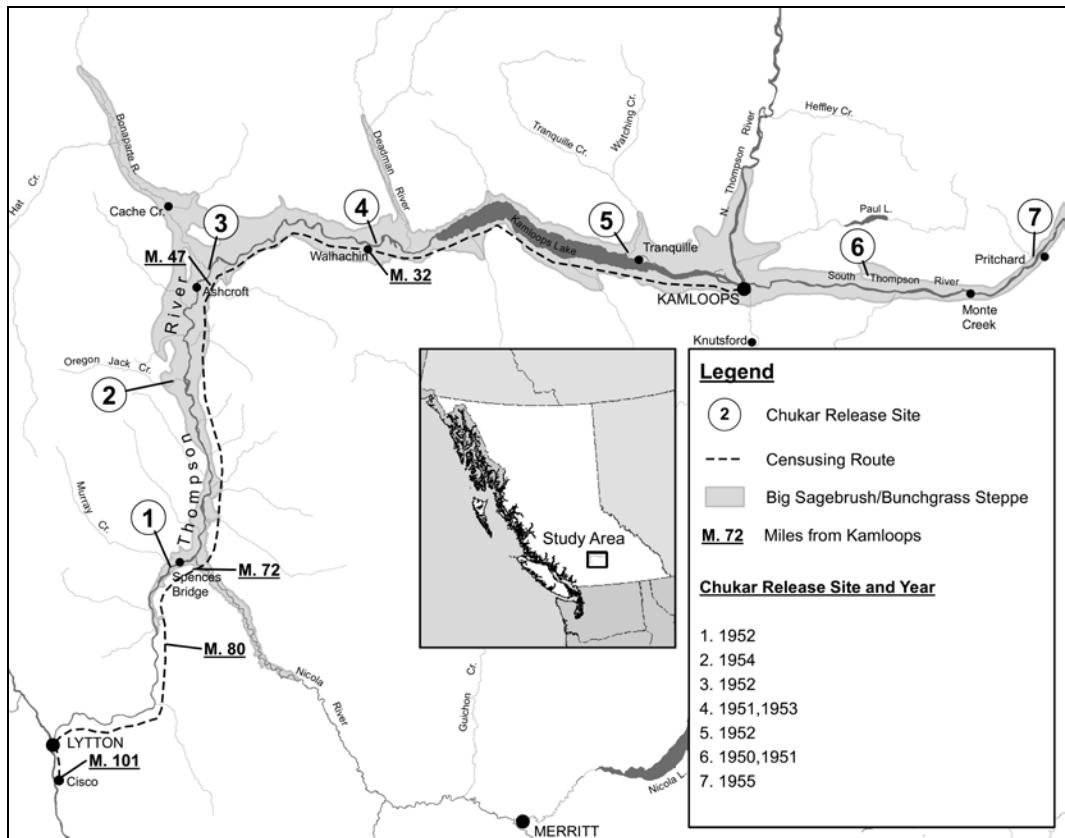


Figure 6. Map of the Thompson River Valley in British Columbia, showing Chukar release sites, thesis census route, and narrow band of big sagebrush/bunchgrass steppe habitat.

An additional 1,728 birds were released in the Okanagan and Similkameen valleys at six locations from Okanagan Landing south to Vaseaux Lake and Keremeos in the Similkameen valley (Figure 7). Sites included 412 birds at Vernon, 67 at Kelowna, 419 at Okanagan Falls, 499 at Oliver, and 331 at Keremeos.⁷ The releases in the Okanagan Valley north of Peachland were unsuccessful.⁸

Since their release in the southern interior of the province, Chukar has been seen at several locations, some quite distant from the original big sagebrush/steppe regions including: Princeton, Anarchist Mountain, Churn Creek, Lillooet, 70 Mile House, Grand Forks, and Creston in the southern interior. In addition, there have been sightings in the coastal

forest region of the province, including Langley, Vancouver, Pitt Meadows, Duncan, Richmond, Qualicum Beach, and Sooke.⁷ In November 1972, eight birds were seen on the side of the Trans-Canada Highway 2 km north of the bridge at Alexander (D.A. Demarchi pers. comm.).

All Chukars released were believed to be of the native Indian subspecies (*A. c. chukar*) and were imported as adult birds from Oregon and as eggs from Washington. A summary of all government-sponsored releases in British Columbia is available in a 1955 report by P. W. Martin.²⁹



Figure 7. By the late 1960s, small numbers of Chukars introduced near Keremeos had dispersed eastward along Richter Pass and were seen in small groups, mainly in higher elevations.⁴ The latest record was of two birds seen near Richter Lake in winter 1998. *Photo by R. Wayne Campbell, Richter Pass, BC, February 22, 1998.*

Known Distribution and Abundance in British Columbia

In British Columbia, the introductions were highly successful and in 1962 there was an almost continuous population of Chukar on both sides of the Thompson River Valley from Lytton to Kamloops. Eastward from Kamloops, Chukar are limited for the most part to the north side of the South Thompson River extending from Kamloops to Pritchard.

Chukar are restricted, in the main, to the lower, (e.g., big sagebrush/bunchgrass steppe) grassland zone that extends from five or 6.5 km south of Lytton to a few miles east of Pritchard at the 195 to 610 m levels and the lower montane (e.g., Douglas-fir/lodgepole pine) timber zone where it approaches the lower altitudes of the valley. Occasional birds frequent the mid-(e.g., bunchgrass steppe) grassland zone (670 to 825 m) and for only a short period during October and November birds occur in the upper (e.g., meadow steppe) grassland zone (825 to 915). Hunter reports indicate that Chukar have been taken in the higher elevations of the lower montane timber zone (915 to 1125 m) but their occurrence here does not seem of any duration.

Note: Observations in the Ashnola valley made during the summers of 1962 and 1963 by the author indicate that Chukar inhabited areas of higher elevations during those years than was determined during the 1961 study. On July 2, 1963, three Chukars were seen at 1,600 m in the Ashnola River valley. Five birds were also seen there on September 1, 1963.

Habitat in Study Area

Vegetation

The habitat occupied by Chukar is typically lower grassland dominated by big sagebrush and bluebunch wheatgrass. The vegetation of the zone has been greatly affected by heavy grazing and areas of climax vegetation are not common (Figure 8). The community that has become dominant over most of the zone as a result of overgrazing is composed of a layer of shrubs along with a sparse understory of perennial and annual grasses and herbs. Cheatgrass is the most aggressive annual.³⁷



Figure 8. Overgrazing by free-ranging cattle in some of the bunchgrass steppe areas of British Columbia have affected climax vegetation and nesting sites for Chukars in the province. *Photo by R. Wayne Campbell, south of Kamloops, BC, May 10, 2009.*

In British Columbia, the big sagebrush/steppe habitat is a relatively narrow zone that occurs primarily at the lowest elevations in four areas. The

Okanagan/Similkameen area is a relatively narrow north/south oriented valley, connected directly to the extensive steppe habitat on the Columbia Basin in Washington State. It is the hottest and driest area in BC. The Nicola Basin is currently not connected to any other grassland; the Thompson River Valley is a wide east-west oriented valley (see Figure 6); the Fraser River valley is a narrow, deeply entrenched north-south oriented area and represents the most northerly extension of the big sagebrush/bunchgrass steppe habitat in North America.

Distribution and Elevation

The lower grassland zone [big sagebrush/steppe habitat, now classified as the very dry hot bunchgrass subzone^{26,37}] is confined to a belt beginning just a few miles east of Kamloops westward to a few miles south of Lytton, and ranges in elevation from the valley floor at 305 m in Kamloops (195 m at Lytton) to the lower slopes of the adjacent plateaus and hills at 610 m (Figure 9).



Figure 9. Typical big sagebrush/steppe Chukar habitat west of Kamloops, BC. Note Kamloops Lake is in the background. *Photo by Dennis A. Demarchi, June 1989.*

Climatological stations are many, but those with long-term records are at Ashcroft, Tranquille and Kamloops airport. The average precipitation at these places ranges from approximately 17.15 to 25.4 cm and the mean July temperatures are from 21.5 to 23.3° C.³⁷

Surficial History of the Area

The whole of the interior of BC was covered by the Cordilleran Ice Sheet during the Pleistocene. In the southern interior the glaciations resulted in a rounding of the hills and ridges and a widening and straightening of the main pre-glacial valleys. As the ice sheets disintegrated and disappeared ice remained in the valleys, blocking the flow of the rivers, as a consequence lakes lay on the sides of that ice, which allowed for the settlement out of gravels, silts and clays. Once the ice finally melted characteristic terraced silt and sand formations so common in the larger valleys remained. While on the mid-and upper slopes local out-cropping of bedrock are common.^{18,34}

This post-glacial environment provides ideal growing conditions for big sagebrush as does the low elevation south-facing rocky slopes.

Agriculture

Beef cattle and sheep ranching, including hay crops during the years of this research, accounted for almost all of the agricultural production.

Methods

Field Work

A study area, approximately 1.6 km long and 0.8 km wide was chosen north of the Range Experimental Station, Agriculture and Agri-Food Canada [formerly called the Dominion Range Research Station] at Kamloops closed in 2013, which is north of the Kamloops Airport and north of the Canadian National Railway tracks (Figure 10). Observations were made at all times of day from early May through August and for a short period during mid-December. Although some observations were



Figure 10. The study area (right in photo) was located north of the Dominion Range Research Station (renamed Range Experimental Station, Agriculture and Agri-Food Canada), at Kamloops. *Photo by Dennis A Demarchi, May 28, 2017.*

made during the week while the author was employed at the Experimental Station, most of the study was confined to weekends. The use of recorded calls to locate Chukars, used elsewhere in western North America, were not used.¹

Most specimens were collected from areas adjacent to the study area and the specimens used for autumn food studies were collected at various points from Kamloops to Walhachin. Aging of chicks in the field was based on the development of seven Chukar chicks kept in captivity. Attempts to sex adult Chukar in the field were based mainly on size (Figure 11). Single adults occurring with broods were considered as females, but it is possible that some of the adults accompanying broods were males.



Figure 11. Identifying the sex of Chukars in the field is subtle and requires personal experience in raising birds in captivity. Females are slightly smaller both in body length and weight. *Photo by Mark Nyhof, Lac Du Bois Grassland Park, Kamloops, BC, April 14, 2013.*

Censusing

Chukar were censused by railroad engineer, William Demarchi (Figure 12), from the cabin of a slow-moving diesel locomotive for a period beginning mid-June 1961 through mid-January 1962 (with the exception of a three-week period in June and July and October) along the Canadian Pacific Railroad right-of-way from Kamloops to Cisco [Siska Creek], 9.6 miles south of Lytton on the Fraser River, BC. Data in this report include only those Chukar censused

from Kamloops to mileage 80 (mid-way between Spences Bridge & Lytton at Squianny Creek) on the Canadian Pacific Railway line. Date, mileage and time of day (Pacific Standard Time) were recorded with three age classes for June and July. The birds were classified as adults, chicks less than 10 days, and chicks 10 days to eight weeks. After mid-August, all birds were classified as adults and were recorded with date, mileage, and time.



Figure 12. A unique segment to this thesis was the incorporation of methodical field observations of Chukars along a railway in the Thompson River Valley by Ray's engineer father William. *Photo by Dennis A. Demarchi, May 2, 1973.*

Laboratory Analysis

Specimens were collected under a sundry permit issued to the author and used for mean weight determinations, gonad activity, food studies, and parasite identification. These studies were conducted at the entomology laboratory in Mission Flats part of the Kamloops Dominion Range Experimental Station and at the University of British Columbia Zoology Department laboratories. A system of sedimentation was employed to separate visceral parasites from fresh specimens collected from the study area. The blood-parasite studies were conducted using Wright's staining technique.

Breeding Biology

Territoriality

Several males exhibited territorial behaviour during the incubation period. Males perched on the highest point in their area and called vociferously (Figure 13), for 10 to 30 minutes with only an occasional rest. Once I observed a male aggressively interacting with two adult Chukar. The birds flew at each other, chucking loudly, but all flushed when my presence was detected.



Figure 13. During the breeding season males utter calls often from the highest points in their territories. Photo by Alan D. Wilson.

Males were observed in groups of two or three individuals from a period just after incubation commenced until coveys were formed in autumn. Several of the birds collected from these small groups of adults were females. Dissection of three of them revealed that all had regressed ovaries. It was not determined whether they had ovulated during the 1961 season. From the large percentage of males collected from the small groups prior to and following the hatching period, it appears that in most instances the male abandons the female during the latter stages of incubation. Mackie states, "The pairing bond continued into the time of incubation. Some males apparently accompanied broods; however there was no evidence to indicate that pair bonds continued beyond the nesting season."²⁷

Mating

Wintering flocks of Chukar began to break-up during late February and most pairing seemed to have occurred around mid-March. No flocks were reported after the last week of March, most birds appeared in pairs or as singles, or infrequently in groups of three. It is noteworthy that these findings remain consistent for those later reported for Nevada and Washington.¹⁴

Most pairs were observed at the 305 to 610 m levels during the mating season although a few pairs were seen at the 610 to 670 m levels.

The mating period was waning when this study began, so observations were not made on female and male activities during courtship. Courtship activities have been described for nearby Washington State.²⁷

Nesting

The nesting building period began in late March and early April and was continued well into June. The first nest was located on May 6, 1961 and was in the process of being built. Three other nests were located during the summer. However, none of those nests was active. The nests were well hidden. Three of the four were built beneath big sagebrush [Figure 14] with a dense surrounding canopy and the fourth nest was found on the face of bedrock outcropping.

Observations on the nest under construction showed that the male assisted the female in building the nest. Each nest consisted of a depression in the ground, scooped-out by the birds and well-lined with dried grasses and sage twigs. Three of the nests contained hatched and unhatched eggs and were well-lined with feathers. The nests were approximately 5 cm. deep and 15-20 cm in diameter.

Nest studies on the Chukar in Washington State^{2,19} have shown that Chukar prefer to nest up slopes and away from creek bottoms and heavy sagebrush areas. Mackie found the opposite to be the rule²⁷ whereas Harper et al.²² found that preferences for nesting cover was not limited to specific growth nor any slope direction. Table 2 lists the nests observed during this study and their locations.

Initial egg-laying was estimated using a method of back-dating described by Mackie on the first brood of chicks observed.²⁷ That brood was observed on May 20, and consisted of a hen and 18 day-old

Table 2. Vegetative cover, location, and clutch size for four inactive Chukar nests on the study area.

Nest	Vegetative Cover	Terrain	Eggs	
			Hatched	Unhatched
1	Big sagebrush-blue- bunch wheatgrass	West-facing slope	11	3
2	Big sagebrush-blue- bunch wheatgrass	South-facing slope	10	2
3	Bluebunch wheatgrass	South-facing talus outcropping	9	0
4	Big sagebrush- cheatgrass	Bottom of gully	-	-



Figure 14. A typical nest of Chukar is built on the ground, well concealed beneath a big sagebrush with adjacent shrub cover at the base of a hill. *Photo by R. Wayne Campbell, near Kamloops, BC, July 8, 2006.*

chicks. Allowing 22 days for incubation indicates that initial incubation began on or near April 28. Chukars lay eggs at a mean rate of 1.3 days per egg. Thus, for 18 eggs at least 24 days were required for clutch completion, placing initial egg-laying on or near April 5. This is believed to have been one of the earliest successful nests in 1961. These findings are consistent with those reported for Nevada and Washington.¹⁴

The appearance of broods less than 10 days old in mid-July and the appearance of a brood on August 31 is a good indication that Chukar commonly renest. In Washington, Chukar may re-nest if an early nest should fail.²⁷

The Chukar Egg

Chukar eggs are cream-coloured and are covered with a reddish-wine fleck. From weights and sizes measured by Mackie,²⁷ the eggs are approximately 40 mm. long and approximately 30 mm. wide, and the average weight of 30 eggs was 22 gm.

Brood Chronology

Three broods about five days old were observed near the study area on May 28, 1961 and several broods of similar age were observed along the railroad census route. By June 18, 17 broods averaging 7.9 chicks less than 10 days old and seven broods of older chicks were observed between Kamloops and Lytton. This indicates that hatching was well under way by mid-June. Hatching continued until late June and then seemed to be checked as only eight broods of

young chicks were observed along the census route from 4-17 July. Broods of chicks less than 10 days old began to reappear after mid-July and 41 broods of the younger chicks were recorded on five trips from July 19 to July 22, when the census was discontinued until August 19. However, no broods were observed on or near the study area after July 22, which indicates that the hatching period ended for the most part in late July.

Using the same method of back-dating described above for the last brood observed, it was estimated that one of the last successful nests of the season was initiated during the first week of August 1961.

Brood Sizes

Average brood sizes were calculated from data collected on the railroad counts during June and July, 1961 and appear in Table 3. High average brood sizes

for both chicks less than 10 days and chicks 10 days to eight weeks reflect good hatching success for the 1961. Average brood sizes of 11.3 chicks for broods less than 10 days and 9.5 chicks for broods greater than 10 days is consistent with results obtained in other areas during good years.^{2,11,27}

The grouping of Chukar broods is reflected in Figure 15. Average brood sizes for both groups increase throughout each period instead of declining as might be expected.

The flocking together of Chukar broods prevents an accurate estimation of mortality rates for both adult coveys and broods. However, from Table 4, the difference between the average brood sizes of the two age classes recorded for the entire period was 11.8 chicks or 15.9 % mortality from less than 10 days to 10 days to eight weeks of age.

Juvenile-to-adult ratios ($n=100$) were calculated

Table 3. Average Chukar brood sizes in June and July, 1961, by age, recorded on railway counts by William Demarchi.

Date	Broods					
	Less than 10 days old			More than 10 days old		
Date	No. of broods	No. of chicks	Average	No. of broods	No. of chicks	Average
June 17-27	16	144	9.0	17	140	8.2
June 30-July 14	4	45	11.2	23	207	9.0
July 15-22	48	578	12.1	92	901	9.8
Total	68	767	11.3	132	1,248	9.5

Table 4. Mortality rate in Chukar broods aged less than 10 days and aged 10 days to eight weeks in June and July, 1961, recorded on railroad counts.

Date	Average Brood Size			
	< 10 days old	10 days-8 weeks old	Difference	% Mortality
June 17-27	9.0	8.2	0.8	8.9
June 30-July 14	11.2	9.0	2.2	19.6
July 15-22	12.1	9.0	2.3	19.0
Total	11.3	9.5	1.8	15.9

from the railroad census data on the assumption that all age groups frequented the census route to the same degree. Total adults were compared with the two age classes of broods recorded for three periods of seven census days each. A final figure of 407:100, (juvenile/adult ratio) is considered a good estimate of

the end results for the season (Table 5). The figures may actually be somewhat higher as many juveniles had developed almost complete adult plumage near the end of the period and were indistinguishable as juveniles. Ratios ranged from 630:100 to 830:100 from hunters' bags in a four-year count in Wyoming.⁴⁰

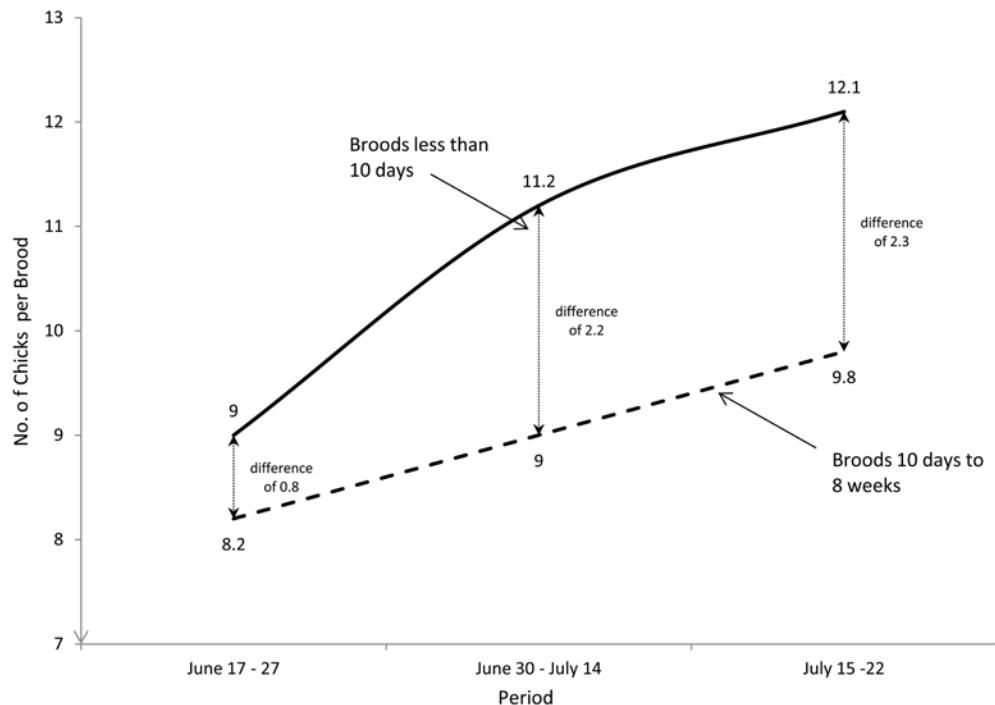


Figure 15. Brood sizes for Chukars less than and greater than 10 days old recorded on railway counts in June and July, 1961, by William Demarchi.

Table 5. Ratios of two age-classes of Chukar chicks to adults ($n=100$) recorded in the Thompson River Valley in June and July, 1961, during railway counts by William Demarchi.

Date	Chick Age Classes		Total
	Less than 10 days old	More than 10 days old	
June 17-27	124:100	121:100	245:100
June 30-July 14	142:100	322:100	464:100
July 15-22	161:100	245:100	407:100

Chick Development

Seven, day-old Chukar chicks were obtained from a game farm³⁶ and used for an aging criteria for broods in the field (Figure 16). Notes were kept

on their development. Results obtained from the observation of the seven chicks appear in Table 6 and support description of development from hatching to adult plumage by other researchers.^{16,22,35}

Table 6. Development of Chukars (*n*=7), from hatching to adults, raised in captivity with reference to other published references on growth.²²

Date	Age ¹	Growth Characteristics
May 20	1	Flight – not capable Height – about 2 inches Body – striped buff-brown and mottled Head – line through eye Beak – black Feet - black
May 30	10	Flight – capable Height – about 4.5 inches Body – mottled dark brown; buff underparts Head – black ear spot Beak – black-brown
June 6	18	Flight – strong Height – about 5 inches Feet – black-brown
June 13	25	Height – about 6 inches Body – reddish under tail feathers Head – red eye ring
June 27	39	Height – 6.5-7 inches Body – banding on sides Beak – red-black Feet - red
July 10	52	Height – 7-8 inches Body – banding almost complete
July 16	58	Height – 8 inches Head – banding on head and neck appearing
July 24	66	Height – 8.5-9.5 inches Head – banding across eyes Beak - red
August 1	74	Height – 9.5-10 inches Body – banding on sides complete Head – banding complete
August 26	99	Height – 10 inches Body – secondaries mottled; rest of plumage adult

¹In days, consecutively.

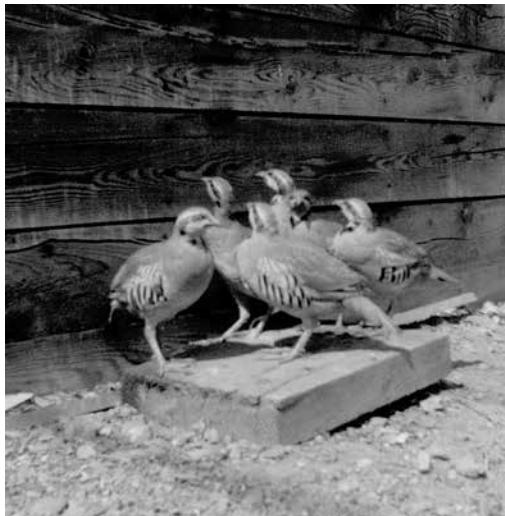


Figure 16. Well-grown Chukar young raised in captivity at Ray's parents' house from chicks to develop an aging criterion for use in the field. *Photo by Raymond A. Demarchi, Kamloops, BC, July, 1961.*

Post-hatching Behaviour

Chukar chicks, like other Gallinaceous birds, follow the female closely. When my presence caused a brood to scatter, the chicks would fly off in all directions. On June 24, 1961, I approached a family of one female and nine, two-week old chicks on a roadway. The birds saw me and flattened-out on the roadway and in the adjacent grass. The female gave a warning call when I approached within 4.5 m of her, causing the chicks to flush. The female flew off feigning injury. After 12 minutes the female began gathering the young by giving quick calls once every 15 to 20 seconds. The chicks answered her calls with four or five cheeps. The female walked up and down the roadway while the chicks emerged from hiding. The time from flushing to collection of all chicks was 21 minutes. The birds resumed feeding and picking gravel as they returned up the hill. No response was made by the chicks or the female to several adults calling about 180 m farther up the slope.

Broods, as well as adults, chose dry silty and sandy soils for dusting during the hottest part of the day (Figure 17). While the young were less than a



Figure 17. During the breeding season adults, chicks, and juveniles dust bathe daily to maintain plumage and likely control external body parasites. Dust-bathing sites include silty and sandy soils along game trails, between patches of big sage, and near natural slumps. *Photo by Dennis A. Demarchi, near Tranquille, BC, May 2017.*

week old, females protected them from the heat by sitting on them, a behavior that was noted on two occasions. Broods sought the protection of dense big sagebrush plants from the direct sun on extremely hot days and were seen feeding only during the cooler periods of the morning and evening.

Nesting Success

Two approaches were taken to estimate percentage hen success for the 1961 season from counts of adult females with and without broods. In one approach, all adult Chukars seen with broods were considered as successful females and all adult Chukar not seen with broods were considered as mates of the successful females and unsuccessful pairs. Table 7 lists the numbers of adults seen with and without broods. In the first approach, success was 88.4% or nearly nine successful hens for each unsuccessful hen. The figure may be biased because of the three assumptions made: 1) all adults seen with broods were females; 2) there is a 50:50 sex ratio in Chukar; 3) that Chukars are monogamous. On the second approach, 70.6 % success was calculated by dividing one-half of the total adults seen (females)

Table 7. Two approaches of estimating percent success of female Chukars based on number of adults seen with/without broods and females counted with broods. Surveys were conducted by William Demarchi along a railway route in the Thompson River Valley, BC, from 17 June to 22 July, 1961

Approaches	Total Number ¹	Total Females ²	Females With Broods	Females without Broods	Total Broods	Percent Success
Adults without broods	538	269	241	28	-	88.4
Adults	538	269	-	-	190	70.6

¹Total number of adult-looking birds counted.

²Assumed half of adults counted were females.

into the total number of broods observed (Table 7). This figure is considered low because the flocking together *habit* was ignored; the number of broods does not equal the number of successful nests. A percent success lying between 70.6 and 88.8 would probably be a good estimate of hen success for the 1961 season. A more accurate estimation was not possible because of the inability to confidently sex Chukar in the field.

Formation of Coveys

Prior to the hatching peak, males left the females and formed groups of twos and threes. Only infrequently did the male return to the female as indicated by a high number of broods seen accompanied by one adult. Other males and unsuccessful females joined these groups as the summer progressed. The first covey of more than

three adults was seen on June 24 which consisted of 13 adults dust-bathing on a south-facing slope in the study area. The second covey was observed June 27 and consisted of 12 adults. After this date, coveys of more than three birds were seen on each day.

Brood flocks became more frequent after the chicks attained six to eight weeks. While families remained together only for short periods during the beginning of the season, they began forming permanent groups after the first week in July.

Table 8 lists the average covey sizes and the ranges for seven months in 1961 and early 1962 (Figure 18). The average covey size for July includes only adult birds whereas those for the remaining months are composed of adults and juveniles. Average covey sizes from July 1961 to January 1962 range from 5.4 to 8.5 birds per covey and seems strikingly low in comparison to covey sizes described for Chukar in

Table 8. Average covey sizes for Chukars recorded in the Thompson River Valley from July 1961 to January 1962 during railway surveys by William Demarchi

Month	No. of Coveys	No. of Birds	Average No.	Range
July	35	189	5.4	3-19
August	272	2,194	8.0	1-33
September	93	792	8.5	1-40
October ¹	-	-	-	-
November	26	140	5.4	1-15
December	123	773	6.3	1-15
January	145	855	5.9	1-25

¹No survey.



Figure 18. Typical Chukar habitat along the shore of Kamloops Lake, BC, from which coveys were observed by William Demarchi (shown) from July 1961 to January 1962. *Photo by Dennis A. Demarchi, August, 1967.*

other areas. Marples²⁸ describes the winter covey as from 50 to 500 birds and covey sizes of from 20 to 40 birds are described by various contributors to the Western States Exotic Game Bird Committee Annual Report.⁴⁰

Most of the dozens of coveys I observed between December 20 and 24 1961, near the study area, could, with some certainty, be classified as being composed mainly of adults, or as being composed mainly of smaller birds – indicating adults, or composed mainly of smaller birds – indicating juveniles and adult females. On December 21, four adult males were collected from a flock of six birds. Because of this evidence plus the fact that the average covey size for three seasons did not exceed 10 birds, I suggest that autumn coveys are of two types: first, a unit comprised entirely of adult males and, unsuccessful females and; second, a unit comprised mainly of juveniles of one or more family units plus the female parent(s) and in some instances, a few adults.

Predation and Mortality

Nest Destruction

Although I did not observe any nests that were destroyed by predation, several egg remains were found on the study area. The most likely predator seemed to be that Black-billed Magpies (Figure 19) had removed the eggs from the nests. Magpies were quite numerous and active throughout the entire study area. Four active magpie nests were removed from the study area and examined for egg and chick remains, but no remains were found. Other authors have shown that Black-billed Magpie play a very important part in nest and chick destruction.^{13,22}

Destruction of nests as a result of agricultural activities does not play a role in mortality because Chukar do not use farm lands as nesting sites. When questioned, farmers operating large farms in the area stated that no nest had been destroyed in the past five years.



Figure 19. The ubiquitous Black-billed Magpie is suspected of being responsible for remains of Chukar eggs found in the study area. *Photo by R. Wayne Campbell*

Mortality of Young and Adults

Very little evidence of predation by ground or winged predators was noted during the study. The remains of two birds that I believed were captured by Northern Goshawks (Figure 20) were found on the



Figure 20. Remains of young and adult Chukars found in the study area were suspected to be from predation by Northern Goshawk. *Photo by Alan D. Wilson.*

study area. And I was able to watch a covey of seven Chukar escape a pursuing goshawk by seeking cover in a dense Russian thistle patch. Several Snowy Owls were reported in the area during mid-December but a search for evidence of predation gave no results. No gallinaceous species were reported as prey for Snowy Owls in a comprehensive summary of prey items in the BC interior through 2008.⁵

Reported aerial and ground predators for other western parts of Chukar range in North America include Sharp-shinned Hawk, Cooper's Hawk, Golden Eagle, Prairie Falcon, Great Horned Owl, and Coyote. All species are found year-round in the Thompson River Valley and could be potential predators.^{6,7,22}

The area is close to residences and is frequented by dogs and cats; probably the most serious of the Chukar predators. Cats were seen in the study area after dark and in the early morning and I observed a feral cat stalking a covey of Chukar that was feeding on the roadway.

Mortality of Chukar along railways and highways, even though they are frequented to a great extent, was negligible. Only three birds were reported to have been killed, one by a car and two by trains.

Climate, particularly weather variations, is probably the chief regulating factor of Chukar populations in British Columbia. The climograph for the lower grassland zone (Figure 21) departs from the optimum requirements during June and January. Christensen blames a cold spring followed by drought for population decline in Chukar in Nevada after a three-year boom.¹⁰ Summer losses caused by drought may occur in isolated areas in the Thompson River Valley but for the most part, the inhabited areas are accessible to free-standing water. Prolonged cold temperatures plus deep snow which makes winter food relatively unavailable, together probably constitute the chief inimical factor on Chukar populations in British Columbia. Large covey losses during the 1955-56 winter had been reported.²⁹ It should be noted that winter losses were high in and around the study areas during January 1962 when ice-sheeting conditions prevailed for a 10-day period. Subsequently, I revisited the area several times during the summer of 1962 and 1963 and the winter of 1962-63 and found very few Chukar there.

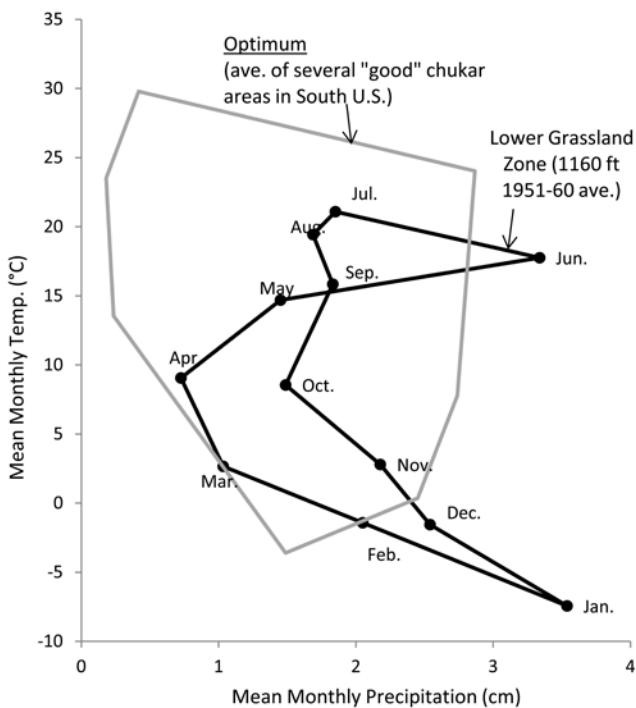


Figure 21. A graphic representation of the relation of temperature and precipitation, at monthly intervals throughout the year, for the lower grassland zone in the study area. In British Columbia, it shows that June is wetter and January is colder than optimum habitat in the United States.

Parasites

External Parasites

Lice collected from four Chukar at Monte Creek and the study area during July were identified as two species: *Culicogaster heterogrammicus* (Nitzsch) (Figure 22) and *Goniodes dispar* (Burmeister). In both species, the given type host is Gray Partridge, but both, and particularly *G. dispar*, are recorded from Red-Legged Partridge. Of the two species, *C. heterogrammicus* was the more abundant. One bird was heavily infested and the other three very lightly infested (G.B. Rich Pers. Comm.).

The mallophaga of a female Chukar collected in December was identified as *Goniodes flaviceps* Rudow, which has been considered a synonym of *G. dispar*, and *Culicogaster* sp. but was not believed to be *C. heterogrammicus*. Rather it was believed to

be *C. heterographus* which is a louse of the domestic hen (G.J. Spencer Pers. Comm.). The infestation of lice varied greatly, one specimen collected at



Figure 22. The external lice *Culicogaster heterogrammicus* (Nitzsch) such as this was identified on a Chukar collected in the study area.

Kamloops and sent to UBC for examination was heavily invested.

It cannot be determined whether or not the introduced Chukar acquired the lice from an association with Gray Partridge in the field or whether they possessed these parasites at the game farm before being introduced.

Internal Parasites

Of 29 Chukar collected in the vicinity of Cache Creek, BC, during 1960 and 1961 and examined for internal parasites at UBC, only two birds contained visceral parasites. Both birds were juveniles and were infected with cestodes [parasitic flatworms] in the small intestine, identified as *Rhabdometra* sp. Those birds were very lightly parasitized and one contained only two cestodes.

Seven specimens were collected during December 1961 and the viscera of five were examined for internal parasites. One bird of the five examined contained two immature parasites of the same apparent species as above, 12 from the duodenum and one from the small intestine. The cestodes could only be traced to the sub family Dilipidinae. These were identified by J.R. Adams (Pers. Comm.).

Two blood smears were taken from each of the seven specimens collected and were examined for blood parasites, but none were found. A female, in good apparent condition, captured by a retriever on December 27 1961, was taken to the Parasitology Laboratory at UBC. Blood smears taken from the bird *in vivo* were examined for blood parasites but none were found.

A thorough examination of the viscera for internal parasites also gave negative results. Between the time of capture and the autopsy date, an extreme swelling at the junction of the tarsus and the toes of one foot became apparent. The cause of the infection was not determined.

Of the 37 Chukar examined for internal parasites, 34 showed no signs of internal parasitism. The three birds found to be infected were so slightly parasitized and were otherwise healthy. From the number of negative studies on internal parasites and blood parasites of Chukar collected throughout the Thompson River Valley, it can be concluded that parasitism is of seemingly little importance.

Literature on internal parasites of "wild" Chukar in North America has not been compiled. However, casual observations of internal parasites by researchers appear to be of no importance.^{2,22}

Several parasites have been described for farm-raised Chukar in the Union of Soviet Socialist Republics [now Russia] where 34 species of helminthes have been identified.²¹ In North America, it is generally felt that "wild" Chukars are relatively free of disease although game farm birds are susceptible to Gapeworm (*Syngamus trachea*), tapeworm (*Raillietina* sp.), infectious coryza, blackhead, and caecal worms (*Heterakis* sp.), intestinal flagellates (*Hxamita* sp.) viral encephalomyelitis,³² and *Trichomonas gallinarum*.⁴¹ None were found in British Columbia.

Food Habits

Forty-seven specimens were collected from May to December, 1961 for identification of crop-contents. Table 9 lists the plant species identified and according to the three seasons. Too few areas were sampled to permit gross generalization; however, the referred foods are given good indication in the table.

Insects did not figure in the diet of this sample of adult Chukar (Figure 23). The crop of a single under-10 day old chick contained one grasshopper.



Figure 23. Plant materials, such as Russian thistle, comprised the bulk of Chukar's diet although some ground-dwelling insects, may be eaten opportunistically. Photo by R. Wayne Campbell.

Spring

Late spring foods consisted mainly of common dandelion buds and flowers and grass tips (Figure 24). Chukars were observed to feed on yellow bell flowers but none of these flowers were present in the crops collected.

Summer

Summer foods varied with the locality in which the sample was collected. Cheatgrass seeds (Figure 25) and alfalfa leaves were the primary sources. The crops containing wheat and oats were collected along the CNR right-of-way near Tranquille. Chukar frequent the right-of-ways of both the CPR and the CNR throughout their range (see section below on Attraction of Roads and Railroad Right-of-Ways).

Table 9. Principal food items identified in the crops of Chukars ($n=47$) from British Columbia over three seasons from May to December, 1961.

Type ²	Food Items	Portion	Seasons ¹			Total
			Spring (5)	Summer (10)	Autumn (23)	
Grasses						
cheatgrass	leaves	-	1(2.0) ³	6(15.9)	4(15.0)	11(8.2)
	seeds	-	5(33.5)	4(3.2)	5(5.5)	14(17.3)
foxtail barley	seeds	-	1(0.5)	-	-	1(0.12)
Indian ricegrass	seeds	1(10.0)	-	-	-	1(2.5)
millet	seeds	-	1(0.5)	-	-	1(0.1)
oats	seeds	-	2(6.9)	-	-	2(1.7)
unidentified	leaves	2(12.0)	4(7.5)	-	-	6(5.0)
Sandberg's blue grass	leaves	-	-	18(73.9)	-	18 (18.4)
wheat	seeds	-	3(4.7)	-	-	3(1.2)
Forbs						
alfalfa	leaves	1(20.0)	6(15.7)	-	1(trace)	8(9.0)
	pods	1(trace)	-	-	-	1(trace)
clover	leaves	-	-	1(trace)	-	1(trace)
common dandelion	buds	3(40.0)	-	-	-	3(10.0)
	flowers	1(18.0)	-	-	-	1(4.5)
	leaves	-	1(0.4)	-	-	1(0.1)
little-podded falseflax	leaves	-	1(0.5)	-	-	1(0.12)
meadow salsify	heads	-	2(9.0)	-	-	2(2.2)
pasture sage	buds	-	-	-	2(3.3)	2(0.8)
Russian thistle	seeds	-	-	2(3.2)	6(43.3)	8(11.6)
	tips	-	-	-	3(2.8)	3(0.7)
yellow salsify	roots	-	1(7.5)	-	-	1(1.4)
Insects						
grasshopper	body	-	1(1.0)	-	-	1(1.25)

¹Four seasons with numbers of food items identified per season in parenthesis.

²Scientific names listed in Appendix 1.

³Number of samples containing each food item with volume percentage in parenthesis, totaling 100 percent for each season.



Figure 24. In spring, Chukars in British Columbia eat all parts of common dandelion. *Photo by R. Wayne Campbell.*



Figure 25. In summer, the seeds of Cheatgrass, also known as drooping brome, dominate the diet of Chukars in the Thompson River Valley of British Columbia. *Photo by Dennis A. Demarchi, near Kamloops, BC. May, 2017.*

Irrigated alfalfa fields were frequented by Chukar throughout the summer and served as a source of both food and water. In California, large feeding groups of 200 to 800 birds were seen feeding in such areas during the late summer and autumn.²² Similar group sizes were not observed during this study. However, hunter reports indicate that groups of from five to 40 birds move onto cultivated fields in the late summer and early autumn to feed.

Autumn

Autumn crop analysis revealed that Sandberg bluegrass and cheatgrass leaves constituted the

principle foods eaten. The samples were collected over a one month period from November to December. It was during this period that Chukars were found at elevations higher than those frequented during the remainder of the year. Early autumn precipitation over the middle and upper grassland zones caused the unusual occurrence of green leafage in Sandberg bluegrass and an early germination of cheatgrass.

Birds taken near cultivated areas during the autumn were reported to contain primarily alfalfa leaves with some cheatgrass seeds and oat grains.

Winter

Winter crop analysis on a sample of nine Chukars revealed the principal winter foods of the Chukar for British Columbia. The samples contained primarily Russian thistle and cheatgrass seeds. Harper et al. put Russian thistle high on the list for winter food²² and Tomlinson states, "The utilization of cheatgrass seeds and blades during nearly every month of the year indicates the importance of this food."³⁸

Birds were noted generally in groups of three to 14 around large Russian thistle plants when feeding. Coveys were seen concentrated along the roadways with roadside ditches and banks during the winter where there was a high occurrence of this plant species.

Weights

Weights and sex were recorded whenever possible, Table 10 is a list of the weight averages for four classes of Chukar. The juvenile weights were recorded for autumn birds only.

The average weight of adult males exceeds the average weight of adult females by 100 g. While the largest birds are usually males, female weights may exceed those of some males. Thus, size alone is not a convincing criterion for sexing adults or juveniles.

Weights of Chukars in British Columbia are similar to those for those of other areas. Reported weights for native birds in India ranged from 623 to 652 g for adult males and 425 to 482 g for adult females in India.²⁴ Wild birds collected in Nevada averaged 615 g for adult males and 502 g for adult females.¹³

Table 10. Mean weights (g) of adults (male and female) and juvenile Chukars.

Adult		Juvenile ¹	
Male (n=14) ²	Female (n=6)	Male (n=6)	Female (n=3)
607 ³	508	485	462

¹Recorded for autumn birds only.

²Sample size.

³In grams.

Competition

Intra-specific Competition

Chukar exhibit territorialism during the nesting season. On several occasions, lone males were observed standing on rocky outcroppings making frequent staccato calls. The male, when approached, remained motionless but continued calling until I approached within three or 4.5 m, and then would run away, rather than fly. Efforts to find a brooding female in the immediate area produced no results.

In one instance, a male, presumably on its territory, was approached by two adult birds and a short but loud fight ensued. Both the intruders and the defending male began chucking energetically and the latter flew at one of the intruders. The three birds flew off in different directions when I was detected. This was the only instance that I recorded any direct aggressive behaviour.

Sometime prior to hatching the males leave the females and join with one or two other males. After this has occurred males no longer defend territory and in most instances, the female and her brood are abandoned.

Family groups moving to and from feeding areas often meet and merge for short periods. On several occasions broods were observed feeding along roadways or in cheatgrass and alfalfa patches along with three or four adults. On July 22, 10 adults and 14 chicks were observed sunning on an area of about 9.3 sq. m. The 24 birds were divided into three separate groups: one group consisted of a flock of eight adults, the second a covey of one hen and two, two-week old chicks, and the third a covey of one hen and 12, four-week old chicks. The chicks ran from

group to group and were apparently ignored by the adult flock. After the chicks darted about for less than a minute, they returned to their respective groups. When the birds were finally alarmed, they flew away, still maintaining the integrity of the three groups.

Broods sometimes banded together and the double or triple family was then maintained by two or more adults (most of which were presumed to be females). Most broods were accompanied by only one female and apparently consisted of one age group.

There was no evidence to indicate competition for feeding areas at any time during the study and the Chukar seems to be highly tolerant to members of its own species. Indirect competition for winter foods that are not scarce but made unavailable by ice and deep snow may result in mortality.

Inter-specific Competition

Chukar tolerate other game bird species and seem to ignore any instances of overlap. During the present study, on two occasions, adult and immature Chukar were observed feeding closely with Ring-necked Pheasants (Figure 26). Generally though, Chukar and pheasant feeding areas do not overlap. A female Ring-necked Pheasant started a nest in a big sagebrush area about 180 m from a Chukar nest site on the study area. Both nests were unsuccessful but this was probably attributable to my disturbing both nests while they were in their early stages.

While Chukars were occasionally found above the 670 m elevation, their presence there seemed of little consequence to Dusky Grouse welfare. The overlap between Dusky Grouse and Chukar habitat may be considered negligible.

Gray Partridge populations have shown no



Figure 26. When introducing exotic game birds, like Chukar, the ecological impact on other native and introduced gallinaceous species, such as the Ring-necked Pheasant must be considered. *Photo by Alan D. Wilson.*

significant decline since the Chukar introductions. The few coveys of Gray Partridges inhabiting the area previous to the establishment of Chukar still persist (P.W. Martin Pers. Comm.). They occupy two different habitats, with only limited overlap in agricultural fields and at springs, the Gray Partridge prefers more open habitat to the Chukar's shrubby and rocky terrain.

Other biologists are of the opinion that competition between Chukar and other upland game species is of little importance.^{2,22} Chukar are known to share watering and feeding sites with other species. Owing to the nature of their habitat preferences, little competition can exist. Although there may be some overlap with the now much reduced Sharp-tailed Grouse at springs and seeps, but generally the Sharp-tailed Grouse prefers level to rolling grasslands and trembling aspen groves.

Requirements and Habitat Associations

Water Requirements

Chukar require free-water only during the hot and dry periods of the late spring and summer months (Figure 27). Chukar were observed making daily trips to free-water mainly during the dry periods although on two occasions adults were observed moving to and from sources of free-water on damp days. Water availability in the Thompson River Valley may not be limiting because the big sagebrush/bunchgrass



Figure 27. During hot and dry periods in their arid to semiarid climate in British Columbia, Chukars can obtain water from lakes, slow-moving rivers (shown), irrigation channels, and agricultural sprinklers. *Photo by Dennis A. Demarchi, South Thompson River east of Kamloops, BC. May 2017.*

steppe is immediately adjacent to the large Thompson River and Kamloops Lake.

Movements to free-water are generally confined to the cooler periods of the evening and morning. However, adult birds were observed on the north bank of the South Thompson River during all times of the day. The crop of an adult male collected after returning from the river, contained a small amount of water. No birds were observed actually drinking from the river, but adults and chicks were seen drinking from irrigation sprinklers (Figure 28). On July 14, two adults and 16, three and four week-old chicks were observed drinking from a sprinkler at the edge of an alfalfa field adjacent to the study area. The birds stood just outside the periphery of the spray and were taking water that collected in droplets on the alfalfa leaves. The covey remained undisturbed for approximately 10 minutes, then left the field and proceeded back up the south-facing slope.



Figure 28. When alfalfa fields are being irrigated in summer in British Columbia, some Chukars may visit the sprinkler wetted plants for water. *Photo by R. Wayne Campbell.*

On May 20, a female and 18 day-old chicks, were observed north of the study area a half mile (0.8 km) from the nearest source of free-water. It was hot and the vegetation and soil in the area were dry. The brood was moving downhill when I saw them, presumably to the nearest source of water.

During autumn, Chukars subsist mainly on green leafage (see Food Habits). The analysis of 27 crops collected in the autumn showed that Sandberg bluegrass and cheatgrass leaves were the principal foods eaten. The green leafage was high in water content and I assume that free-water is not a necessity when succulent vegetation is available.

The eight crops examined from birds collected during winter contained chiefly mature Russian thistle and cheatgrass seeds. While the moisture content is normally quite low, the seeds were saturated in all eight crops. The birds were collected while feeding on snow-covered plants and had taken in some snow and ice along with the seeds. Free-water would be of little use to Chukar when snow is available. No observations were made on food habits during the early spring. However, during spring, precipitation causes the regrowth of both annuals and perennials and the birds likely secure enough moisture then from the green feed and dew.

The Chukar is a drought-tolerant species and experiments on penned Chukar by Greenhalgh² in Utah have shown that Chukar can persist for long

periods without water. Eight adult Chukar survived without water (commercial feed constituting the only feed) in a pen 0.25 ha for a period of 81 days and were described as being in excellent condition at the conclusion of the experiment.

Dependence on the Lower Grassland (big sagebrush/steppe) Zone

In British Columbia, Chukar are generally restricted to the lower grassland (big sagebrush/steppe) zone with the exception of an eight-week period during the autumn. The lower grassland zone, which is in the very dry climatic moisture regime in the Thompson Basin ecosection occurs between the altitudes of 195 and 610 m from a few kilometres east of Pritchard, west along both sides of the South Thompson (Figure 29) and Thompson rivers to Cisco [Siska Creek], on the Fraser River south of Lytton.

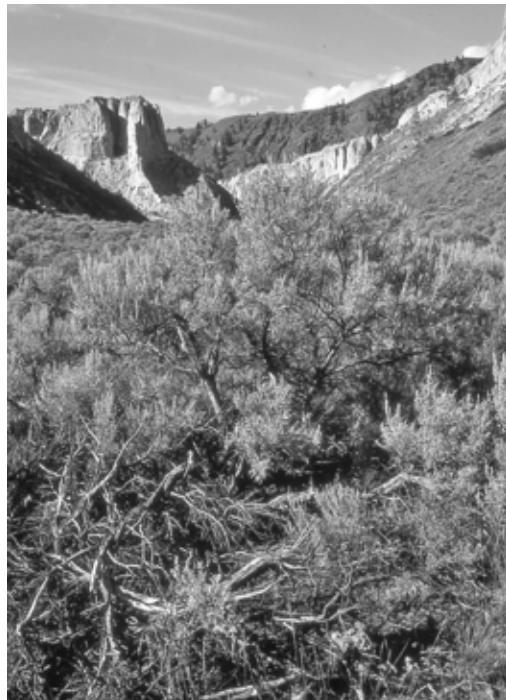


Figure 29. Typical big sagebrush/steppe Chukar habitat on the north side of the South Thompson River near Kamloops, BC. *Photo by R. Wayne Campbell, July 24, 2005.*

Chukars are not present when the lower grassland zone grades into the coast-interior wet climate regime in the Coast and Mountains ecoprovince to the south and the interior wet climate regime in the Columbia Mountains ecoregion to the east. Occasional coveys and small flocks were observed in the middle grassland zone (670 to 825 m in elevation) and Chukars are known to occur at and above the upper grassland zone (825 to 915 m) for a short period in mid-autumn.

Depending on climate and geographical location, the elevation of prime Chukar habitat varies considerably. Similar big sagebrush/bunchgrass habitat in the Columbia Basin in Washington State lies between 140 and 850 m, which is comparable to its location in British Columbia (D.A. Demarchi pers. comm.) whereas in Nevada prime Chukar habitat occurs between 1,200 to 2,700 m, while in Hawaii, Chukar habitat can vary between 900 and 3,100 m.¹²

The climographs (Figures 21 and 30) reveal the climatic conditions found at each of the three grassland zones. The lower grassland climograph (see Figure 21) fits the optimum Chukar climatic requirements for all months except June and January for a 10-year average. It is not likely that the deviation of climograph for June from the optimum imposes stress upon Chukar populations. However, the deviation for January almost certainly exerts an influence on mortality.¹¹ concluded that high Chukar mortality in Nevada in 1954 was a result of drought following a cold spring. In BC, it appears that drought is not an important factor but that deep snows associated with freezing temperatures constitute one of the primary inimical factors.

Climographs for the upper and middle grasslands (Figure 30) for a two-year average indicate the low correlation of the climate found at these levels with the optimum requirements. Data for these zones are incomplete as records were only kept from April

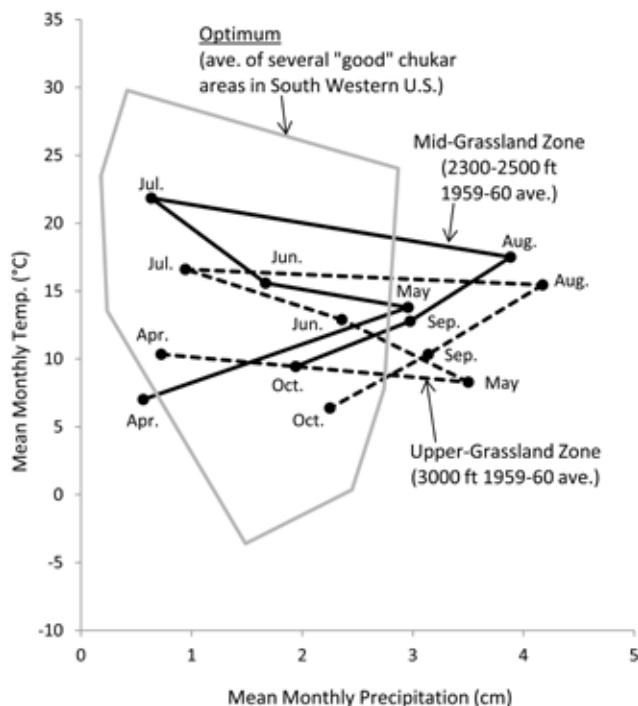


Figure 30. A graphic representation of the relation of temperature and precipitation, at monthly intervals throughout the year, for the mid-and upper grassland zone in the study area.

to October. The climographs for these areas are sufficiently removed from the optimum during the nesting season so as to make these areas unfavorable. Colder temperatures and deeper snowfalls than those that occur at the lower zone during December to February (not shown by these figures) also make these areas unfavourable as Chukar habitat.

Relationship with Agriculture

Chukars found near cultivated fields utilize the crops grown but agriculture is not a necessity as large numbers of Chukar have established themselves in strictly non-agricultural areas. They also visit cropland to obtain water from sprinklers.

Specimens taken near irrigated alfalfa fields nearly always contained some green alfalfa leafage and alfalfa ranked fifth in the order of volume percentage of the total crop analysis (see Table 9, page 126). Chukar feeding on cultivated crops were never observed more than 30 m into the field. Rather, they remained on the edge closest to their natural cover.

Chukar avoid agricultural areas as nesting sites and consequently suffer very little nest destruction through agricultural activities. No instances of mortality or nest destruction were reported to me from the two large farms near Tranquille, BC.

One instance of light damage to a cultivated crop was reported at Savona. Chukar fed on potatoes that were being harvested. It is likely that other instances of damage occurred but crop depredation by Chukar apparently is of no economic importance in British Columbia. In California however, reports of damage to alfalfa fields by groups of several hundred Chukars occurred during 1954 and 1955.²²

Relationship with Railroads and Roadways

Chukars are found in the greatest densities along the right-of-ways of both railroads (Figure 31) and secondary roads throughout the valley for most of the year. The railroad right-of-ways holds four main attractions for Chukar: a good supply of spilled grains, possibly a passage to access a river



Figure 31. Year-round, Chukars visit the gravel berms of railway tracks (centre) for grit throughout the Thompson River Valley. Photo by Dennis A. Demarchi, Kamloops Lake, BC, August, 1967.

for water, an available supply of grit on berms, and a wide variety of weeds growing along disturbed banks and ditches. Birds were observed huddled next to the rails on cold days during the winter and seemed apparently sought the rails as a source of heat or protection from the wind.

At one location near Halston siding, the Canadian National Railway tracks pass through the middle of a large agricultural area. The right-of-way is bounded on the south by orchards and on the north by large abandoned hop fields. Chukars frequented the tracks in this area along with Ring-necked Pheasants. As many as 30 Chukars were observed feeding along its 1.6 km length throughout the summer. Efforts to find Chukars in the orchards and hop fields bounding the right-of-way produced no results. When alarmed, Chukars almost never entered the fields but flew over the hop fields to the hillside some 450 m away or farther up the tracks.

Disturbed sites along secondary roads passing through big sagebrush/steppe habitats are used by Chukars as dust-bathing sites during the breeding season. When the Trans-Canada Highway (Highway 1) was upgraded in British Columbia in the 1960s, the expressway, from Lytton to Pritchard through Chukar habitat, created a threat to Chukars feeding roadside on grit. The total impact from collisions with vehicles is not known but does occur (Figure 32).

Daily Habitat Relationships

Chukars are most active in the early morning and late afternoon during the warm spring, summer and warm autumn months (Figure 33). Although Chukars were observed at all times of the day, adults and broods were observed feeding and moving to and from water sources mainly during the early morning and late afternoon periods. Calling was frequent from sunrise to within five hours after sunrise, then it virtually ceased until late afternoon when it was resumed until an hour before sunset.

Chukar sought sheltered dusting and roosting sites during the hottest part of the day, which usually occurred one or two hours before noon until three or four hours after noon. Coveys of adults sought shaded banks and rocky out-croppings and chicks sought the cover of dense sagebrush plants and shaded sites. Very few chicks or adults were observed moving to



Figure 32. The main diet of Chukars in British Columbia includes plant seeds with tough shells or hulls that must be prepared for digestion by ingesting grit. Some of the grit is picked up along railway tracks and edges of roadways. Between the late 1970s and early 1990s, several dead Chukars were found dead along a stretch of the Trans Canada Highway 1, between Cache Creek and Kamloops (R.W. Campbell pers. comm.). Photo by R. Wayne Campbell, near Savona, BC, June 20, 2009.

and from water sources during the hottest part of the day. Rather, they were found up the slopes and away from the river and roadways.

Table 11 lists the frequencies at which Chukar were seen along the census route for three parts of the day within and between three age groups. The total number of birds seen per mile between 10:00 am and 15:30 pm is less than one-third that for the other two times, and would possibly been lower if data from the cooler days during the period had been omitted.

During the winter, Chukars did not exhibit preferences for particular areas during the day. From the limited observations made, it would appear that the birds roost and seek shelter during the night and on extremely cold days in protected areas and spend the remainder of the day feeding and sunning in the more exposed feeding areas.



Figure 33. From spring to autumn, Chukars frequent a wide variety of habitats depending on their immediate life requisites. *Photo by Alan D. Wilson.*

Table 11. Frequency (birds per mile) of three age-classes of Chukars recorded at three time periods during the day in June and July and August and September, 1961, in the Thompson River Valley during railway surveys by William Demarchi. Birds recorded in autumn could not be aged.

Time ¹	Adults	June and July			August and September	
		1-10 days old	10-56 days old	Total	Total	
05:30-10:00	0.40 ²	0.57	0.87	1.87	2.72	
10:00-15:30	0.16	0.15	0.26	0.52	1.45	
15:30-21:30	0.40	0.40	0.85	1.71	3.95	

¹Pacific standard time.

²Birds per mile.

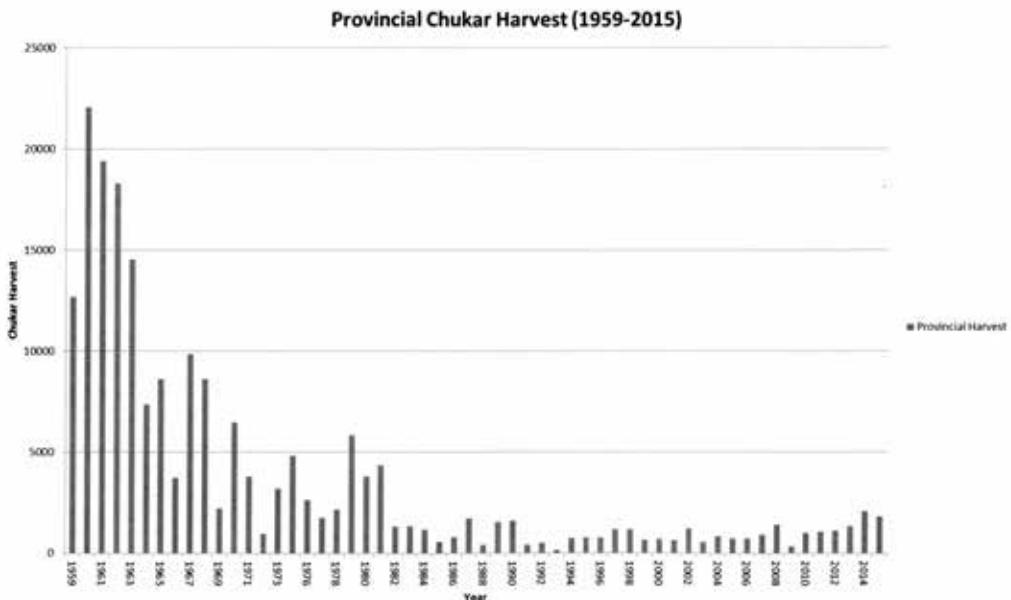


Figure 34. Provincial Chukar hunter harvest trends from 1959 to 2015 showing the rapid population increase after its releases in the 1950s with a population high from 1960 to 1963 and the decline thereafter. This graph includes harvest data from both the Thompson-Nicola region and the Okanagan sub-region; however, the majority is from the former.

Management

The recent distribution of Chukar (2015) is very similar to the distribution in the early 1960s other than a few gaps locally that appear to temporarily fill in when Chukar reproduction is high. Chukars are still commonly found up to 730 m on both sides of the Thompson River Valley. Chukars have established themselves along the Nicola River from Spences Bridge to Merritt and along the Fraser River from Lytton to north of Churn Creek. Chukar numbers in the Okanagan sub-region are extremely low (D. Jury pers. comm.).

The hunter harvest trend from 1959 to 2015 suggests current Chukar numbers are a fraction of what they were when they peaked in the early 1960s (Figure 34). The current harvest of approximately 1,000 birds is about 5% of the harvest highs of approximately 20,000 birds in the early 1960s. Using this ratio and an annual harvest rate of approximately 10% to 20%, the Chukar

population in the early 1960s likely peaked between 100,000 and 200,000 birds. Current population size in the Thompson River Valley is possibly between 5,000 and 10,000 birds (D. Jury and R.W. Ritcey pers. comm. 2017). Although numbers are greater in the western United States, the trend of high numbers a few years after their introduction followed by a rapid decline and a leveling off at much lower numbers than in their peak years is the same trend as in British Columbia (D. Buban, A.M. Curtis, and S. Demsey pers. comm. 2017).¹⁴

Chukar is a popular game bird through much of the western United States and British Columbia. It can survive in human-altered landscapes and therefore requires less management than native upland species. However, to ensure sustainable populations for hunting and viewing, on-the-ground habitat management programs, especially related to cheatgrass and water, may be necessary. Comprehensive management guidelines and Chukar biology literature are available.^{13,17,25,31,33}

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- Figure 35.** Raising, transporting, and releasing gallinaceous game birds at the turn of the 20th Century was a major endeavour for sportsmen groups.
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- Figure 36.** The rocky bluffs east of Vaseux Lake in the southern Okanagan Valley is a good place to observe Chukar year-round. *Photo by R. Wayne Campbell, February 18, 1998.*
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Figure 37. Snow, especially at higher elevations in British Columbia (above 426 m), can restrict access to food supplies for Chukars. The tracks and flight feather imprint in the snow in this photo are near the upper limit of big sagebrush habitat north of Kamloops Lake, BC. Photo by Dennis A. Demarchi, December 1973.

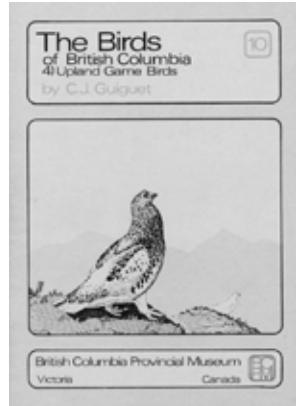


Figure 38. The popular handbooks on birds published by the BC Provincial Museum often contained information conveyed to museum staff that would not otherwise be published. This was especially true for upland game birds.

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- Figure 39.** Graduate student theses often provide specific answers to assisting with developing management plans for upland game birds. Photo by R. Wayne Campbell, Snake River, ID, August 16, 1996.
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Figure 40. William Demarchi, Ray's late father, was an enthusiastic participant in his son's field projects involving upland game birds. In this photo, he is collecting seeds from an Antelope bitterbrush (*Purshia tridentata*). Photo by Nevis Demarchi, Vaseux Lake, BC, August, 1964.

Resource Operations, Kamloops region.

My wife Carol Hartwig retyped my thesis in MSWord. All figures from the original thesis were redrafted by Duncan Richards, GISolutions Inc., Victoria, BC. I am grateful to wildlife photographers R. Wayne Campbell, Dennis A. Demarchi, Nevis Demarchi, Carol Hartwig, Mark Nyhof, and Alan D. Wilson for use of their images.

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Appendix. Alphabetical list of common and scientific names by group.

Plants (taxonomy from e-flora)

alfalfa (*Medicago sativa*)
Antelope bitterbrush (*Purshia tridentata*)
big sagebrush (*Artemisia tridentata*)
bluebunch wheatgrass (*Agropyron spicatum*)
[now *Pseudoroegneria spicata*]
cheatgrass (*Bromus tectorum*) [Figure 41]
clover (*Trifolium* sp.)
common dandelion (*Taraxacum officinalae*)
foxtail barley (*Hordeum jubatum*)
Indian ricegrass (*Stipa hymenoides*)
little-podded falseflax (*Camelina microcarpa*)
meadow salsify (*Tragopogon pratensis*)
millet (*Setaria* sp.)
oat (*Avena sativa*)
pasture sage (*Artemisia frigida*)
Russian thistle (*Salsola tragus*)
Sandberg's bluegrass (*Poa secunda*)
trembling aspen (*Populus tremuloides*)
unidentified grass (Gramineae)
wheat (*Triticum* sp.)
yellow bell (*Fritillaria pudica*)
yellow salsify (*Tragopogon dubius*)

Animals follow the American Ornithologists' Union checklist and supplements for birds and the mammalian species accounts (American Society of Mammalogists) for mammals.

Black-billed Magpie (*Pica pica*)
Chukar (*Alectoris chukar*)
Cooper's Hawk (*Accipiter cooperii*)
Coyote (*Canis latrans*)
Dusky Grouse (*Dendragapus obscurus*)
Golden Eagle (*Aquila chrysaetos*)
Grasshopper sp. (*Melanoplus* sp.)
Gray Partridge (*Perdix perdix*)
Great Horned Owl (*Bubo virginianus*)
Northern Goshawk (*Accipiter gentilis*)
Prairie Falcon (*Falco mexicanus*)
Red-Legged Partridge (*Alectoris rufa*)
Ring-necked Pheasants (*Phasianus colchicus*)
Sharp-shinned Hawk (*Accipiter striatus*)
Sharp-tailed Grouse (*Tympanuchus phasianellus*)
Snowy Owl ([*Bubo scandiacus*])



Figure 41. Cheatgrass, an invasive winter annual grass, is common in big sagebrush ecosystems in British Columbia. It is considered a noxious weed that has become established in disturbed sites and quickly expands (centre) due to its prolific seed production. *Photo by Dennis A. Demarchi, near Kamloops, BC, May, 2017.*

About the Author

The idea for this undergraduate thesis on Chukar Partridge evolved from the author's experiences as a young naturalist and hunter growing up in the Thompson River Valley and manifested itself serendipitously at the peak of population abundance for this introduced species. A summer job at the Kamloops Range Research Station in 1961 provided experience in field studies plus access to professional expertise, a nearby study site, and laboratory facilities. The author (Figure 42) then completed a master's degree on the ecology of California Bighorn Sheep prior to joining the British Columbia Fish and Wildlife Branch as Kootenay Regional Wildlife Biologist in 1964. After a 28 year stint as Regional Wildlife Section Head managing the region's rich wildlife resource, he was transferred to the Habitat Protection Branch in Victoria and was given the assignment of coordinating the provincial government's initiative to double the province's parks and protected areas. While continuing as Protected Area Specialist he took on the job of Chief of Wildlife Conservation and retired in 1997 after initiating the Identified Wildlife Program, leading the province's Grizzly Bear

conservation strategy and revising the province's hunting regulation standards and procedures.

Over the years, Ray's career was enriched by a number of international wildlife studies in several third world countries namely Venezuela, Guyana, and Kenya as well as personal wildlife excursions throughout Canada, northern Europe, Mexico, Costa Rica and the United States visiting numerous national parks and national wildlife refuges. From 1997 to 2007, he and his wife, Carol Hartwig, formed a wildlife consulting firm completing thinhorn and bighorn sheep status reports, wildlife habitat inventories, assessments and plans for both government and private organizations. Following their retirement in 2007, Ray and Carol participated in coastal waterbird surveys as citizen volunteers and several initiatives dealing with water quality and flows in the Cowichan watershed.

They currently make their home on the north shore of the wildlife-rich Cowichan River estuary while maintaining a connection with friends, family, and wildlife issues in the East Kootenay.

Ray and Carol are Life Members of the Biodiversity Centre for Wildlife Studies.



Figure 42. For 28 years, Ray served as the Regional Wildlife Section Head with the British Columbia Fish and Wildlife Branch in the Kootenay region. *Photo by Carol Hartwig, Chemainus River estuary, BC, August 21, 2017.*