

CLIMOGRAPHIC COMPARISONS OF THE CHUKAR PARTRIDGE HABITATS
IN INDIA AND WESTERN UNITED STATES

by

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CLIMOGRAPHIC COMPARISONS OF THE CHUKAR PARTRIDGE HABITATS IN INDIA AND WESTERN UNITED STATES

INTRODUCTION

The object of this study was to ascertain by use of climographs if rainfall and temperature were important factors in the establishment of the exotic chukar partridge, Alectoris graeca chukar (Gray), in parts of western United States. Recorded climatic data from two locations in India near the home ranges of abundance were compared with similar records for selected areas in western United States where the birds have been successfully introduced and established. Only selected locations in the states of California, Nevada, Oregon, and Washington were considered. Although the partridge may be established in Colorado, Idaho, Montana, New Mexico, Utah, and Wyoming, the degree of success in these later places is not definitely known at this time.

Various investigators reporting on the chukar partridge in the United States have frequently suggested that low rainfall areas were definitely connected with the successful establishment and that failures have occurred in areas having high precipitation (rainfall). The following examples illustrate this point:

Galbreath and Moreland from Washington reported regarding rainfall as:

"No populations of chukars have been found thriving in the state of Washington where annual precipitation exceeds 25 inches." (14, p. 38)

Christensen from Nevada also said:

"In a typical area where the chukars are established (Nixon, Nevada) the average annual precipitation, based on an 11-year record, is 5.55 inches." (8, p. 27)

Harper, Harry and Bailey from California also informed the same thing as:

"Chukars have become established in the desert and semi-arid regions throughout California, where yearly precipitation seldom exceeds 10 inches." (18, p. 48)

Edminister summarizes the general belief that low annual rainfall is associated with successful establishment of chukar partridge in the United States when he stated:

"The result of chukar introductions in this country show clearly that this bird is very much limited in its range of climate; in fact, it is probably one of the most closely restricted of all our game birds. Aridity seems to be dominant consideration; no chukars have been successfully established in humid areas or even in the prairie zone of 20 to 30 inches of rainfall." (12, p. 363)

Temperature also seems to be somewhat important as pointed out by the following.

Gordon W. Gullion, Wildlife Technician, Nevada Fish and Game Commission, reporting on observations made in Nevada stated:

"The bulk of well-established populations is in areas with a January average temperature above 28° F. and under 40° F." (16, p. 150)

Glen C. Christensen discussing temperatures in Nevada said:

"Generally, the areas of the state which now successfully support chukar populations are characterized by short, hot summers and long, moderately cold winters. Again using Nixon, Nevada, as an example, the minimum recorded temperature in an 11-year period was -24° F., and maximum 107° F. During this period the average temperature for January was 30.7° F., and the average temperature for July was 72.2° F. At a study area in the Pyramid Lake district, weather records for the years 1952-1953 clearly illustrate the daily range of temperatures. In January 1953, the average range between highest and lowest daily temperatures was 12.1° F. As the year progresses this range increases, reaching its height during the summer months. In July 1953, the average daily range was 27.2° F., and the greatest daily range during this month was 32° F." (8, p. 27)

Galbreath and Moreland in reporting on chukar areas of eastern Washington stated that winter temperatures are sometimes quite low and summer temperatures over 100° F. occur every summer. The normal average monthly winter temperatures for January at Yakima near good chukar areas is 27.4° F. On February 1, 1950, the temperature was -25° F. An estimated 65 to 75 percent winter kill of chukar partridge in eastern Washington ranges occurred during January and February 1950 and was associated with an

unusual heavy snowfall which remained crusted for several weeks. Most of the deaths probably resulted mainly from malnutrition (14, p. 38 and 45)

Biddulph in his article "On the Birds of Gilgit" pointed out that the rainfall in India, where chukars are plentiful, is only five inches a year. The climate is dry and subject to great extremes in temperatures. (4, p. 32)

Marshall reporting on the climate of Chamba, India, which is near chukar areas, describes it as:

"The climate is, as might be supposed, very varied, from the suffocating heat in summer of the low closed-in valleys to the bracing cold of the glaciers among the eternal snows." (26, p. 404)

Whistler in his article "Birds of Lahul, Northwestern Himalaya" reported on the climate of Lahul, India, where the annual rainfall is 23.08 inches a year and the rains are equally distributed in all months. The annual mean temperature is 43.3° F. The minimum temperatures range from 13.4° F. to 50.2° F. and the maximum temperatures range from 33.3° F. to 73.6° F. The sun is very hot during the summer months but the air remains keen and bracing. (41, p. 156)

From these references there are indications that there may be an important correlation between low rainfall and transplanting success in western United States. Also,

some of the references suggest that the bird is tolerant of fairly wide temperature extremes.

A general survey of the literature was made to provide background material on the life history of this bird, but it was found that there was a paucity of printed information on the biology and habits of this species in India. However, three excellent reports from California, Nevada and Washington (18, 8, 17) were available and provided detailed life history data on the chukar in those states.

THE CHUKAR PARTRIDGE

Taxonomic position

The chukar partridge, Alectoris graeca (Meisner), belongs to an old world genus which includes red-legged rock partridges. It is widely distributed in parts of southern Europe and Asia. According to the American Ornithologist's Union 1957 check-list of North American birds, the native areas are:

"From southeastern France, southern Switzerland, southern Germany, Hungary, Yugoslavia, Bulgaria, northern Turkey, Caucasus, Kazakh S.S.R., Altai, Outer Mongolia and Manchuria, south to the Islands of the Aegean Sea, Italy, Sicily, Greece, Crete, Cyprus, northern Arabia, Iraq, Baluchistan, northern India, Nepal, eastern Tibet, and inner Mongolia." (1, p. 147)

Three additional species A. rufa, A. barbara, and A. melanocephala are also present in parts of Europe and Asia. Although twenty-two subspecies of A. graeca are recognized (32, p. 62-67), only the A. graeca chukar (Gray) of India will be considered in this thesis because it is the form thought to be successfully established in the several areas of western North America.

The systematic position of this subspecies follows:

Class: Aves

Sub-class: Neorithes

Super order: Neognathae

Order: Galliformes

Colors of Soft Parts:- The irides are brown, yellowish, orange or even reddish brown, the margins of the eyelids crimson or coral to brick red; the eyelids themselves grey; the bills are crimson or coral to deep coral red, often dusky or culmen, and generally so at the base and about the nostrils; the legs and feet vary from coral pink to deep-red; claws dusky brown. In young birds the bill is brownish black and the legs and feet orange-red.

Measurements:- The bird varies most extraordinarily in size, but the very majority of the specimen available for examination have not been sexed, and though there is no doubt the males average bigger than the females, the extremes of size seem to be much the same in both sexes. The wing runs from 140 to 180 mm., both of these extremes being specimen from the Simla Hills, the average of 80 birds is 157 mm., culmen 19 to 21 mm.; tail 78 to 105 mm. Hume gives the weight as 'male 19 to 27 ounces, female 13 to 19 ounces.'

Young Bird in First Plumage:- Dull brownish grey, each feather above with white tip and two black spots next to it, head is a little more rufescent; tail grey with mottley bars of black and white, the outer feather tinged with rufous; below dirty brownish-white with faint brown bars.

Young birds of the year, otherwise adult in plumage, often retain some of the barred wing quills of the first plumage bird.

Chick in Down:- Crown pale bright rufous; above pale fulvous, with four stripes of speckled rufous and black; wings pale fulvous, a little deeper on chest."

Chukar partridge observed at the Ellensburg Game Farm in Washington during the summer of 1958 appeared to coincide in general to the above description. (Figures 2 and 3)



Figure 1. An adult Chukar partridge



Figures 2 and 3. Young Chukars at Ellensburg Game Farm

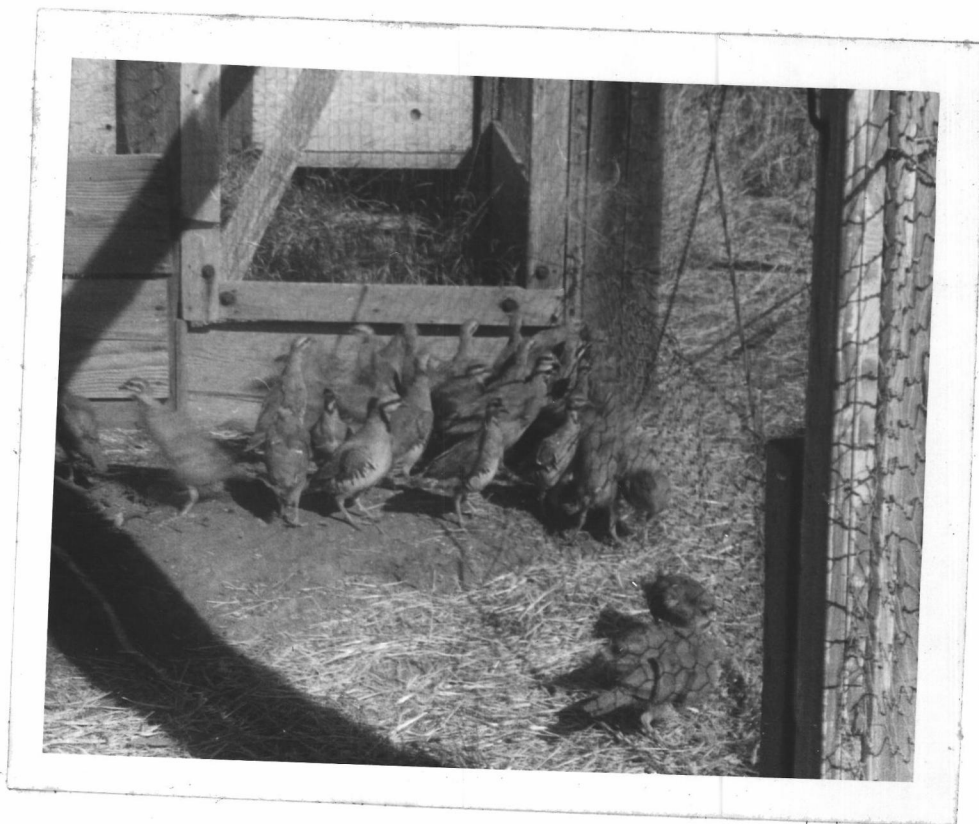


Figure 4. Some Chukars at Ellensburg Game Farm



Figure 5. Trough used for feeding Chukars at Ellensburg Game Farm

Distribution in India

The chukar partridge is present in northern India and some parts of west Pakistan and eastern Nepal. From records in several publications, the native distribution in India is Kashmir, Himachal Pradesh, the hilly districts of the Punjab, and the southern slopes of the Himalaya (Figure 6 and 7). Some published records of occurrence follow:

Irby (21, p. 236) observed chukars in the Kumaon hills in the Punjab, in bare and rocky hillsides. Tytler (37, p. 203) reported the bird from Simla to Missourie, where it is common from 4,000 to 6,000 foot grassy slopes and barren lands. Marshall (26, p. 423) said that the bird is plentiful in Chamba, which was a native state at that time and now it is in Himachal Pradesh. Frome (13) reported the bird from the Simla Hills of the Punjab.

Biddulph (4, p. 93), Cordeaux (9), Davidson (11, p. 39), Whistler (40, p. 1005), and Bates (3, p. 539) reported the chukar partridge throughout Kashmir. Hellmayr (32, p. 154) accepted Srinagar as the type locality of the chukar partridge. Ward also reported chukars in the Kashmir and Jammu states (38, p. 943-949).

In 1922, Stuart-Baker (36, p. 305-312) gave the distribution of the chukar partridge which is found throughout the Himalayas as far as Nepal and the hilly districts of the Punjab.

Whistler again reported that the chukars are plentiful in Lahul (42, p. 200) and Spiti (41, p. 628) of Himachal Pradesh. He also found the bird in the Kangra district of the Punjab (43, p. 774). Wynter-Blyth (45, p. 346) and Lowndes (25, p. 29-37) reported chukars from the northwest of Nepal at the slopes of the Himalaya. Koelz (23, p. 102) also found the bird in the district of Spiti of Himachal Pradesh.

Since climatic records of the chukar partridge locations in India are not available, the weather data covering a period of years for two cities located near areas of abundance were selected for analysis. These locations are Leh and Srinagar. Srinagar is in the middle of the vale of Kashmir and is the capital of the Kashmir state. It is situated $34^{\circ} 5'$ N latitude and $74^{\circ} 50'$ E longitude. The terrain is hilly. The city is 5,200 feet above sea level. The vegetation around Srinagar is mainly grassy, although other vegetations also are found there. The mean monthly temperature in January is 32.1° F. and 76° F. in July.

Leh is a small town in the northwest of Kashmir. The exact location is 34.05° N latitude and 77.34° E longitude. Leh is 11,529 feet above sea level and the terrain is hilly. The vegetation of this place is mainly grassy, devoid of big trees. The temperature rises rapidly in the summer. The rays of the sun in the unclouded summer are very strong. Rainfall is scanty. The air is extremely dry and bracing.

In India, the year is popularly divided into three seasons. The cold season is from October to March, the hot season is from March to June, and the rainy season is from the middle of June to October (22, p. 155, 191-192).

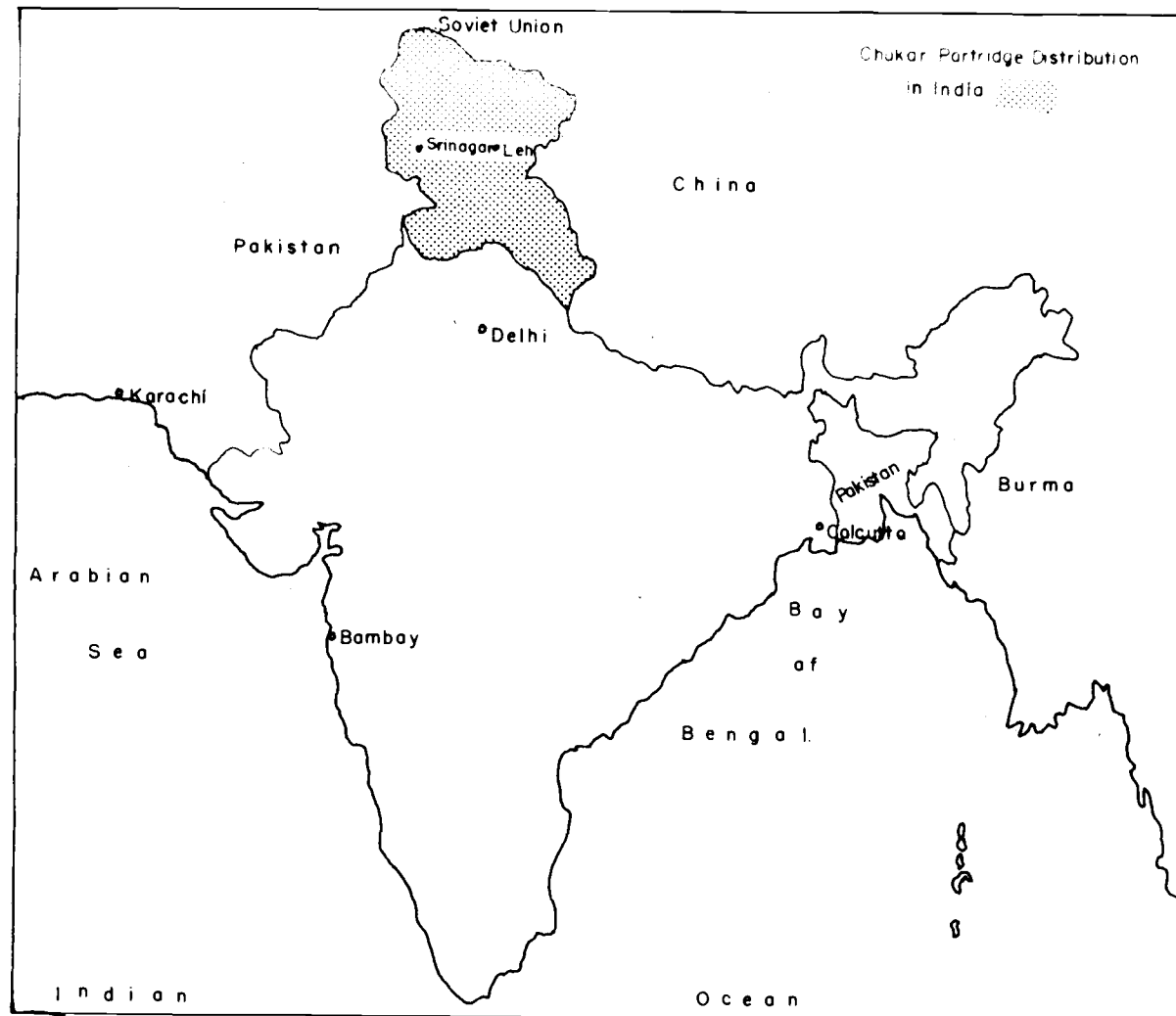


Figure 6. Distribution map of Chukar partridge in India

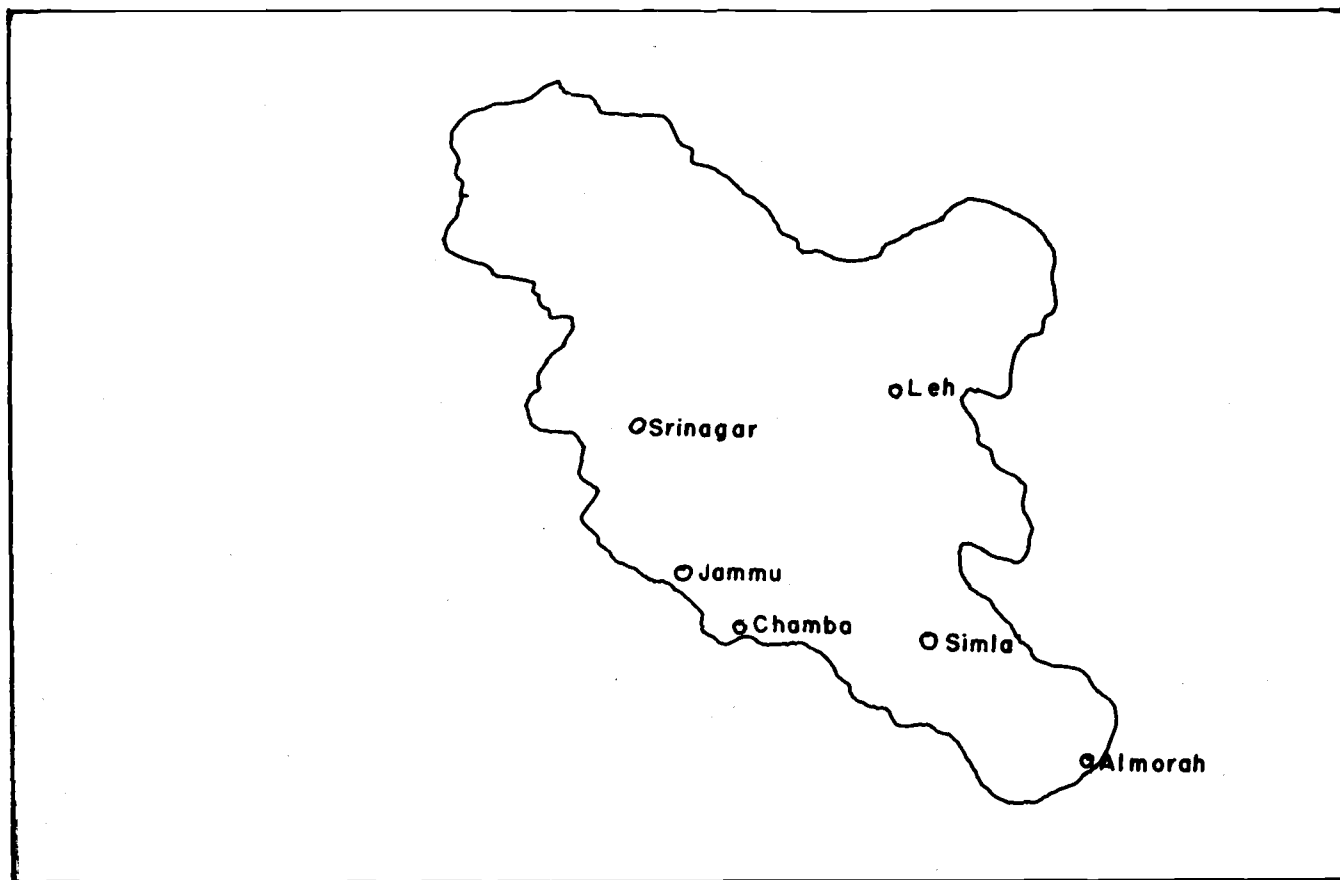


Figure 7. Distribution map of Chukar partridge showing some cities
in the range in India

INTRODUCTION AND ESTABLISHMENT OF THE CHUKAR PARTRIDGE IN THE UNITED STATES

According to the American Ornithologist's Union 1957 check-list of North American birds (1, p. 147), the chukar partridge has been established in parts of California, Nevada, Washington, southern Idaho, central Wyoming, and southwestern Colorado. The bird is also known to be established in parts of eastern and central Oregon. Although attempted introductions have been made in most of the other states as well as Nova Scotia, Canada, no reference was found to substantiate successful establishment in such areas.

The first attempts to introduce the chukar partridge in the United States dates back to 1893. Mr. W. O. Blaisdell of Illinois brought five pairs from Karachi, British India, which were liberated at Macomb, Illinois. The liberation was unsuccessful.

Distribution of the chukar partridge in California

In 1925, Frank E. Booth of San Francisco brought chukar partridges, purchased in Calcutta from a game handler, to his private game farm in California. In 1928, the California Department of Fish and Game obtained several birds from Mr. Leland Smith, a private game farm breeder at Woodbard, California, who had obtained his

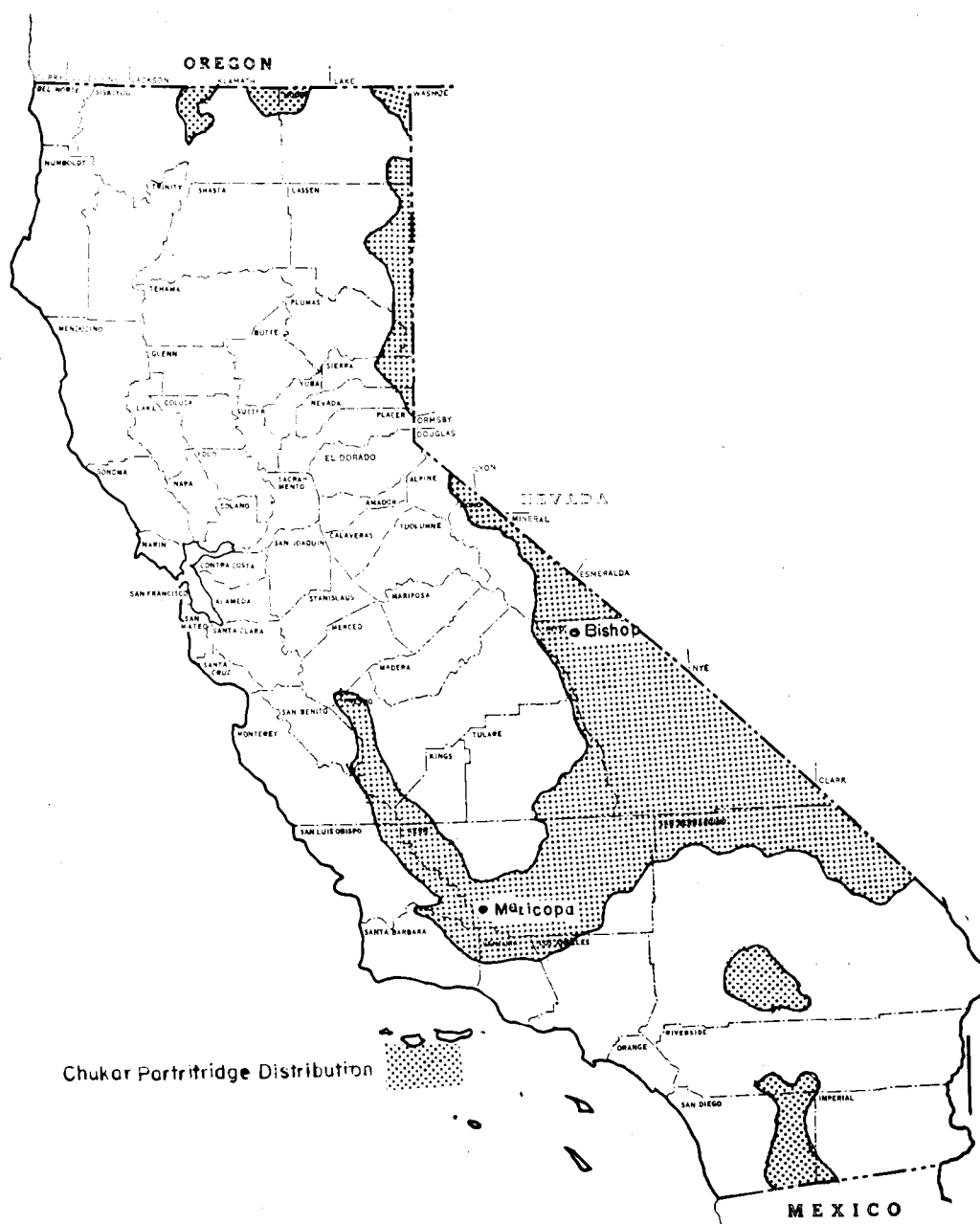


Figure 3. Distribution map of Chukar partridge in California

original stock from Mr. Booth. An additional ten chukars were imported from Calcutta for use as breeders on the State Game Farm at Yountville. It is believed that birds raised and liberated in California were Alectoris graeca chukar (10).

The California Department of Fish and Game first liberated chukars in 1932 in Riverside, San Bernardino, and Shasta counties. By 1953, over fifty thousand game-farm-reared birds had been released in all counties of the state except four, and the first hunting season was in 1954.

The established distribution in California in 1958 is presented in Figure 8. In almost all cases establishments were in semi-arid regions where the annual rainfall did not exceed 20 inches.

Distribution of the chukar partridge in Nevada

In Nevada, Mr. Ira Hamlin Kent of Fallon, was the first person to bring the chukar partridge from India. He received six pairs of chukars from Calcutta in 1933. From that initial stock he produced enough birds to make the first known release of the chukar partridge in Nevada. This release was made in the Fallon area in Churchill county in 1934. Gullion (16, p. 149-153) reported this release and added that some birds were also

introduced in the area east of Reno at about the same time. Christensen reported (8, p. 13-14) that by the fall of 1935, some chukars were distributed in Churchill, Douglas, Esmeraldo, Humboldt, Lander, Lyon, Nye, Ormsby, and Washoe counties.

In addition to the plantings made by the Nevada Fish and Game Commission, a number of private individuals and sportsmen's clubs also introduced chukars from time to time. By 1953, chukars were established in 14 out of the 17 counties in Nevada. The Nevada Fish and Game Department is now attempting to introduce chukars in the remaining three counties in Nevada.

Major chukar populations in Nevada are found in the western and central parts of the state. The chukar is only sparingly established in some locations in eastern Nevada. These are the Virgin Mountains in Clark county; Clover Mountains, Ursine area and the south end of Egan Range in Lincoln county; White Pine Range in White Pine county; Quinn Canyon, Grant and Horse Ranges in Nye county; Diamond Mountains, Alpha, Simpson Park Mountains in Eureka county; the canyon of the South Fork of the Humboldt River, Carlin Canyon, Abode Range, and the Metropolis area in the Elko county (16, p. 133). Figure 9 presents the known distribution areas of the chukar partridge of Nevada. In November 1947, the first hunting

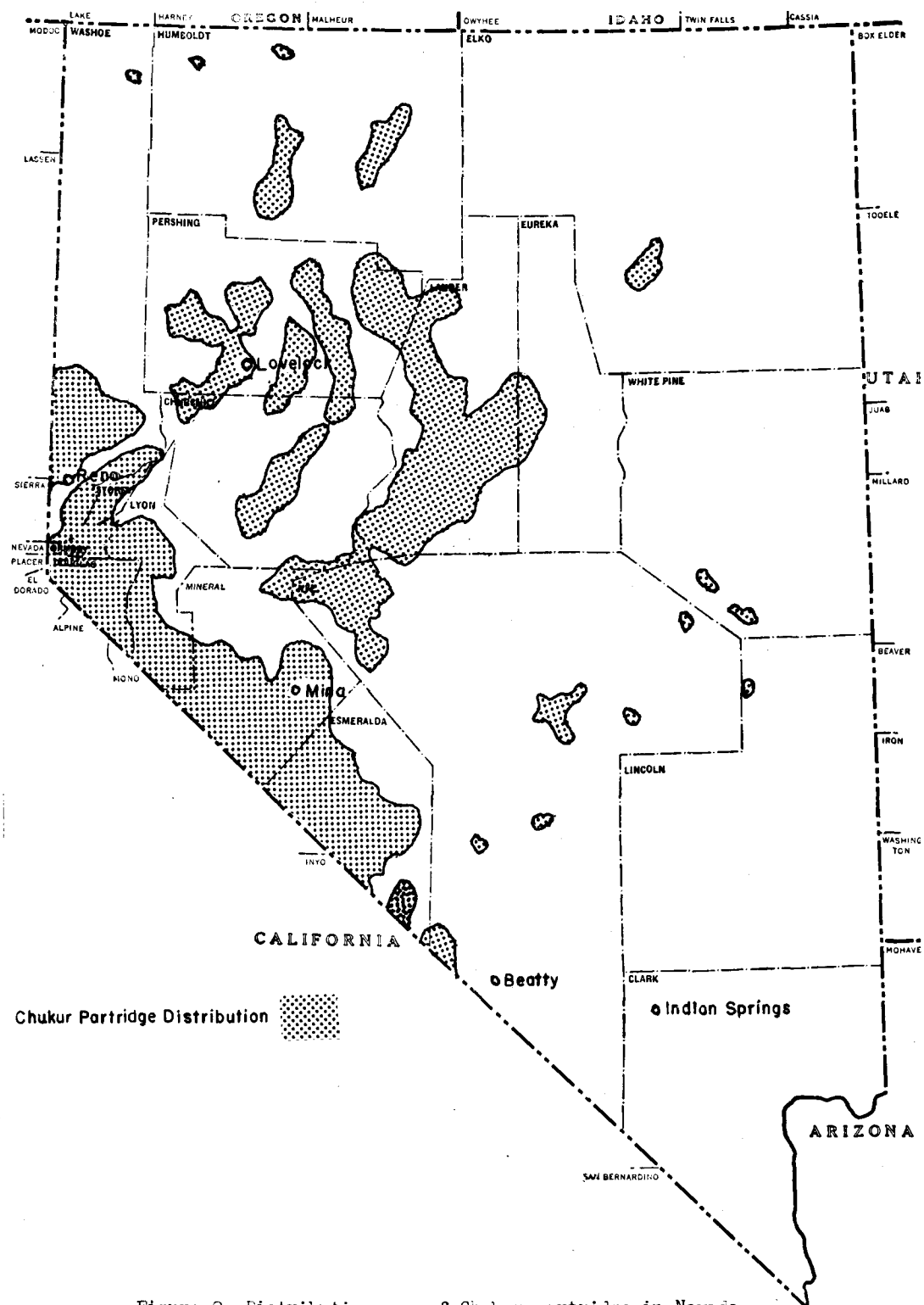


Figure 9. Distribution map of Chukar partridge in Nevada

season of chukar partridges was held in Nevada. Open seasons have been held each year since.

Distribution of the chukar partridge in Washington

According to Moreland (29, p. 400), the first plantings of the chukar partridge in Washington state were made in Grant and Garfield counties in 1931 and 1932. These birds were not successful in establishing themselves. Later four pairs of chukars were obtained from a private game breeder in California, the farm stock of which was imported from Calcutta (2, p. 154-161). These were used for brood stock for the first game-farm production of chukars in Washington. They were first raised at the Ellensburg Game Farm, which was later moved to Yakima. Moreland (29, p. 400) reported the first successful releases were made from this game farm in 1938, and in 1952 in 20 counties in Washington state. During the period from 1938 to 1942, 3,962 chukars were raised and released from game farms (2, p. 154-161). Forty-six plantings were made during that period. Ten plantings were made in the area west of the Cascades, which did not become established and they were considered failures (14, p. 6).

Plantings were made in all 20 counties of the Washington state. Galbreath and Moreland (14, p. 9)

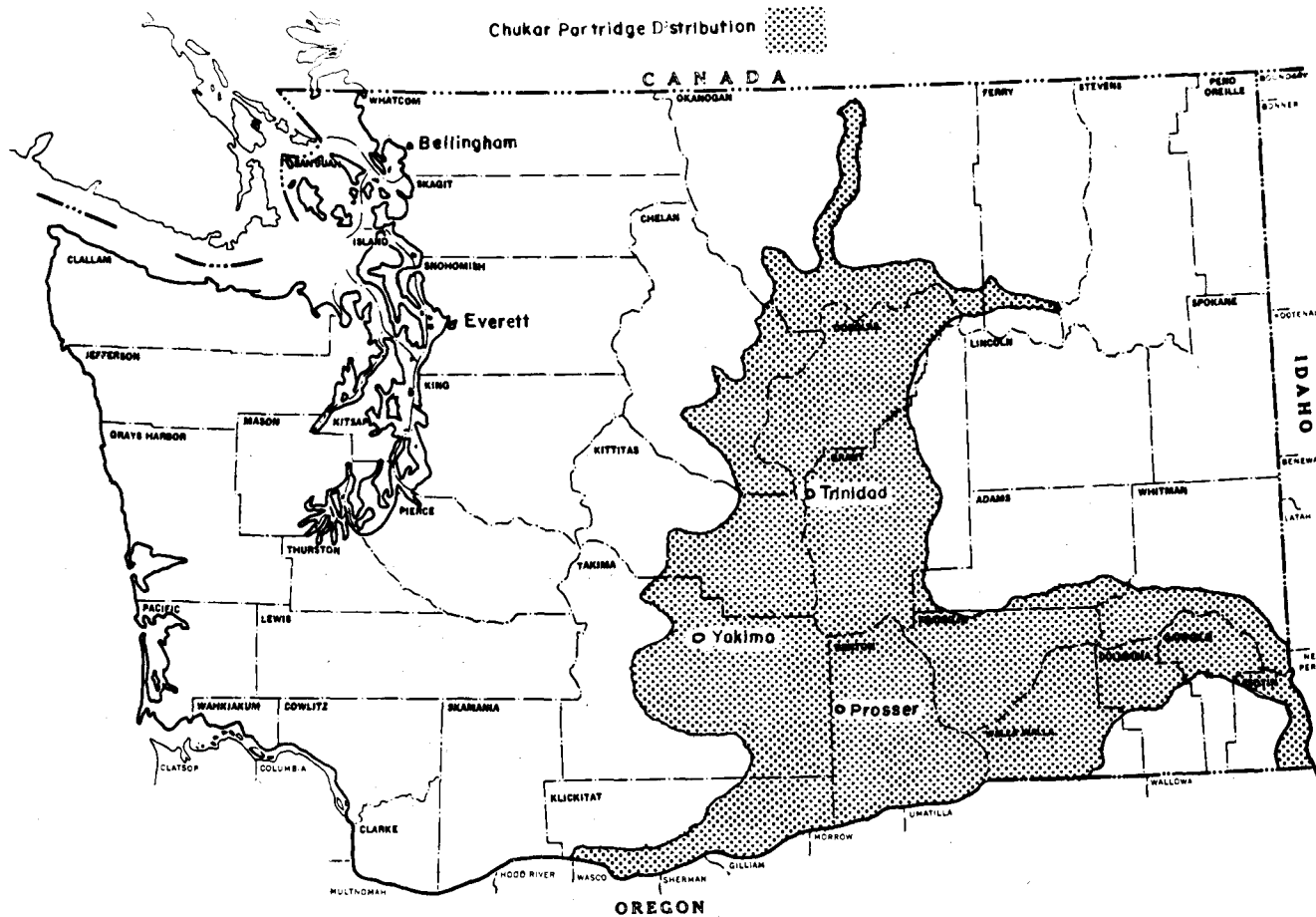


Figure 10. Distribution map of Chukar partridge in Washington

reported in 1953 that the chukars were permanently established in the eight counties of Washington state. These are Adams, Benton, Chelan, Douglas, Grant, Kittitas, Okanogan, and Yakima. Small populations of the chukars are also found in Lincoln and Walla Walla counties.

The present established distribution areas of the chukar partridge in eastern Washington, as supplied by the Chief of the Game Management Division, State of Washington, are given in Figure 10. According to Barnett:

"By 1948 it was apparent the chukar has not only established in Washington, but was present in sufficient numbers in some areas to warrant an open season." (2, p. 154)

The first hunting season of the chukar partridge in Washington state was in 1949. Regular seasons have been opened every year since 1949.

Distribution of the chukar partridge in Oregon

The Oregon State Game Commission began its program of introducing chukars into eastern Oregon in 1949 (27, p. 251-253). During the summer of 1950, eggs were obtained from the Washington State Game Division and were hatched at the Hermiston Game Farm. Later, additional eggs were obtained from the game departments of Idaho and Wyoming, and hatched at the Ontario Game Farm. These game-farm-reared chukars were first released in Oregon in

1951 on the west side of Hart Mountain in Lake county.

The biennial report of the Oregon State Game Commission for 1955-56 (31) reported that chukars were successfully established along the breaks of the Deschutes, John Day, Malheur, and Owhyee rivers. The present distribution areas, as supplied by the Director of the Oregon State Game Commission, are given in Figure 11. The chukar seems to prefer the steep, rocky sage and grassland type country adjacent to water, and has become established in such sites. It is believed that additional plantings of chukars will be made as there are many potential habitat areas in central and eastern Oregon.

The first open season on the chukar partridge in Oregon was held in 1956; also hunting was allowed in 1957 and 1958.

Distribution of the chukar partridge
in other western states

Moreland reporting at the Fifteenth North American Wildlife Conference in 1950 stated that he did not know of any successful establishment of the chukars east of the Rockies (29, p. 409). Although chukars have been introduced into all states of the United States, it seems to establish itself only in the western states. Chukars are plentiful in the states of California, Washington, and

Nevada. In Oregon it appears to be doing reasonably well in some areas of the state. Besides these states, chukars are reported in Colorado, Idaho, Montana, New Mexico, Utah, and Wyoming. A brief discussion of chukar introductions in the last six mentioned states follows:

Colorado: Sandfort (34, p. 244-250) reported that chukar partridges are found in at least 12 out of 63 counties. All the established birds were from game farm stocks. The game department released birds during the period from 1937 to 1946, in the 52 counties of the state. It is their opinion that although the chukar partridge is few in numbers, it may be establishing itself in parts of Colorado.

Idaho: The first attempt to propagate Alectoris graeca chukar goes back to 1930 when the game department first obtained brood stock from California for game-farm production. Some of the birds thus raised were liberated in 1933 in Nez Perce county. These birds dwindled in number and finally disappeared. Later in 1937-38, additional birds were purchased from an Oregon game bird breeder. These were raised on game farms and releases again started in 1939. Chukars were liberated in 21 counties and were apparently successful in establishing in 8 counties of the state of Idaho (33, p. 162-169).

Montana: From the Biennial Report of the Montana Fish and Game Commission for May 1, 1954 - April 30, 1956, the following quotations were given regarding this exotic species:

"The chukar partridge has been introduced from southern Asia during the more recent years. Up to the present time, approximately 20 major plants have been made. Field observations have indicated a fair degree of nesting success. It is difficult as yet, however, to determine the degree of establishment of this desirable game bird in Montana. From the present planting program it has been determined that the birds tend to thrive in the more arid rocky sections of the state. If successful establishment is obtained, it will fill an important niche in the game bird habitat in Montana."
(28, p. 32)

Thus it would appear that establishment of the chukar partridge in Montana is still doubtful.

New Mexico: The New Mexico Department of Game and Fish liberated both Indian chukar, Alectoris graeca chukar, and Turkish chukar, Alectoris graeca kleinii. Between 1931 and 1957, the department released 7,678 birds in 17 of the 32 counties. Besides these, some private individuals also liberated chukars in New Mexico. The department stopped raising the Indian chukar as a game-farm bird in 1955. (5, p. 4) The degree of success of Indian chukars in New Mexico is

still doubtful. Now the department is giving importance for liberation of Turkish chukars.

Utah: The so-called chukars of Utah vary in origin. First attempt was made in 1947, when the department purchased chukars to introduce in the state of Utah. Some birds were released near Salt Lake City and some of the birds were raised as brood stock (15, p. 168-170). The department also raised sufficient numbers on game farms to permit a release of chukars in two areas in Utah during 1952. The department also liberated Turkish chukars.

Wyoming: The present nucleus of breeding stock was obtained as eggs from the Montana Game Farm. First release was made in 1938, when 55 birds were liberated. Again in 1939-40 birds were released from that stock. Breeding birds were also purchased from the Alpine Ranch in California (39, p. 168-170). Chukars have since been released, in almost all counties and in all sorts of habitats, with doubtful establishment of the chukar partridge in the state. Further details of the distribution of the chukar partridge is not known.

COMPARISON OF HABITATS IN NATIVE AND INTRODUCED RANGES

No detailed study on the typical habitat of the chukar partridge in its native range in India was found. It is difficult to give an accurate description of the habitat of the chukar in its native range since so little is recorded regarding this phase of the bird's life requirements.

In India the chukar is present in all altitudes from the plains to 14,000 feet elevation. Occasionally it may be found as high as 16,000 feet during the summer months. Usually they inhabit the broken, rocky areas interspersed with hills and ravines. Generally this partridge is not found in forested areas although it may occur sometimes in grassy uplands. Chukars are not found in humid areas where rainfall is prolonged for many months. The chukar is a bird of the desert and seems to prefer the rocky, barren, dry hills.

Lowndes (25, p. 29-37) reported the habitat of the Indian chukar to be the barren and rocky hillsides. Wynter-Blyth (45, p. 346) states that the chukar is found on open hillsides and slopes. Bates (3, p. 559) found that chukars were common on the steep slopes. In Kumaon, chukars are common in the bare, rocky hill areas (21, p. 236). Tytler (37, p. 203) reported that

the chukar is common at the 4,000 to 6,000 foot levels on grassy slopes as well as barren lands.

During the British reign many amateur ornithologists studied this bird and observed it under field conditions. Some of these observations were published in various magazines and journals and thus help to provide at least sparse information on the bird's habitat. Although lacking detail, these reports confirm the belief that although the chukar may exist at various high elevational levels it seems to prefer the dry, broken, rocky areas and is not found in the tree forests or in the dense humid rainy areas.

In the United States the chukars are found in different arid habitats. Habitat studies have been made by several people in the different states and are briefly summarized as follows.

In the state of Washington, chukars have flourished on the steep, rocky and dry slopes in the semi-arid areas (14, p. 10). Barnett (2, p. 154-161) reported the chukar range in the state of Washington as talus slopes, rock outcroppings, cliffs and bluffs, and brushy creek bottoms.

Moreland (29, p. 399-409) gives a complete description of preferred habitat and reports several successful plantings of chukars. He describes the optimum range



Figure 12. Typical habitat of Chukar partridge in Oregon



Figure 13. Typical habitat of Chukar partridge in Oregon

which is 25 percent talus slopes, 10 percent rock up-thrusts, 10 percent bunch grass and blue grass association, 3 percent brushy creek bottom, and 52 percent sage and cheat grass association. Slopes associated with this growth should have a difference in elevation of more than 200 feet and be over 7 percent in grade. In Washington, chukars are permanently established in areas from 575 feet to 4,000 feet elevation. Chukars failed in the flatland wheat country where they were tried. The birds migrated to the river canyons and established there (24).

In Nevada, chukars generally inhabit the rough mountain ranges, broken by steep, rugged canyons, with wide valleys between ranges. It is also found in talus slopes and rocky outcrops. Slopes with angles of 30 to 40 degrees and elevation from 4,000 to 8,000 feet are preferred (8, p. 1-77).

In California, chukars are found from 280 feet below sea level in Death Valley to 14,495 feet above sea level in the highest peak, Mt. Whitney. Chukars are found in deep, rough, rocky canyons and steep sided gullies.

Not much has been reported about the vegetation in their native Indian range. In western United States, bunch grass, cheat grass, and sagebrush are the prevalent plants in most of the chukar's habitat (12, p. 362). The bird does not thrive in marshland, wooded areas, or



Figure 14. Typical habitat of Chukar partridge
in Washington

extensively open areas (30, p. 207-216).

Thus it appears that suitable habitat for chukars in the western United States includes rocky outcrops, talus slopes and steep canyon walls. Such areas are barren, wind-swept, and with scanty vegetation.

Nest locations in India as described by Hume:

"The nest composed of little grass or a few leaves, at times laid on the flat surface of the ground; at others in a slight depression, natural or scrap by the birds; is placed often in fields; often under the shelter of some tuft of grass or dwarf bush on a grassy hillside; occasionally under some similarly situated rock barely shaded by tufts of dropping fern." (19, p. 431)

Stuart-Baker also reported the nest of chukars in India as:

"The nest is, as a rule, merely a hollow scratched in ground, and lined with a little grass or a few leaves sometimes; however, it makes quite a compact pad of grass leaves and other rubbish with a well-formed depression in the center for the eggs. Frequently it may be found in open nullahs or on rocky hillsides, merely protected from the sun and rain by a rock or stone, but more often a site is selected amongst bushes, scrub, willow-bushes or ferns, which shade as well as screen it from enemies, human or otherwise. It is never, apparently, placed in very thick scrub, and certainly never in forest, but may sometimes be found in fairly long grass, especially if there are patches of rocky and bare ground close by." (36, p. 308)

The nest locations in the United States, as reported by Galbreath and Moreland in Washington, are as follows:

"Each nest was merely a depression in the ground about four inches deep and eight inches in diameter, built near the base of a decumbent sage, contained a lining of dried grass and few feathers." (14, p. 21)

Christensen (8, p. 40) in Nevada, and Barnett (2, p. 154-161) in Washington gave similar descriptions of nest locations.

In California, nests are found on slopes of rolling hills with outcropping of shale sandstone and granite. There is no apparent preference or direction of slopes.

CLIMOGRAPH COMPARISON OF CHUKAR LOCATIONS IN INDIA AND THE UNITED STATES

Since it is generally recognized that temperature and moisture are two important climatic factors influencing the success or failure of some species when introduced in foreign locations, climographs have been employed for comparing in a general way the precipitation and temperatures of native areas for some insects, mammals, birds, and other animals with locations into which these forms have been or may be introduced (35, p. 18), (7, p. 226) and (6, p. 809). In this particular study, the main objective was to ascertain if mean monthly temperatures and precipitation when plotted as climographs could be used to show a relationship with the native areas of the chukar partridge in India with those of several successful locations in the western United States.

In each of the climograms, the mean monthly rainfall in inches was plotted as the abscissa and mean monthly temperatures in degrees Fahrenheit were recorded on the ordinate. Then all the points were connected consecutively to form a closed diagram.

Table 1 presents the average monthly precipitation and temperatures for the two Indian locations. Weather records for Leh are based on a 60-year period and for

Srinagar 50 years. The climographs for these two locations are presented in Figure 15.

An inspection of the two Indian climographs shows that the diagrams do not coincide at any corresponding monthly point. Although both locations are in arid regions having mean annual precipitations of less than 26 inches, Leh has much less rainfall during each month of the year and is colder during the fall and winter months than is the case at Srinagar. The average annual rainfall at Leh is only 3.26 inches while at Srinagar it is 25.99 inches. Some rainfall occurs at both locations during each month of the year (Figure 23).

The mean monthly temperature at Leh ranges from 18.7° to 63.35° F. and at Srinagar the range is from 32.1° to 76.0° F., the highest occurring in July and the lowest in January at both locations (Figure 30). Temperature extremes throughout the year usually do not exceed -10° in winter to 85° F. in summer at Leh; while at Srinagar the extremes usually do not exceed 10° to 95° F. (20, p. 1-321).

Since the two climographs for Leh and Srinagar did not coincide, a composite diagram was made for the two locations to be used later in comparing with climographs made for successful chukar areas in the United States.

The composite climograph was made by connecting seasonal monthly extremes occurring in January and July (Figure 16).

Then climograms were made for Maricopa and Bishop in California; Reno, Lovelock and Mina in Nevada; Madras and Redmond in Oregon; and Yakima, Prosser and Trinidad in Washington. All of these later locations are near established chukar areas. In addition, climographs were made for Bellingham and Everett located in western Washington, which are near unsuccessful chukar partridge release areas.

California

The climographs for Maricopa and Bishop (Figure 17) do not correspond with those for the locations in India, except for a few isolated points. However, most of the fall and winter months fall within the composite climograph of Leh and Srinagar, but do not do so for spring and summer months. The main difference in the climographs appears to be that corresponding mean monthly temperatures at Leh are always considerably less than at either the California locations (Figure 30). On the other hand, corresponding mean monthly temperatures at Bishop and Srinagar are almost identical. When the mean monthly precipitations are compared with the two Indian

areas (Figures 23 and 24), it is evident by inspection that rainfall in the two California areas is slightly greater than at Leh but not as great as at Srinagar.

The conclusions are that climographs for the California areas do not correspond with those for the two Indian locations; but there are similarities in rainfall to that of Leh and in temperatures to that of Srinagar.

Nevada

The climographs for Reno, Lovelock, and Mina (Figure 18) are quite similar to those for the two California locations, differing only slightly because of less warmth in the summer months. These Nevada stations fall for most of the year within the composite climograph for Leh and Srinagar, except for summer months which are slightly higher in temperatures. The mean monthly temperatures at the three Nevada stations, although not quite identical, are for the most part slightly less than at Srinagar but warmer each month of the year than at Leh (Figures 30 and 31).

When the mean monthly precipitation for the Nevada stations are compared to Leh there is considerable similarity evident, being slightly greater at all Nevada locations, which have considerably less rainfall than

occurs at Srinagar (Figures 23 and 25).

Conclusions are that climographs for the Nevada areas do not correspond with those for the two Indian locations. However, there is a similarity in rainfall with that of Leh and not for Srinagar; and temperatures in Nevada are similar to Srinagar but not for Leh.

Washington

Although climographs for Yakima, Prosser, and Trinidad (Figure 19) do not coincide to either of the two Indian locations, they do indicate an intermediate condition between that of Leh and Srinagar in that precipitation is slightly greater than at Leh but considerably less than at Srinagar (Figures 23 and 26). Monthly temperatures fall for the most part slightly below Srinagar and always higher than at Leh (Figures 30 and 31).

Two additional climographs were constructed for Bellingham and Everett, located in western Washington, near which unsuccessful chukar liberations were made (Figure 22). These climographs nowhere correspond with that of Leh in mean rainfall or temperature. There is some overlapping with that of Srinagar, but differ considerably in having greater rainfall during the fall and winter months (Figures 23 and 29). In other words, the annual rainfall at Bellingham and Everett, 33.63 and

34.81 inches respectfully, exceeds that of Srinagar by at least 7 inches annually.

Oregon

Climographs for Madras and Redmond, which are almost identical, show the same general agreement with the other successful locations in western United States (Figure 20). However, all monthly points for these two Oregon locations fall within the composite climograph for Leh and Srinagar, except for July and August which almost coincide. These two Oregon locations are slightly warmer than Leh during all months of the year. The mean monthly temperatures at Madras and Redmond are presented graphically in Figure 31.

The mean monthly temperature of Madras and Redmond are less than at Srinagar but only slightly greater than Leh. Monthly rainfall at the two Oregon stations (Figure 27) are similar to chukar areas in Washington, somewhat greater than Leh, and not nearly as much as at Srinagar.

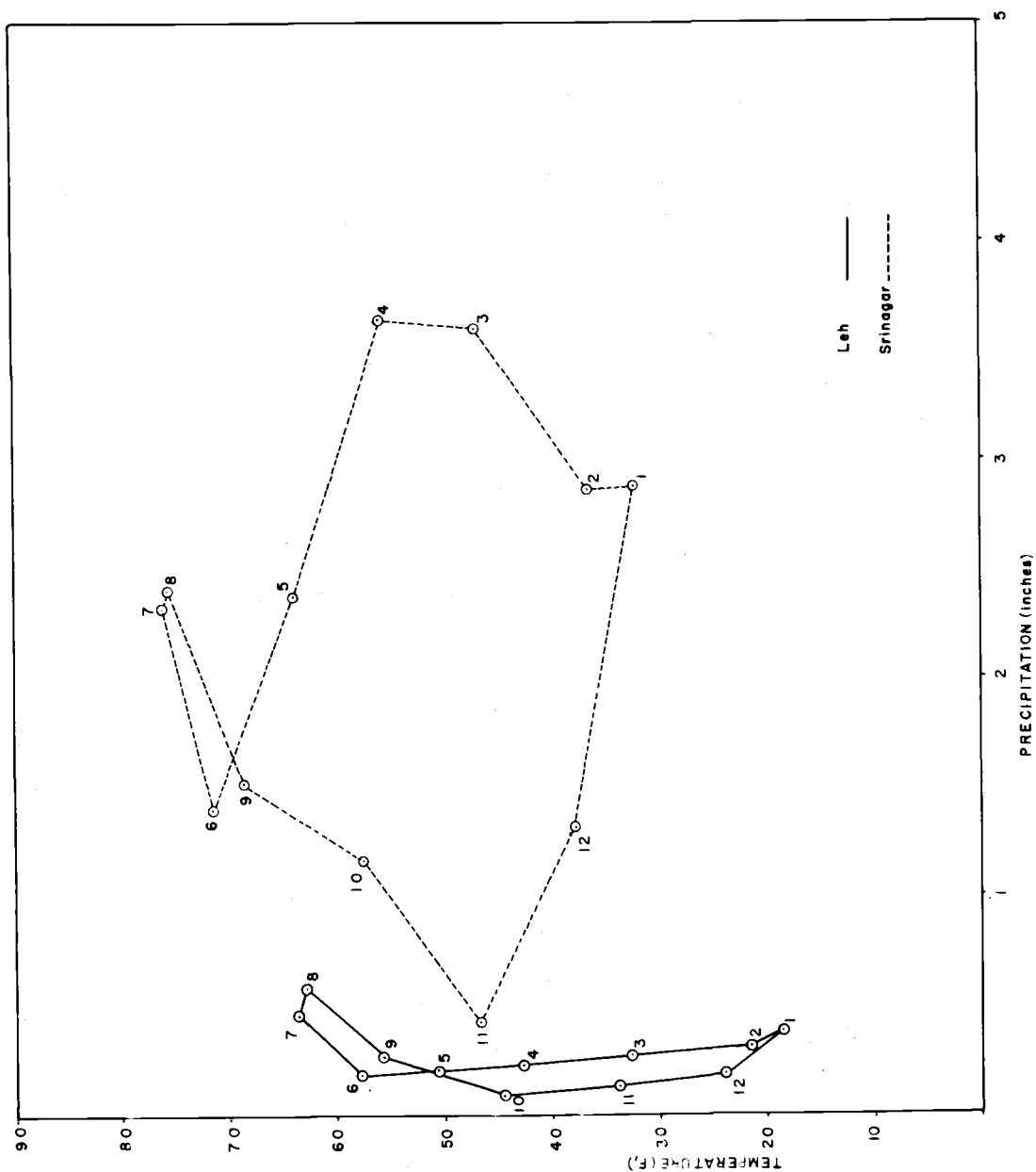


Figure 15. Climographs showing mean monthly temperature and precipitation of two Indian locations of the Chukar partridge

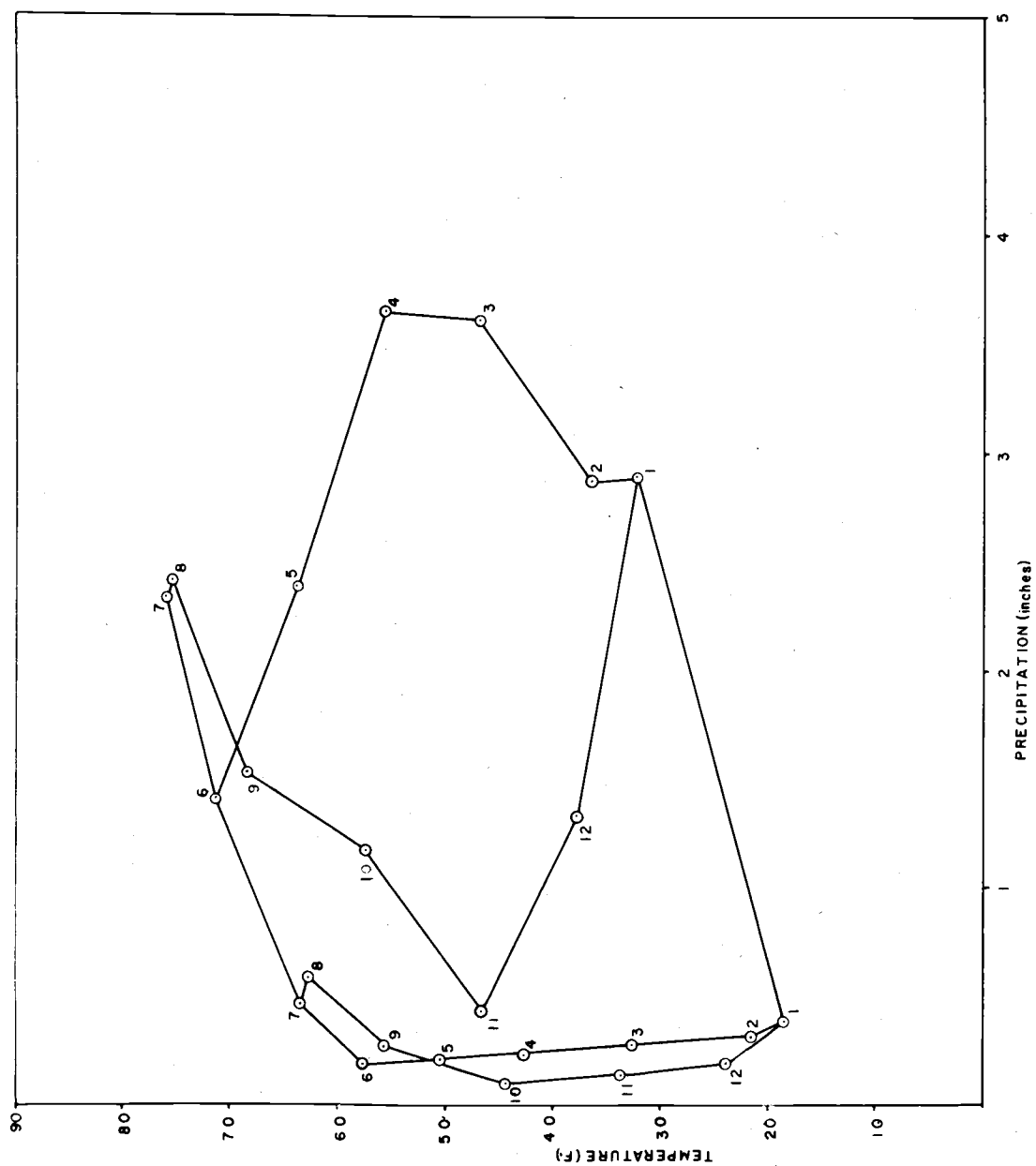


Figure 16. Composite climograph of two Indian locations

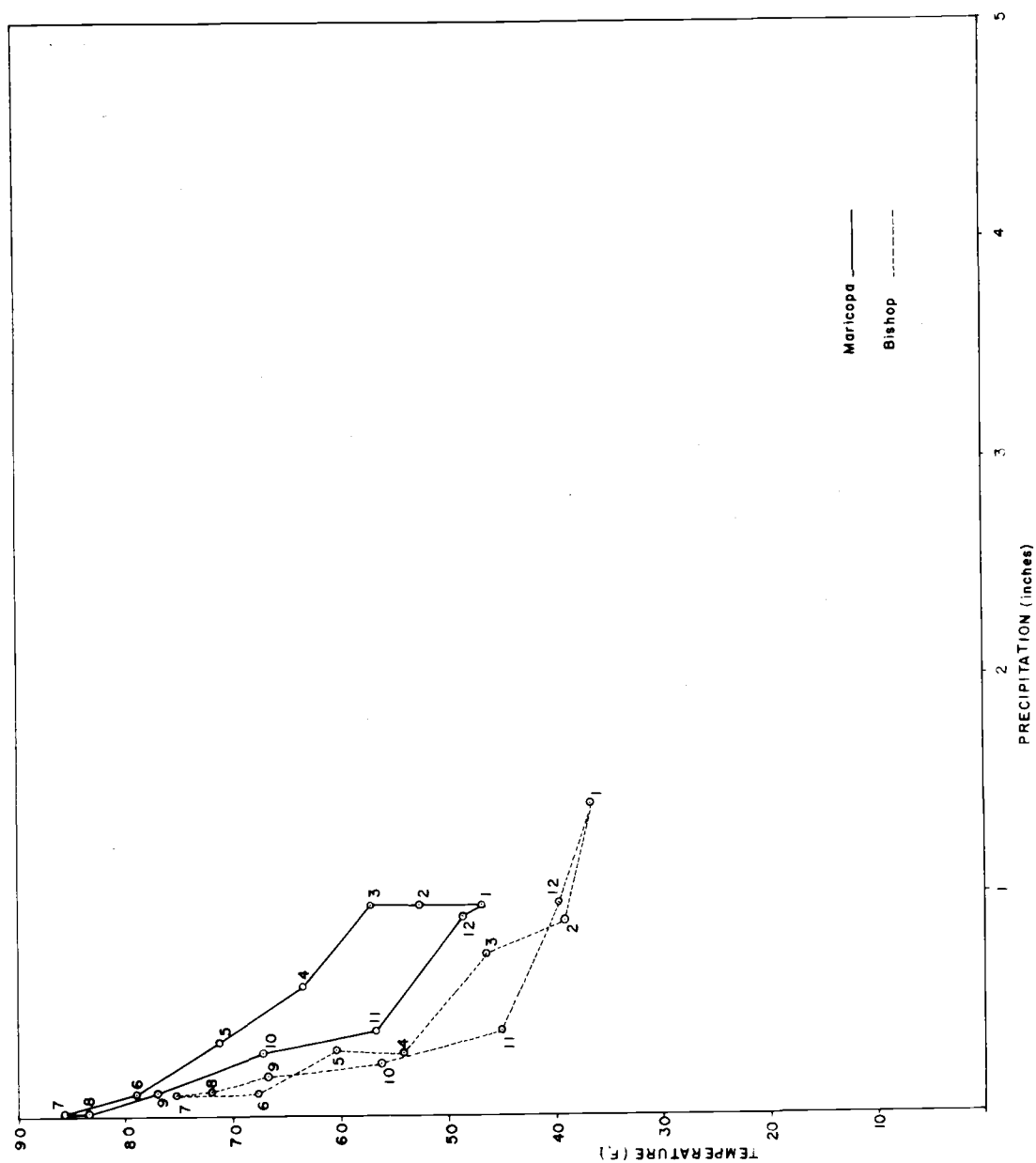


Figure 17. Climographs showing mean monthly temperature and precipitation for established Chukar partridge locations in California

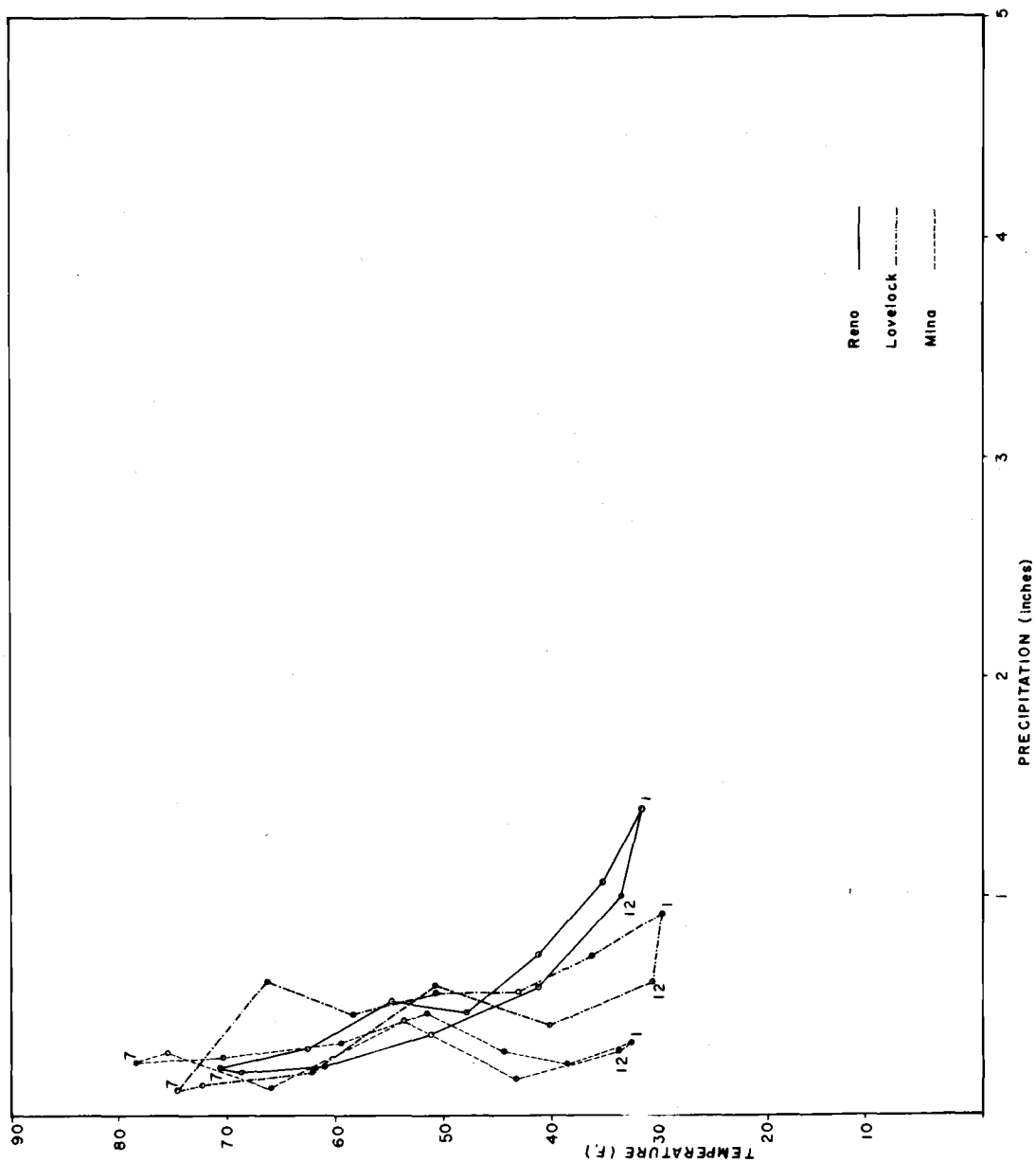


Figure 18. Climographs showing mean monthly temperature and precipitation for established Chukar partridge locations in Nevada

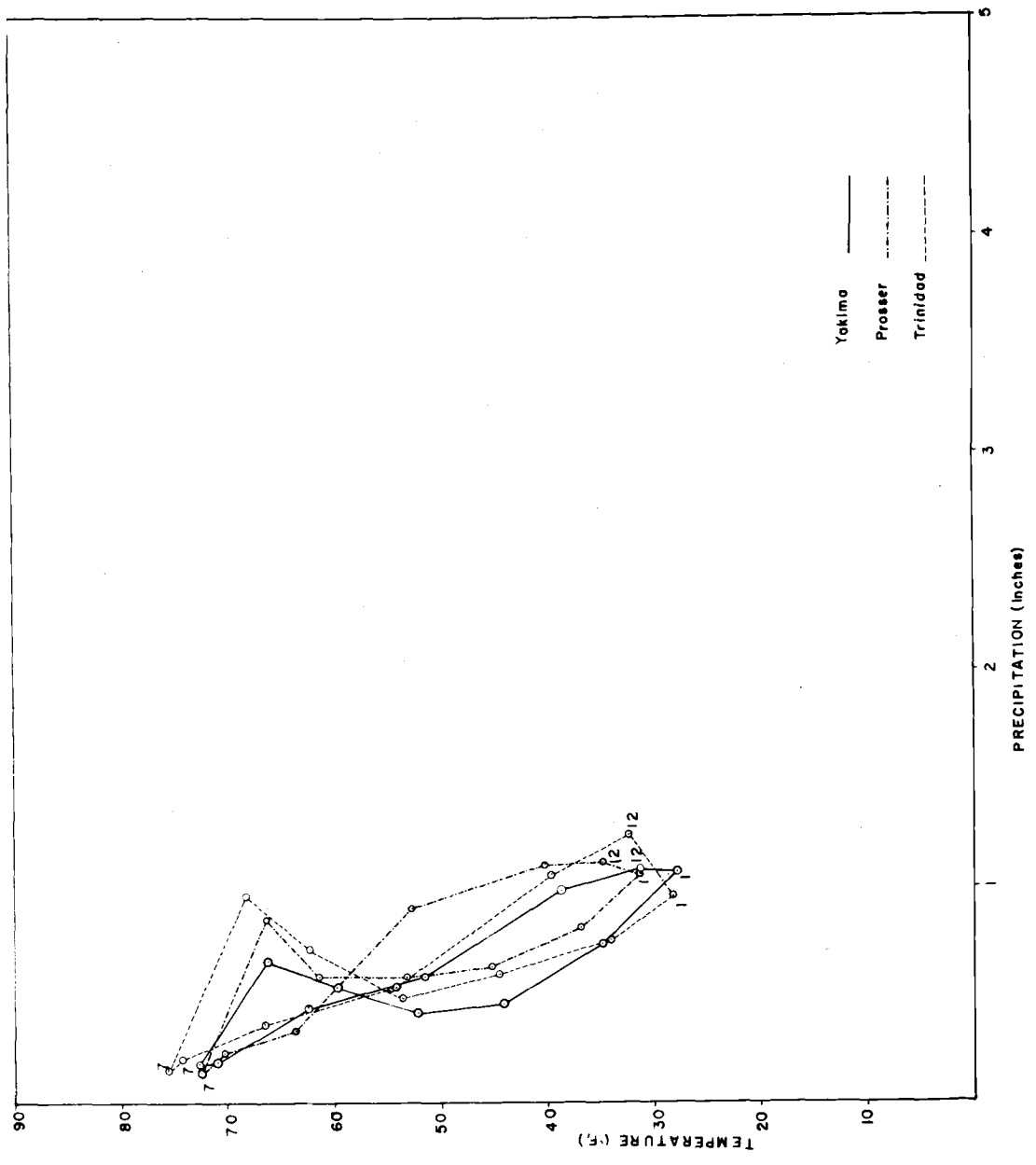


Figure 19. Climographs showing mean monthly temperature and precipitation for established Chukar partridge locations in Washington

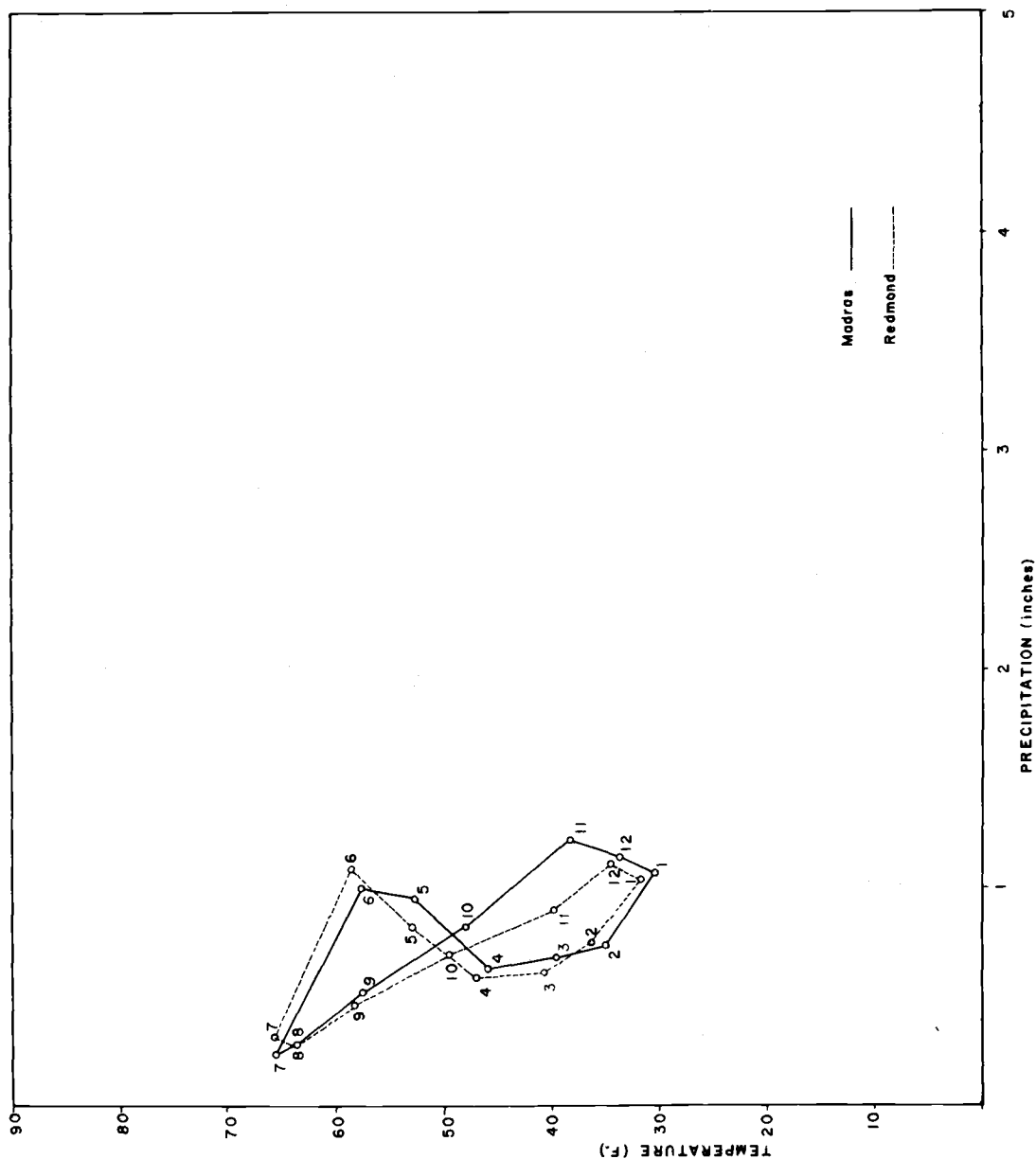


Figure 20. Climographs showing mean monthly temperature and precipitation for established Chukar partridge locations in Oregon

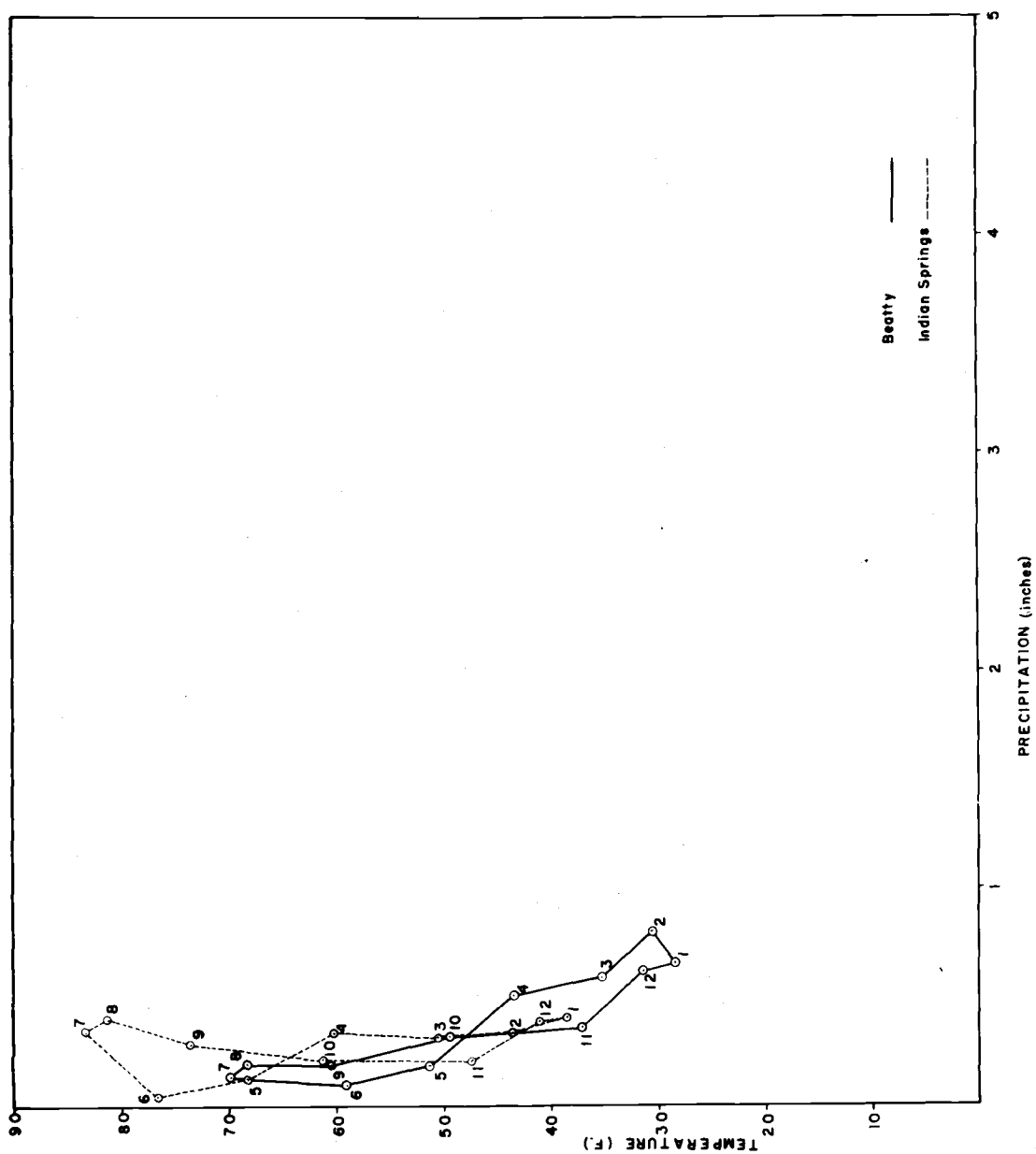


Figure 21. Climographs showing mean monthly temperature and precipitation for unsuccessful Chukar partridge locations in Nevada

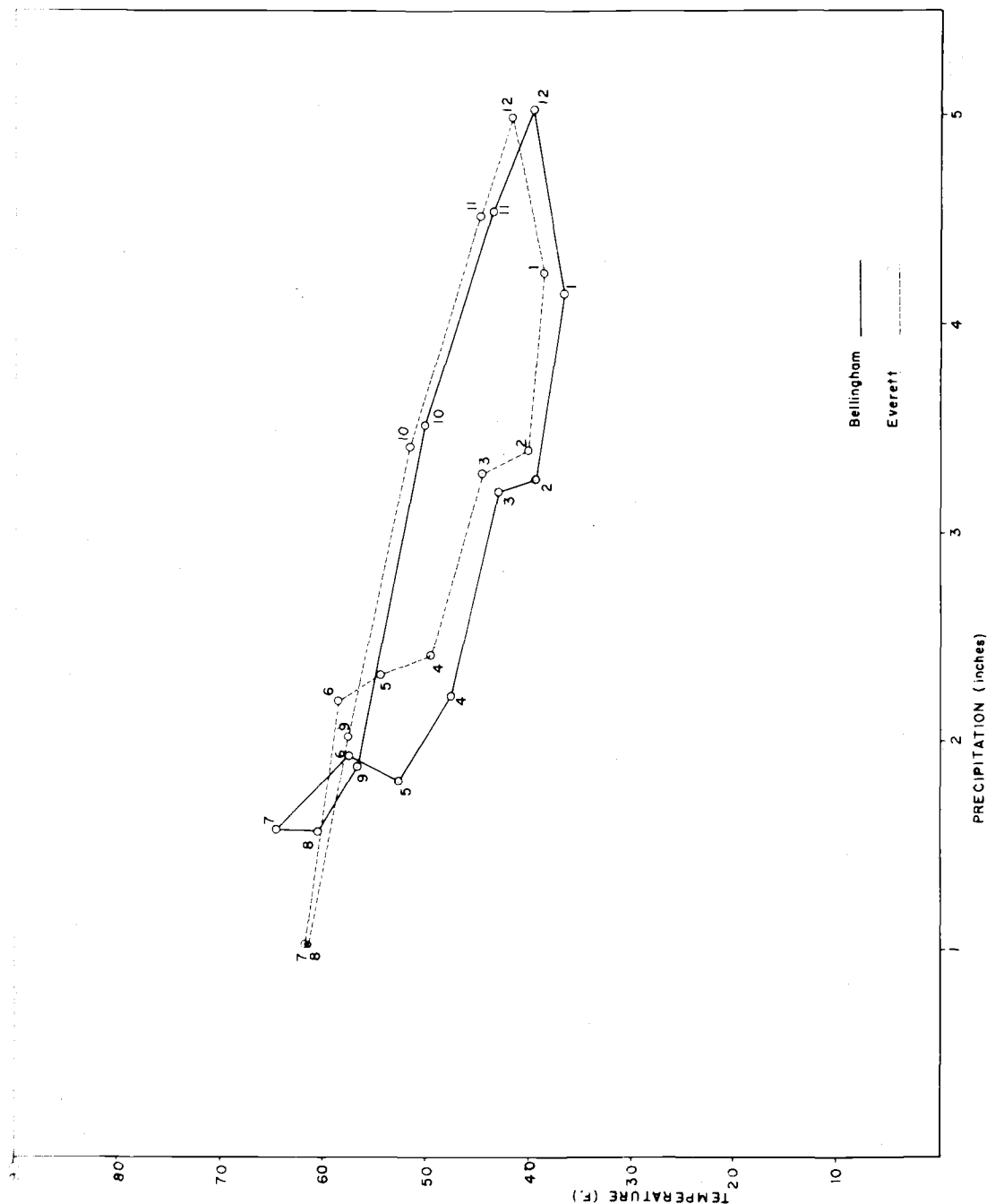


Figure 22. Climographs showing mean monthly temperature and precipitation for unsuccessful Chukar partridge locations in western Washington

Figure 23. Graphs showing mean monthly precipitation in two Indian locations



Figure 24. Graphs showing mean monthly precipitation for established Chukar partridge locations



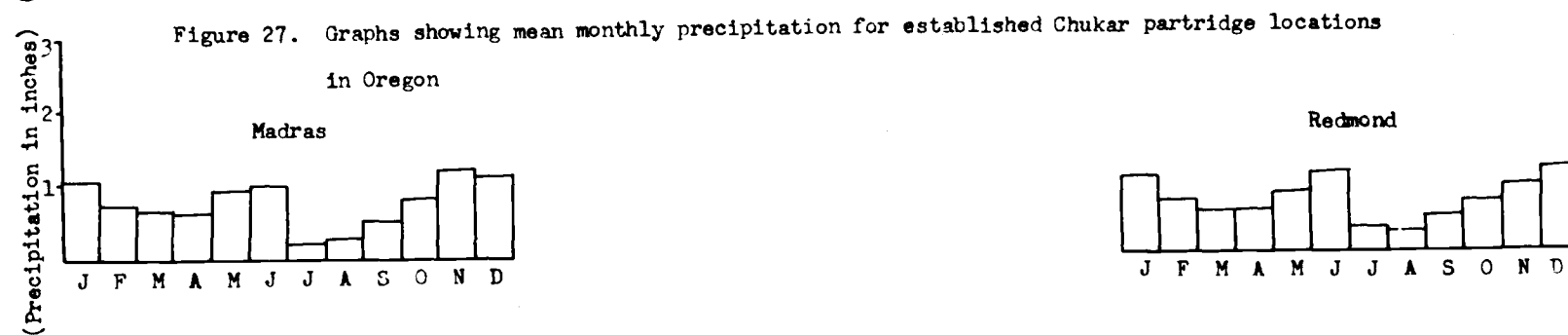
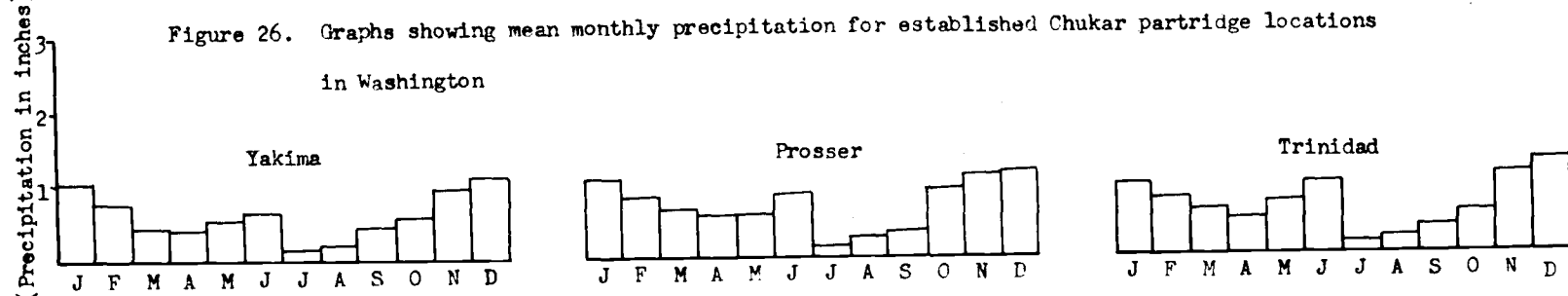
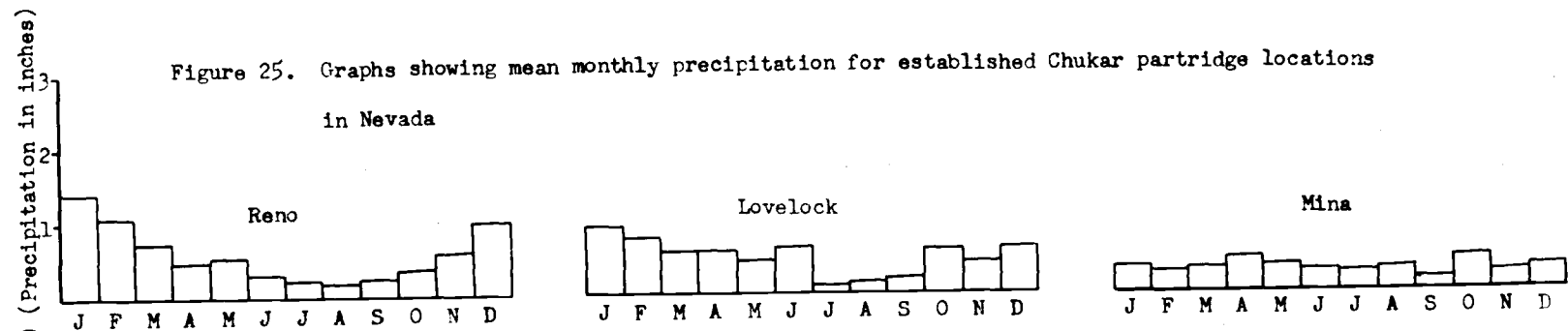


Figure 28. Graphs showing mean monthly precipitation for unsuccessful Chukar partridge locations

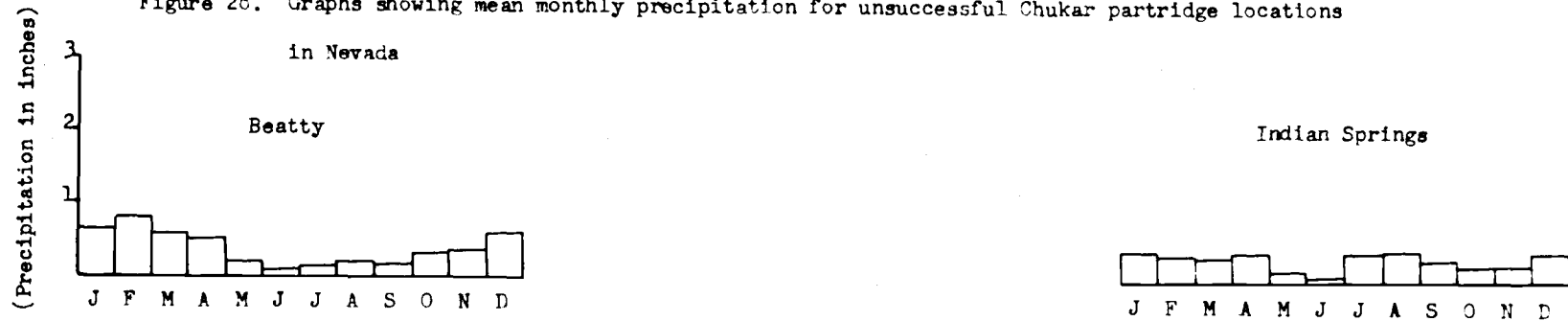


Figure 29. Graphs showing mean monthly precipitation for unsuccessful Chukar partridge locations

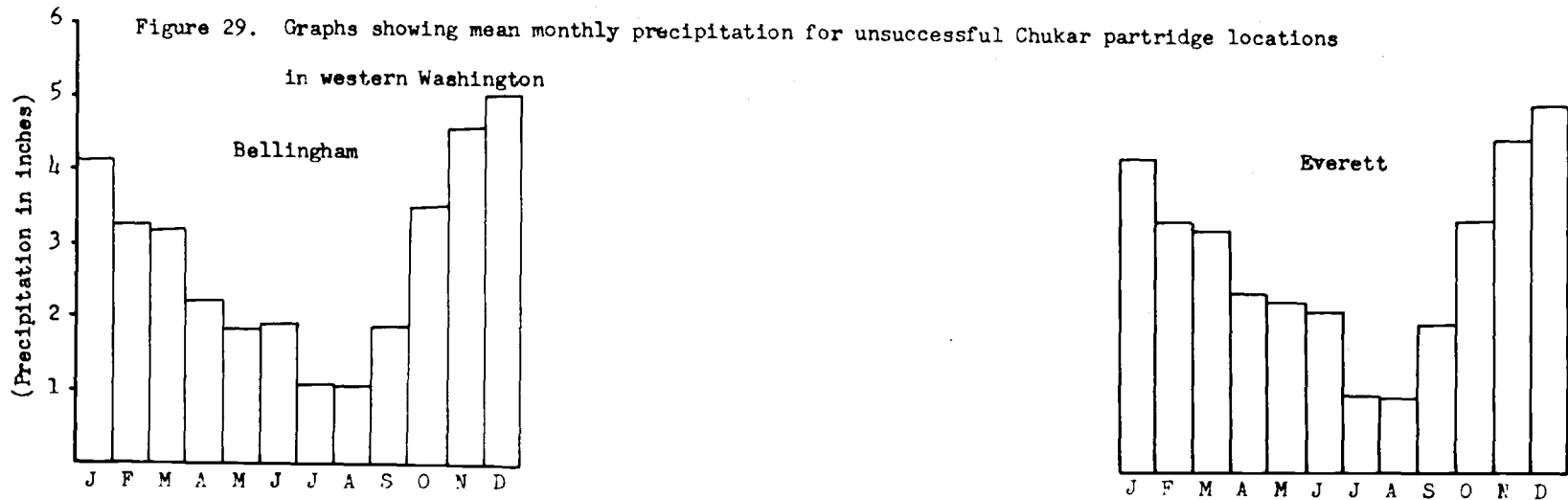


Figure 30. Graphs showing mean monthly temperature in Indian and Californian locations

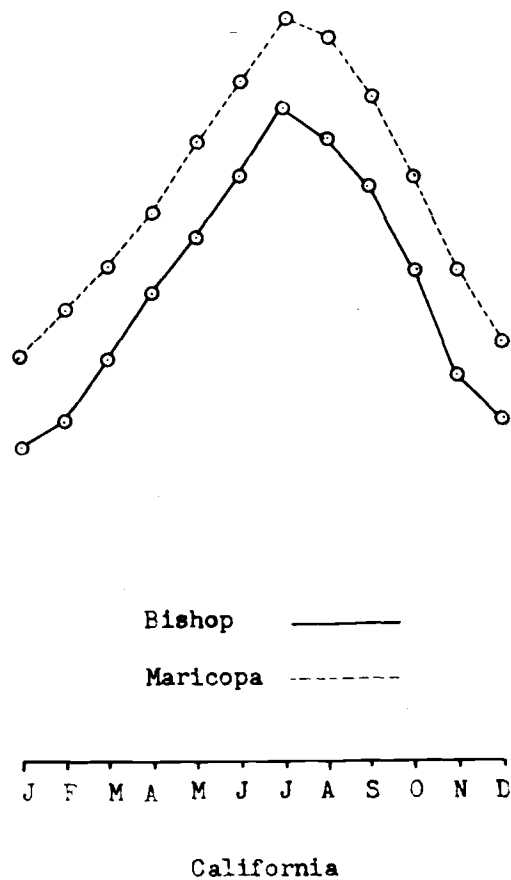
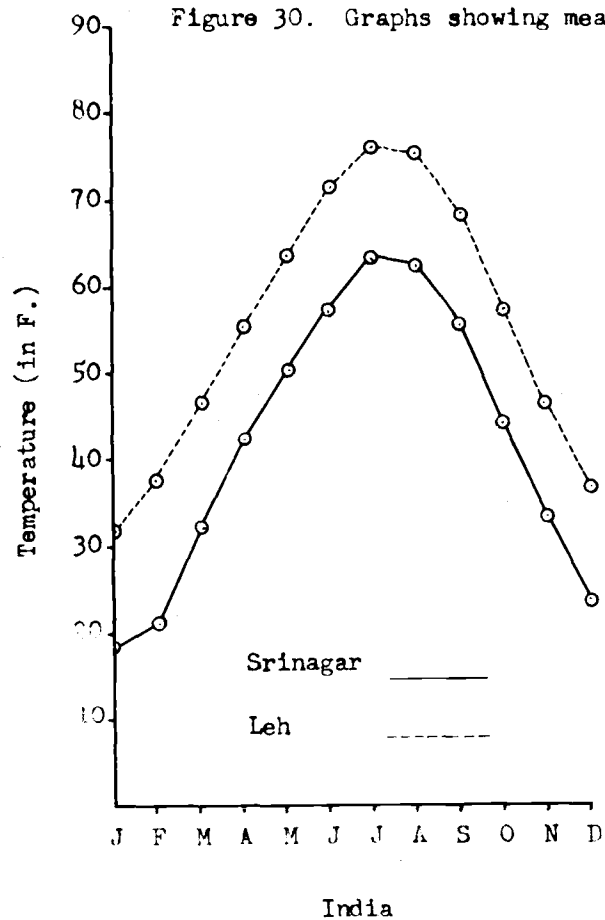


Figure 31. Graphs showing mean monthly temperature in established Chukar partridge

locations in Nevada, Washington and Oregon

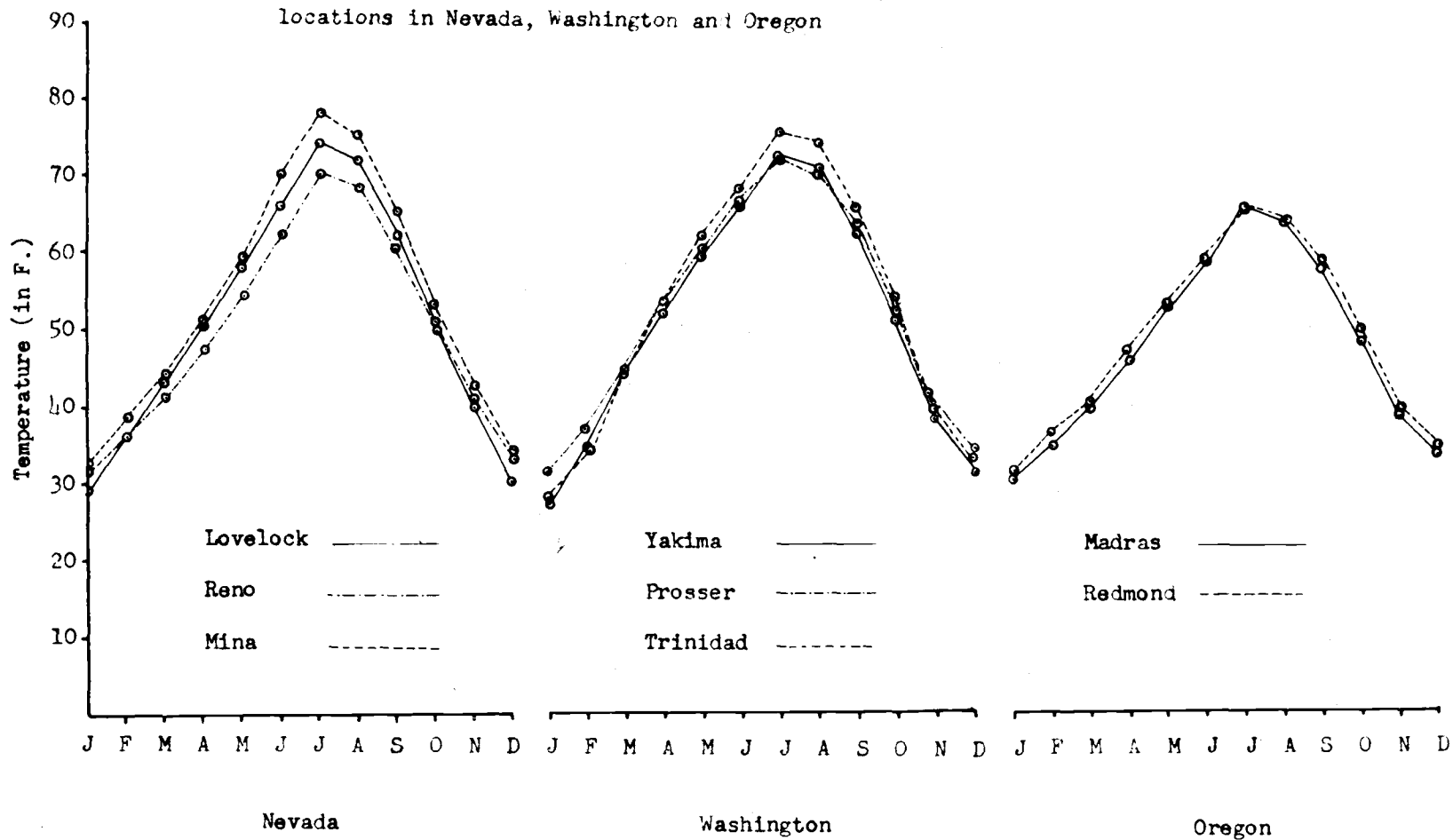
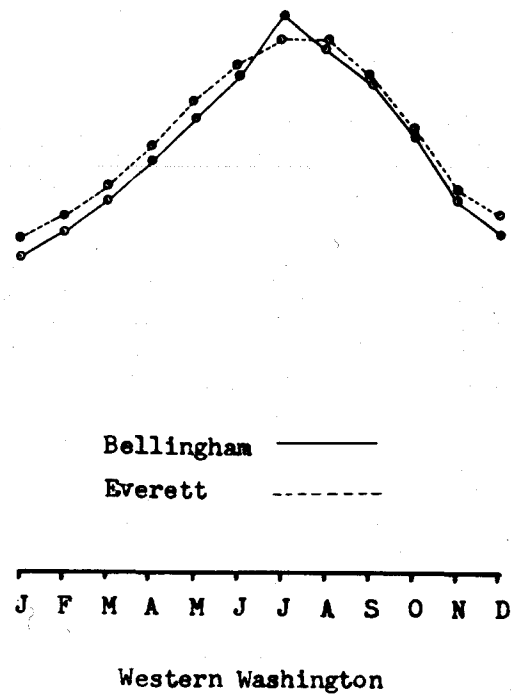
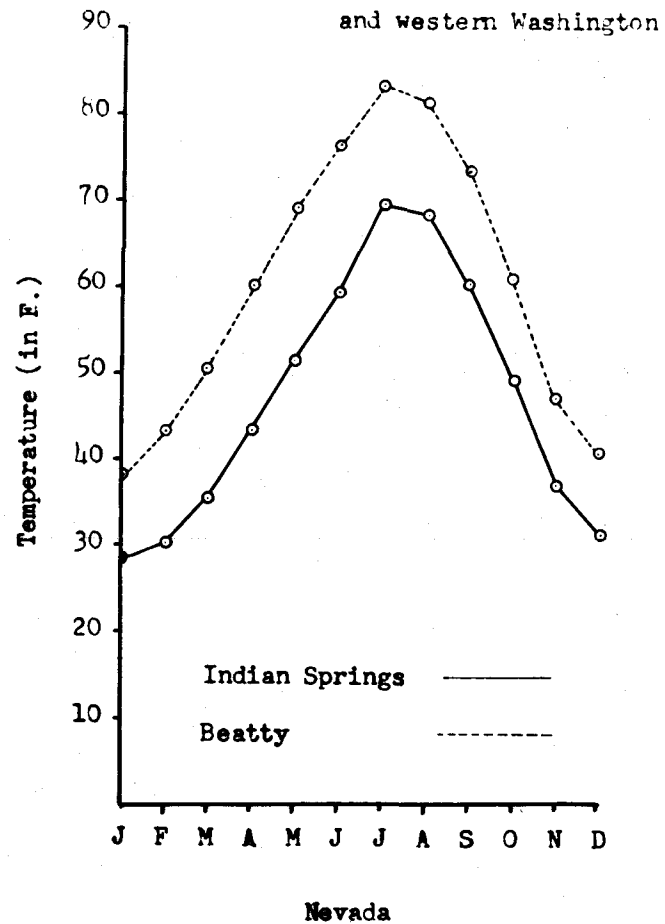


Figure 32. Graphs showing mean monthly temperature in unsuccessful locations in Nevada



DISCUSSION AND CONCLUSIONS

Climatic records covering a period of years for only two Indian cities located near chukar partridge areas could be found. These were for Leh and Srinagar located on the southern slopes of the Himalayan mountains in northern India. Climographs for these two areas indicate that the bird in India occurs in at least two distinct arid types for the climograms do not coincide. Leh has an average annual precipitation of only 3.26 inches and Srinagar has an average annual precipitation of 25.99 inches. Most of the successful chukar partridge areas in the western United States have an average annual precipitation of less than 10 inches a year and complete failures have most frequently occurred in areas in which the annual precipitation usually exceeds 20 inches. The only recorded indication found regarding establishment in areas exceeding 20 inches of precipitation was in New Zealand about which G. R. Williams (44, p. 2-6) stated that the bird "seems to have flourished best where the rainfall is less than 25 inches a year as in central Otago." There is a probability that Leh and Srinagar may represent the two annual precipitation extremes in India as indicated by average annual precipitation in locations of establishment.

The two Indian areas differ also in mean monthly temperatures, being somewhat higher each month at Srinagar. Because of differences in mean rainfall, the climographs do not overlap at any point.

No climograph for a successful western United States area exactly corresponds with either that of Leh or Srinagar. In a composite climograph for the two Indian locations, most of the western areas can be included except for the summer and early fall months. Therefore, it is concluded that since climographs for Leh and Srinagar do not correspond and since there is only partial agreement of some monthly points for successful western United States areas, such diagrams cannot be used for predicting the success or failure of the chukar partridge when introduced in foreign areas.

Although climographs do not appear adequate for predicting chukar success or failure in projected areas of liberation, a relationship is indicated when mean monthly and annual rainfall and mean monthly temperatures are considered separately. Mean annual precipitation in successful western United States areas ranges from 3.56 inches at Mina, Nevada, to 9.39 inches at Madras, Oregon. This is within the range of 3.26 inches at Leh and 25.99 inches at Srinagar, with all of the United States locations following closer to conditions found at Leh. Also,

it was noted that at the two Indian locations and at all successful United States locations that on the average some precipitation can be expected during each month of the year.

There were two exceptions found as to low rainfall and failure of chukars to become established. These were at Indian Springs and Beatty, Nevada, which have mean average precipitation of 3.46 and 4.68 inches respectively, and usually some precipitation is recorded during each month of the year (Figures 21, 28, and 32). A number of causes, biological and physical, could account for failure at these two Nevada locations. For example, it has been noted in California, Nevada and Washington, that during nesting season and during the warm weather of the summer, the birds are usually within one mile of water (18, p. 26), (8, p. 61) and (14, p. 54). Since available water in late spring and summer in warmer areas appears to be necessary, it is highly possible that unsuccessful liberations have been made in otherwise seemingly favorable habits. However, it is not known to the writer if this available water requirement was missing in the Beatty and Indian Springs liberations.

When temperatures are considered, it is evident that in all successful United States liberation areas the corresponding average monthly temperatures are above that

of Leh, some being intermediate between Leh and Srinagar; and occasionally such as at Maricopa the corresponding average monthly temperature may exceed those of Srinagar by 2° to 5° F. In this connection, it is interesting to note that the mean average monthly temperature at Bellingham and Everett, Washington, areas near two unsuccessful liberations, are a few degrees lower in June, July and August than at Leh; also in these two western Washington locations the mean annual precipitation is 33.63 and 34.81 inches respectfully, exceeding that of Srinagar by at least 7 inches annually.

The main conclusion drawn in this study is that climographs based on mean monthly temperatures and precipitation are not adequate for prognosticating success or failure of the chukar partridge when introduced into new locations, because the monthly points of all successful western United States locations are similar but not quite identical to Leh and they are quite different than those for Srinagar. Also, temperature and precipitation in climographs for Leh and Srinagar do not coincide or even overlap. However, there are possibilities that the stock of chukar partridge successfully introduced into western United States may have been from a physiological race originating near Leh via Calcutta and that a separate physiological race of the bird may occur at Srinagar.

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A P P E N D I X

Table 1. Climatological data for locations of chukar partridge in India

Leh (Average 60 years)		
<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	18.7	.38
February	21.65	.31
March	32.6	.28
April	42.85	.23
May	50.4	.22
June	57.8	.18
July	63.35	.47
August	62.8	.59
September	55.75	.27
October	44.5	.10
November	33.6	.14
December	24.0	.19
Annual	42.3	3.26

Srinagar (Average 50 years)		
<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	32.1	2.90
February	36.8	2.84
March	46.9	3.61
April	55.7	3.65
May	63.9	2.38
June	71.3	1.40
July	76.0	2.33
August	75.5	2.42
September	68.5	1.53
October	57.2	1.17
November	46.7	0.44
December	37.9	1.32
Annual	55.85	25.99

Table 2. Climatological data for established chukar partridge locations in California

<u>Maricopa (Based on 39 years of record)</u>		
<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	47.0	.97
February	52.5	.97
March	57.3	.97
April	63.6	.59
May	71.1	.34
June	78.9	.10
July	85.6	.01
August	83.8	.02
September	76.9	.11
October	67.2	.29
November	56.9	.39
December	48.7	.92
Annual		5.68

<u>Bishop (Average of 1900-1918, 1943-56)</u>		
<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	36.6	1.42
February	39.2	.96
March	46.7	.74
April	54.1	.29
May	60.2	.30
June	67.9	.10
July	75.1	.10
August	72.0	.11
September	66.1	.18
October	56.2	.24
November	45.0	.40
December	39.9	.98
Annual		5.16

Table 3. Climatological data for established chukar
partridge locations in Nevada

Reno (Average of 58 years)		
<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	31.8	1.40
February	36.2	1.06
March	41.3	.74
April	47.9	.48
May	54.8	.52
June	62.4	.31
July	70.4	.22
August	68.8	.20
September	61.0	.23
October	51.1	.38
November	41.3	.59
December	33.6	1.00
Annual	57.45	7.13

Lovelock (Temperature average 34 years, and rainfall average 21 years)		
<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	29.6	.93
February	36.2	.74
March	43.1	.57
April	50.4	.57
May	58.3	.47
June	66.4	.62
July	74.3	.72
August	72.1	.14
September	62.2	.20
October	50.9	.60
November	40.1	.42
December	30.6	.61
Annual	51.2	5.99

(Nevada locations continued on next page)

Table 3 (contd).

Mina (Temperature average 36 years, and rainfall average 22 years)		
<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	32.5	.33
February	38.5	.24
March	44.2	.30
April	51.2	.47
May	59.5	.34
June	70.1	.27
July	78.2	.24
August	75.5	.28
September	65.9	.13
October	53.4	.44
November	43.2	.22
December	33.8	.30
Annual	53.8	3.56

Table 4. Climatological data for established chukar partridge locations in Washington

<u>Yakima (Average 50 years)</u>		
<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	27.9	1.07
February	34.9	.74
March	44.1	.47
April	52.2	.42
May	59.8	.54
June	66.1	.66
July	72.9	.18
August	71.0	.19
September	62.4	.44
October	51.7	.58
November	38.8	.98
December	31.5	1.08
Annual	51.1	7.35

<u>Prosser (Average 25 years)</u>		
<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	31.4	1.06
February	37.0	.81
March	45.1	.67
April	53.1	.58
May	60.6	.58
June	66.5	.85
July	72.6	.14
August	70.5	.24
September	63.8	.34
October	52.8	.90
November	40.2	1.10
December	34.9	1.11
Annual	52.4	8.34

(Washington locations continued on next page)

Table 4 (contd).

Trinidad (Average 25 years)		
<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	28.2	.96
February	34.1	.75
March	44.6	.60
April	53.7	.49
May	62.2	.72
June	68.3	.96
July	75.7	.16
August	74.2	.21
September	66.6	.37
October	54.4	.54
November	39.8	1.06
December	32.5	1.24
Annual	52.9	8.06

Table 5. Climatological data for established chukar
partridge locations in Oregon

Madras (Average 25 years)		
<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	30.4	1.06
February	35.0	.74
March	39.9	.58
April	45.9	.64
May	52.6	.95
June	58.6	1.00
July	65.4	.24
August	63.6	.28
September	57.4	.52
October	47.9	.82
November	38.2	1.22
December	33.5	1.14
Annual	47.4	9.29

Redmond (Average 25 years)		
<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	31.8	1.04
February	36.2	.70
March	40.8	.56
April	47.0	.58
May	53.0	.82
June	58.4	1.08
July	65.6	.32
August	63.8	.28
September	58.3	.46
October	49.8	.69
November	39.9	.90
December	34.6	1.11
Annual	48.3	8.54

Table 6. Climatological data for unsuccessful chukar partridge locations in Nevada

Beatty (Temperature average 20 years,
and rainfall average 14 years)

<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	28.4	.66
February	30.4	.80
March	35.5	.59
April	43.7	.51
May	51.5	.19
June	59.2	.10
July	69.9	.14
August	68.4	.20
September	60.6	.19
October	49.4	.32
November	37.1	.36
December	31.7	.62
Annual	47.2	4.68

Indian Springs (Temperature average 13 years,
and rainfall average 14 years)

<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	38.7	.41
February	43.7	.34
March	50.4	.32
April	60.2	.34
May	69.1	.13
June	76.6	.05
July	83.4	.35
August	81.5	.41
September	73.8	.28
October	61.3	.22
November	47.4	.22
December	41.1	.39
Annual	60.6	3.46

Table 7. Climatological data for unsuccessful chukar
partridge locations in Washington

Bellingham (Average 25 years)		
<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	36.8	4.14
February	39.5	3.25
March	43.0	3.19
April	47.8	2.21
May	52.8	1.81
June	57.4	1.93
July	64.4	1.08
August	60.4	1.07
September	56.5	1.88
October	50.1	3.51
November	43.3	4.54
December	39.5	5.02
Annual	49.0	33.63

Everett (Average 25 years)		
<u>Months</u>	<u>Temperature</u>	<u>Precipitation</u>
January	38.6	4.24
February	41.1	3.39
March	44.7	3.28
April	49.5	2.42
May	54.4	2.32
June	58.6	2.19
July	61.9	1.03
August	61.7	1.02
September	57.8	2.02
October	51.8	3.41
November	44.6	4.51
December	41.1	4.98
Annual	50.5	34.81