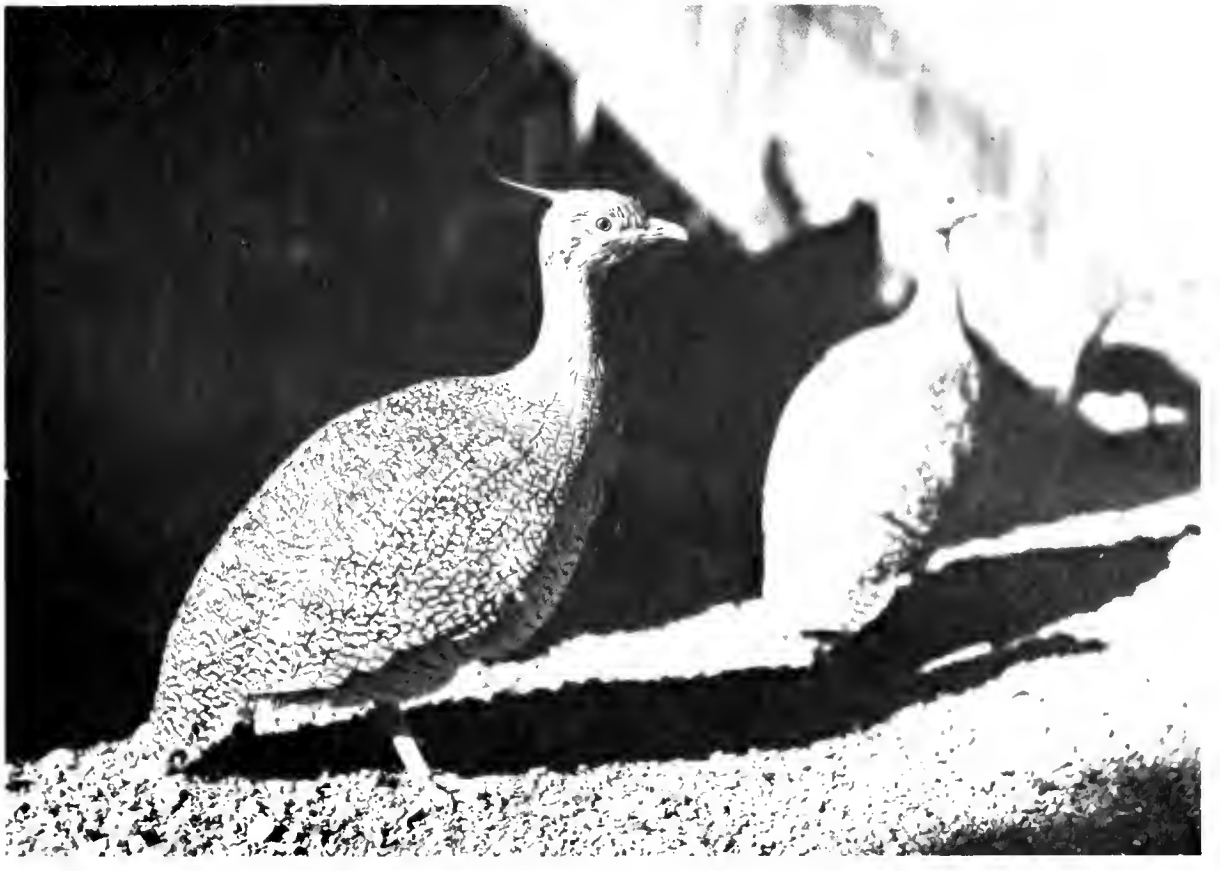
A Study of the CRESTED TINAMOUS of Argentina



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Special Scientific Report--Wildlife No. 131

UNITED STATES DEPARTMENT OF THE INTERIOR, WALTER J. HICKEL, *SECRETARY*
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A Study of the CRESTED TINAMOU of Argentina

by

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Bureau of Sport Fisheries and Wildlife

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THE FOREIGN GAME INVESTIGATION PROGRAM

Year by year the number of individuals seeking relaxation through hunting is increasing. Yet the area available for this sport is slowly decreasing. Likewise, much of the habitat which mothers the game crop is becoming less and less able to produce shootable surpluses under the impact of clean farming, over-grazing, drainage, power equipment, increased use of insecticides and herbicides, scientific forestry, urbanization, and declining soil fertility.

Faced with this situation, common sense dictates an all-out effort to increase habitat productivity. But there are many habitats which have been so thoroughly changed by man that native game species can no longer maintain themselves there in numbers sufficient to provide good hunting. Competing interests and the cost of reversing this trend are so great that only a part of these lands can be restored to reasonable productivity in the foreseeable future. For these habitats, new adaptable species possessing a high hunting resistance should be sought, so that such areas might provide greater hunting opportunities. This is the logic behind the foreign game investigation program as developed cooperatively by the U. S. Fish and Wildlife Service, 45 cooperating State Fish and Game Commissions, and the Wildlife Management Institute.

The program is based on requests for assistance from State Fish and Game Commissions following an ecological appraisal of their game-deficient habitats. After such information is in hand, biologists are assigned to make a careful study of game species occupying similar habitats and climates in foreign countries. From dozens considered, one or two may be selected on the basis of such characteristics as habits, reproductive capacity, resistance to predation and disease, relations to agriculture, ability to withstand heavy hunting pressure, and the possibility of competition with game species native to the United States. Modest, carefully planned trial introductions of these species, utilizing wild-trapped or farm-reared individuals, carefully quarantined before shipment, are then carried out in cooperation with interested State Fish and Game Commissions. Unplanned or "hit and miss" introductions are actively discouraged.

On the cover

An adult crested tinamou, Mendoza, Argentina, destined for trial liberation in western States.

CONTENTS

FOREWORD

Because State game departments have asked for game birds to fill desert habitats, both hot and cold, Foreign Game Investigation Program personnel have taken a careful look at a likely prospect, the crested tinamous of Argentina. Eight subspecies of this tinamou thrive in arid, semiarid, and temperate parts of Argentina and Chile where scrub vegetation is like that of the hot desert in our southwestern States. Farther south in Argentina, in Patagonia, one subspecies of the crested tinamous lives in an environment similar to, but not as cold as, that of our western States of mid-latitude. These States experience considerably more snow, blizzards, and subzero temperatures than does Patagonia.

On the basis of literature surveys and preliminary field and pen studies from 1964 to 1967, at least two of the crested tinamou subspecies, Eudromia elegans elegans and Eudromia elegans albida, appeared to be well worth trial introductions into arid hot desert habitats from southern California eastward to southern Texas. A third subspecies, Eudromia elegans patagonica, which occurs in the Argentine Patagonian steppe zone, may be adaptable to dry areas to the north with somewhat colder conditions. This report presents research findings which may be used to judge the feasibility of introducing crested tinamous into areas of our Southwest where climate, vegetation, and soil are analogous to those of their native range.

During field studies from 1964 to 1967 in Argentina, the author was able to visit the habitats of all eight subspecies of the crested tinamou, and he received ready assistance from Argentine officials including Dr. Juan Carlos Godoy, Director of the Office of Hunting and Conservation of the Fauna for the Republic of Argentina; Dr. A. Ruiz Leal, Botanist, University of Cuyo, Mendoza; Dr. William H. Partridge, Curator, National Museum of Natural History, Buenos Aires; and Dr. C. C. Olrog, Ornithologist, National University of Tucuman, Instituto "Miguel Lillo". Field assistants who helped in gathering material were Ernesto Roco, Dario Mehajlovich, Luis Arturo and Rudolfo Scaiola, all from Mendoza Province, Argentina. Very special thanks for the loan of breeders and for information about rearing crested tinamous in aviaries is extended to Senor Antonio Sanchez of San Rafael, Mendoza Province.

When I conducted field work away from the Mendoza station, my wife Norma Bohl handled the daily work of producing and caring for tinamous in our observation and rearing pens. She also spent considerable time compiling notes on pen and field observations of tinamous for inclusion in this report. Most of the parasites were extracted, preserved, and forwarded by her to Mrs. Janet Bump in Buenos Aires for preliminary work after which specimens were forwarded to pathologists of the University of Georgia for final examination. From Dr. Gardiner Bump, Biologist in Charge, FGIP, additional data on the crested tinamous inhabiting La Pampa and Buenos Aires Provinces were kindly made available for inclusion in this report.

Acknowledgment is made to Stanford University Press for permission to reprint certain maps from The North American Deserts by Edmund C. Jaeger (1961). Appreciation is also extended to Prentice-Hall Inc. and the University of Maryland, Department of Geography, for permission to use several maps from The Agricultural Resources of the World, Vol. 1, Atlas of the World's Resources (1954). All photographs were taken by the author unless otherwise noted.

Special thanks are due Drs. Elon Byrd, Forest E. Kellogg, and Annie K. Prestwood, University of Georgia, Southeastern Cooperative Wildlife Disease Study, for their identification of Eudromia parasites.

Wayne H. Bohl

ABSTRACT

Detailed discussions of the crested tinamous, Eudromia elegans elegans and E. e. albida, and less detailed information about E. e. patagonica, include habitat preferences, climate, food and water uses, general habits and behavior, reproduction, predation, diseases and parasites. Competition with other wildlife and economic relations of crested tinamous in their native range are analyzed and, as far as possible, projected to conditions in possible regions of liberation in the United States. Propagation techniques and trapping methods are discussed. Summarized are important considerations and recommendations for the crested tinamou as a new game bird that might be considered for experimental introduction into the western United States.

TINAMOUS IN GENERAL

Tinamous are nonmigratory birds found from southern Mexico to Patagonia in Argentina. The tinamou's body is compact; the tail is very short and often hidden by down-drooping upper coverts; the bill is slender, often elongated, and slightly curved downwards; the wings are short and rounded. In some species the hind toe is elevated or lacking. Tinamous range in size from smaller than a bobwhite quail to somewhat larger than a domestic chicken. Most are rather inconspicuous with gray, brown or cinnamon plummage accented with soft bars, stripes or spots. The sexes are externally alike in color though often the female weighs slightly more than the male. Preferred types of cover vary from open grasslands through brush to forest, usually excluding wet or swampy sites. Tinamous thrive in climates which range from tropical to lower temperate and in which precipitation varies from less than 6 to over 80 inches annually. Although tinamous are the principal upland game birds of Central and South America, they seem to be much more closely related by palate structure and behavior to the rather primitive rheas than to partridges, quail or grouse. The breastbone is strongly keeled but the heart is smaller than that of other birds with comparative body size, which may account for their rapid but often unsustained flight. As with most ratites, the male makes a simple, well-concealed nest on the ground and incubates the eggs, often being forcefully encouraged by the more aggressive female. Incubation periods are brief, varying from 16 to 21 days depending upon species size. The eggs are surprisingly large, often attractively colored in wine, brown, green, blue or purple. They have a hard, porcelainlike though relatively thin shell. The chicks are precocial, some taking to wing when only about 15 days old. The brood often scatters shortly thereafter. In Argentina, second and even third nestings are common.

In the most recent classification of the Tinamidae by Hellmayr and Conover (1942), 9 genera, 43 species and 105 subspecies were recognized. Subsequently some revision of species and subspecies has been suggested, and need for further study of the entire family has been indicated by these and other taxonomists.

TINAMOUS OF ARGENTINA AND CHILE

Taxonomic Distribution

Considerable attention has been given recently to tinamous resident in Argentina and Chile. Revisions of the genera Nothura (spotted tinamous) and Eudromia (elegant or crested tinamous) were published by Conover in 1950. Nine years later Olrog (1959) of the Instituto "Miguel Lillo," Tucuman, Argentina, suggested a revision of the latter genus and recognized a new subspecies of Nothura and of Nothoprocta. In 1963 he recognized 7 genera, 15 species and 29 subspecies. Johnson (1965) recorded 5 species and 7 subspecies of tinamous with representatives in Argentina and Chile.

Identification and distribution of these tinamous according to Hellmayr and Conover (1942) as modified by Conover (1950) and Olrog (1963) including observations by Bump and Bohl (1965) are as follows:

Order Tinamiformes
Family Tinamidae

Genus and Species	Number of Subsp.	Common name	Distribution[a]
Tinamus solitarius	Monotypic	Solitary tinamou	Province of Misiones. Also eastern Paraguay and southeastern Brazil.
Crypturellus obsoletus	6	Brown tinamou	Misiones. Also eastern Paraguay, eastern and southern Brazil.
Crypturellus undulatus	6	Undulated tinamou	Eastern Formosa. Also eastern Bolivia, Paraguayan Chaco and adjacent Brazil.
Crypturellus parvirostris	Monotypic	Small-billed tinamou	Misiones. Also eastern Peru, Bolivia, Paraguay and southern Brazil.
Crypturellus tataupa	4	Blue tinamou	Northwest from northern Entre Rios, Santa Fe, Cordoba, and parts of San Juan. Also southeastern Bolivia, Paraguay and southeastern Brazil.
Rhynchotis rufescens	4	Red-winged tinamou	Misiones south to Buenos Aires, eastern La Pampa, Cordoba, northern San Luis, Catamarca and north to Jujuy. Also southeastern Bolivia, Paraguay, Uruguay and southern Brazil.
Nothoprocta ornata	3	Ornate tinamou	From 2,500 to 4,000 meters in northwestern Argentina. Also northeastern Chile, Bolivia and north to central Peru.
Nothoprocta perdicaria	2	Chilean tinamou	From sea level through valleys and uplands to 1800 meters of north central to south central Chile.

[a] Argentine Provinces are noted first. See figure 1 for Province locations.

Nothoprocta cinerascens	2	Large brushland tinamou	Paraguayan Chaco south to Cordoba and northern and eastern La Pampa, west to northeastern Mendoza and north to Jujuy. Also in southern and eastern Bolivia, and adjacent parts of Paraguay.
Nothoprocta pentlandii	3	Canyon tinamou	Cordoba, San Luis west to northern Neuquen and Mendoza, and north through the mountains to Jujuy. Also northeastern Chile and southern Bolivia.
Nothura darwinii	5	Pale spotted tinamou	Northwestern Argentina south to northern Chubut, east to southern Buenos Aires, La Pampa and Cordoba. Also mountains of southeastern Peru and Bolivia.
Nothura maculosa	7	Spotted tinamou	Salta, Formosa and Misiones south through Buenos Aires to northern and eastern Rio Negro, eastern Chubut and northern and southeastern Neuquen. Also southern Brazil, Paraguay and Uruguay.
Eudromia elegans	8	Crested tinamou	Cordoba, southern Santa Fe, western Buenos Aires south to Santa Cruz, west and north to Santiago del Estero, Tucuman and Salta. Also near Aysen in southern Chile.
Eudromia formosa	2	Lillo's elegant tinamou	Eastern Salta and Tucuman, western Santiago del Estero, western Chaco and Formosa. Also the Paraguayan Chaco.
Tinamotis pentlandii	Monotypic	Puna tinamou	Jujuy and Salta to northern Catamarca from 4,000 to 4,500 meters. Also northern Chile, Bolivia and southern Peru.
Tinamotis ingoufi	Monotypic	Patagonian tinamou	Steppes and mesas of southern Rio Negro, Chubut and Santa Cruz. In Chile between Aysen and Magallanes.

Taxonomy, Common Names, and Distribution

Order	Tinamiformes
Family	Tinamidae
Genus	*Eudromia*
Species	*E. elegans*
	E. formosa

Subspecies	Common name	Distribution in Argentina, Paraguay, and Chile[a]
E. e. intermedia	Tucuman crested tinamou	Extreme western Tucuman, border of Salta, eastern Catamarca and perhaps western La Rioja (Chilecito).
E. e. magnistriata	Santiago del Estero crested tinamou	Western and southern Santiago del Estero, eastern Tucuman, northern and western Cordoba, eastern Catamarca, and La Rioja.
E. e. riojana	La Rioja crested tinamou	Described from southern La Rioja; suggested as northern San Juan Province.
E. e. albida	Pale elegant tinamou	Described from southern San Juan; probably confined to Province of San Juan.
E. e. elegans	Elegant crested tinamou	South-central Cordoba, San Luis, Mendoza, La Pampa, bordering inside western Buenos Aires to southeastern Buenos Aires, northeastern Neuquen, and Rio Negro.
E. e. devia	Neuquen crested tinamou	Western Neuquen from upper Rio Neuquen (Chos-Malal) south to the upper Rio Limay (Collon Cura) at elevations around 2,500 feet.
E. e. multiguttata	Eastern crested tinamou	Buenos Aires, eastern La Pampa, and possibly eastern Cordoba and southern Santa Fe.
E. e. patagonica	Southern crested tinamou	Northern Chubut south to the valley of Rio Santa Cruz and west to the Andes. Also occurs in Chile around Chile Chico south to Lago Buenos Aires.
E. f. formosa	Lillo's elegant tinamou	Eastern Tucuman, western Santiago del Estero, eastern Salta, western Chaco, western and eastern Formosa.
E. f. mira	Paraguayan elegant tinamou	Possibly Argentine Chaco. Arid parts of the Paraguayan Chaco.

(a) Argentine Provinces are noted first. See figure 1 for Province locations.

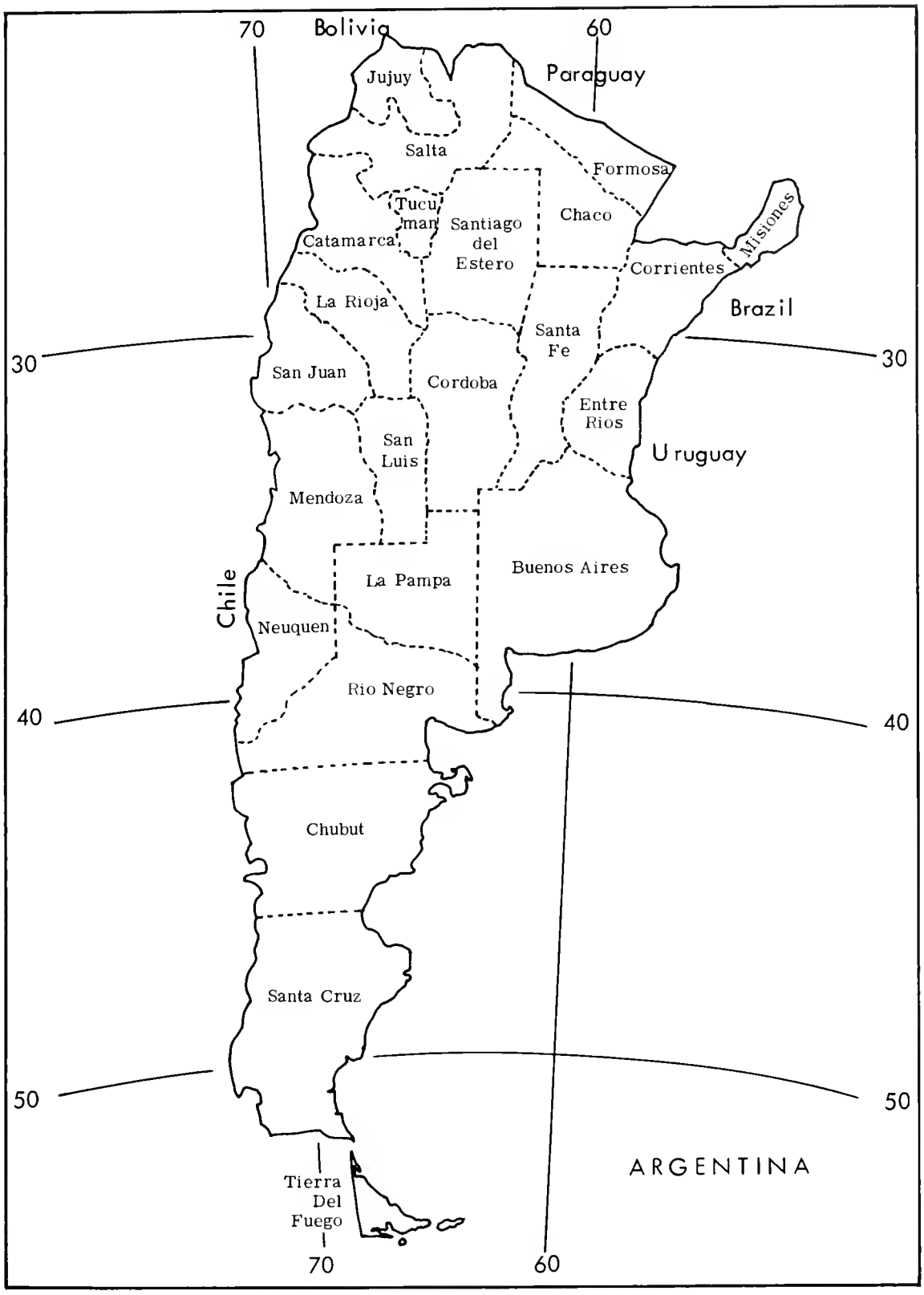


Figure 1. Argentine Provinces referred to in this report.

The Latin generic name Eudromia means "good runner" while the species name elegans refers to elegant. Many Spanish common names have originated from areas of Argentina, Chile, and Paraguay while English names crept into the picture as translations. The crested tinamou is the only species studied which, as an adult, has a crest of 2 to 3-inch feathers, hence the common name. This and other common names are listed:

Crested tinamou	English (general)
Elegant tinamou	English
Copetona	Spanish (Argentina)
Martineta	Spanish (Argentina and Chile)
Martineta copetona	Spanish (Argentina)
Martineta copetona comun	Spanish (Argentina)
Perdiz copetona	Spanish (Argentina)
Perdiz de copete	Spanish (Argentina)
Martineta tinamou	Spanish (Argentina)
Vuari	Araucano (Argentina)
Cunio y Yulmi	Patagonia (Argentina)
Schopfsteisshuhn	German
Tinamou huppe	French

Olrog (1963) used the Spanish common name, martineta, for eight races of elegans, and applied martineta de Lillo to the second species, formosa.

Although detailed attempts have been made to study and classify crested tinamous, much remains to be learned of their taxonomy, based on the recent collection of new study skins by Bump and Bohl (1965). Subspecies of elegans were first described in the 1800's; in the nineteenth century discoveries of new elegans subspecies led to the reporting of patagonica, devia, albida, riojana, intermedia, formosa and mira, the latter two now consolidated by Olrog (1959) into formosa.

As recently as 1959 Olrog attempted to clarify what he considered a misunderstanding over the earlier description of Eudromia formosa and E. mira. He stated "there exists certain confusion as to the different spp. and ssp. of Eudromia due probably to the redescription of formosa by Dabbene and Lillo (1913), who seem to have used one specimen (the male) of formosa and one specimen (the female) of elegans for this purpose. In any case it is shown that Eudromia formosa is not a subspecies of elegans but a very distinct species, and furthermore that Eudromia mira (Brodkorb) is possibly only a subspecies of formosa."

Conover (1950) cited the "woeful gaps", with fresh material needed from the following regions of Argentine crested tinamou range: eastern Santiago del Estero to La Pampa, western Rio Negro, eastern Neuquen, Chubut, and Santa Cruz. As a natural aftermath to this call for more crested tinamou material, Olrog (1959) described in "Neotropica" a new subspecies, riojana, and revised the species formosa. Olrog's (1963) classification and distribution of Argentine birds followed. Considering the crested or elegant tinamous alone he listed eight subspecies of elegans and two of formosa. This report follows the classification by Conover (1950) and Olrog (1959), (1963) pending further critical taxonomic evaluation of the genera Eudromia, the crested tinamou. In figure 2 the collection sites of crested tinamous, Eudromia elegans ssp. by the Foreign Game Investigation Program, 1964-67 are shown as well as those reported by Olrog (1959).

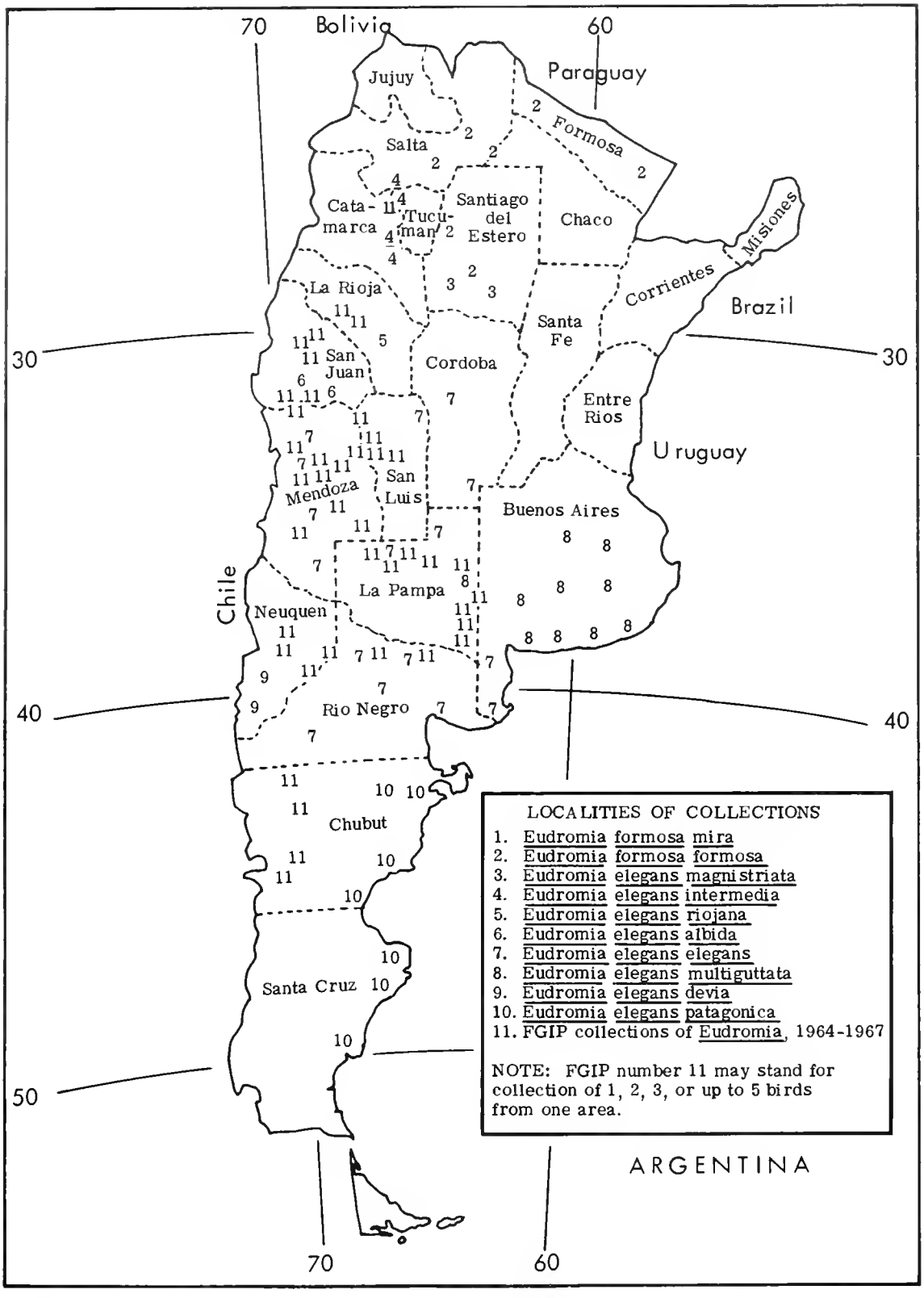


Figure 2. Collection of crested tinamous, Eudromia elegans ssp., by the Foreign Game Investigation Program, 1964-1967, together with localities reported by Olrog (1959).

Status and Relative Abundance

Subspecies emphasized in this report include the crested tinamous E. e. albida, E. e. elegans, and E. e. patagonica. By earlier projection these three subspecies were thought to have climatic-soil-vegetative counterparts in portions of the hot and cold desert zones of western United States. The first two subspecies were chosen for detailed study as representing the Argentine game bird living in arid to semiarid desert habitats.

The eight races of crested tinamou, E. elegans, in Argentina are distributed between latitudes 26° S. in southern Salta Province and 50° S. in Santa Cruz Province. Latitudes of the United States into which three subspecies are being considered for trial introduction would extend from about 30° N. to possibly 40°40' N.

Relative abundance of the three races of crested tinamous, determined mainly by call counts, can be characterized as follows: E. e. patagonica, living in the colder dry Patagonian steppes of western Chubut and Santa Cruz Provinces, has its lowest numbers in the areas nearest the Andes; E. e. albida has fair to good sustaining populations in the hot deserts of San Juan Province; and E. e. elegans, from Mendoza, San Luis and La Pampa Provinces, has the highest populations of the three.

In western Argentina hunters avidly pursue the crested tinamou, often throughout the year, so it is surprising that this bird is still common over most of its native range. Its numbers are reduced only where farming practices extensively alter the original brushland vegetation or in areas adjacent to human settlements where year-round hunting, even during the breeding season, and eating of the bird and its eggs by country workers, have taken their toll. Many hunters talk of bagging as many as 300 to 400 crested tinamous in the late 1940's in a few days of drive-hunting through the brushlands in central Mendoza Province. Today, large landowners are preventing this type of pressure by limiting access to their lands and the very best crested tinamou populations are found in suitable habitat on these large ranches and on other areas where the birds are not hunted.

Transplantations

There may have been liberations of the crested tinamou in various arid or semiarid habitats of the world but records are either unavailable or very sketchy. Austin (1961) indicated that tinamous had been introduced into North America for sporting purposes but these efforts had not met with success.

Crested tinamous have been raised at various game farms, private and State, in the United States but an adequate quantity has not been reared to liberate the species in sizeable numbers into suitable habitat. The game departments of California and Nevada made small trial releases of crested tinamous in their desert regions during 1968 and 1969, respectively. One small liberation of crested tinamous by a private breeder near Brigham City, Utah is known but results were negative (personal communication, Jessop B. Low, Logan, Utah).

De Costa (1953) reported that by 1900 crested tinamous had been acclimatized in Europe. This seemed to infer that members of the genus survived and reproduced in the hunting reserves but apparently few, if any, remain today.

Description

Field identification

Sexes of the crested tinamous are alike in external coloration. The female is generally slightly heavier than the male. Crested tinamous have three toes and no rear spur, a very short tail covered by long upper tail coverts, and a rather long bill. Feather color is mostly grayish brown with many tawny spots and black bars on the back, effectively camouflaging the individual in its habitat. Although taxonomically far removed from pheasants, quail, partridges and francolins, crested tinamous externally resemble another member of this family, the guineafowl of Africa.

Key to subspecies of Eudromia elegans

Olrog (1959) gives the following key for distinguishing subspecies of crested tinamous by the size of spots on body feathers and width of stripes on feathers of the lower back:

Group 1. -- Small spots
- E. e. multiguttata -- very fine stripes, at times almost absent
- E. e. albida -- narrow stripes
- E. e. elegans -- rather wide stripes
- E. e. devia -- wide stripes
- E. e. patagonica -- very wide stripes

Group 2. -- Large spots
- E. e. intermedia -- stripes very narrow and pale
- E. e. riojana -- stripes rather narrow and black
- E. e. magnistriata -- stripes exceedingly wide and black

Coloration of males and females of certain subspecies

Pending further critical taxonomic study by the Bird and Mammal Laboratories, U. S. National Museum, of crested tinamou skins collected by FGIP personnel, the following description by Conover (1950) indicates the separation of the three subspecies with which this report is concerned.

E. e. albida -- This subspecies is the palest of all known races of the crested or elegant tinamou. The upper parts are closest in coloration to those of the more northern intermedia, but paler and more heavily spotted with buffy white. Under parts are different from other crested tinamou with a tendency to being immaculate on the belly while chest feathers have dark shaft streaks.

E. e. elegans -- This is the typical race, characterized by its light gray-brownish coloration. It can be distinguished from more northern and western Eudromia races by its more barred belly and abdomen.

E. e. patagonica -- The upper parts are dark olive gray with a silvery overtone, moderately spotted with buff and white. Dark shaft streaks to the feathers of the foreneck and broad chest are predominant. In this race the dorsal surface is darker, more olivaceous and less buffy than typical elegans and similarily is more olivaceous and much less spotted than the nearby race devia. The dark shaft streaks to the foreneck and chest feathers are much broader than any of the other races except formosa. The rest of the under parts are similar to the typical elegans.

Male and female -- Sexes are similar in color and form for all Eudromia elegans subspecies. Conover (1950) described male and female coloration and feather arrangements of the type specimen of Eudromia e. patagonica as follows:

"Top of head, cheeks and neck all around buffy gray, each feather with a wide shaft streak of dark brown; a crest of long, recurved, dark brown feathers, edged, except at the tip, with brownish gray; an inconspicuous band of white extending from above the eye over the ear coverts and part way down the sides of the neck, and another from the gape to below the auriculars; throat white; mantle, back, rump, upper wing coverts, tertials and upper tail coverts dark olive gray with a faint silvery overtone, and moderately spotted with buff and white and vermiculated and barred with black; secondaries brown, broadly barred with white; primaries brown, notched on the outer and barred on the inner web with white; chest buffy white, narrowly barred with brown, each feather with a broad dusky shaft streak; upper breast, belly, flanks and under tail coverts buffy white barred with dusky, the dusky bars about half as wide as the light interstices; crissum, vent and thighs immaculate buffy white; under wing coverts white, irregularly mottled with dusky. Wing 209, tarsus 38, middle toe with claw 33, culmen 24 mm."

Type specimen descriptions which would apply to the male or female of subspecies albida and elegans were not given by Conover (1950) in the same detail as those for E. e. patagonica characterized above. In fact, the type specimen of E.e. albida is a flat skin with many of the under parts missing. However, Hellmayr and Conover (1942) state that specimens of E. e. albida were similar to examples of E. e. morenoi but much paler with the white spots and broken bars of upper feathers large, the light markings being more extensive than the darker ones. Further, feathers of the lower hind neck were extensively marked with dull ivory yellow and the light markings on the under surface likewise were more extensive. The average measurements in mm. for two albida specimens, which were very worn, were: wing 211, tail 97 1/2, tarsus 40 1/2, and bill 25. The subspecies E. e. morenoi noted above is now known as E. e. elegans.

The iris of crested tinamous is a caramel brown color in both male and female, the bill grayish, rather slender and slightly down-curved. Legs are whitish gray, with three toes as in Tinamotis. Spurs have not been observed in specimens of Eudromia. The tarsus is reticulated or covered with polygonal plates on the sides and back with the toes scutellated or scaly. Primary flight feathers number 10.

Young -- When seven weeks old crested tinamous looked like miniature adults and averaged 208 grams in weight (table 1). At 28 weeks the young averaged 768 grams and had molted eight of their 10 primaries. De Costa (1953) describes the young birds as looking like their fathers but having a darker brown and black spotting and a more pronounced small white stripe from the base of their crest feathers towards the back of the head.

Hybrids

Preliminary studies indicate that crossbreeding does not occur between races of crested tinamou in the wild where their ranges overlap. As more material is gathered for comparison this picture may be altered. At the moment, edges of the ranges of the crested tinamous are poorly defined.

Body Measurements

An examination of weights of 87 specimens collected from 7 of the 8 elegans subspecies showed no outstanding differences between the races or sexes. In general, crested tinamous average about 14 to 15 inches in length and stand, when alert, about 15 inches high, including the crest.

Comparisons of weights for adult males and females of two subspecies of crested tinamous are as follows:

	Males		Females	
	Average weight	Largest	Average weight	Largest
Eudromia e. albida	676 grams	695 grams	749 grams	836 grams
Eudromia e. elegans	680 grams	809 grams	709 grams	892 grams

It is of general interest that the very largest female of all of the races collected by FGIP personnel was a Eudromia e. multiguttata which weighed 893 grams. Females of this subspecies averaged 858 grams.

In recent correspondence, Dr. Richard C. Banks, Bird and Mammal Laboratory, U. S. National Museum, indicates that preliminary study of FGIP-collected tinamou skins suggests that "there is a trend of increased size (wing length) to the north and to the west." In general his wing measurements show the smaller birds coming from Rio Negro Province along the Colorado River with larger wing measurements occurring northward through La Pampa and San Luis, then westward into Neuquen Province. Further, there is an increase from Neuquen northward through the brush areas of Mendoza Province. Crested tinamous collected further north in arid desert areas of San Juan, La Rioja and Tucuman Provinces are significantly larger. Southward from Neuquen there is again an increase in size through western Chubut Province.

Table 1. Weights, feather lengths, and molt for juvenile crested tinamous, Eudromia e. elegans and E. e. albida.

Age	Weight in grams		Range of lengths, mm.				
	Median	Range	Crest	Primary #8	Longest primary	Tail feather	Primary molting
At hatching	33.0	30-39	10-15	-	-	-	-
One week	44.0	41-58	13-22	21-30	31-43 #5, #6	20-25 plumelike	-
Two weeks	54.5	37-77	11-20	24-52	34-60 #5, #6	15-30 plumelike	-
Three weeks	74.5	63-109	12-27	45-69	58-80 #5, #6	12-42	-
Four weeks	101.0	85-142	19-38	64-87	73-97 #6, #7	45-67	-
Five weeks	130.0	109-179	22-40	83-98	89-110 #6, #7	57-79	-
Six weeks	175.0	154-220	37-45	98-112	103-117 #6, #7	74-87	some molting in #3, #4
Seven weeks	208.0	181-265	37-50	108-127	111-125 #7	73-93	-
Nine weeks	297.0	263-311	50-68	119-135	-	76-96	molting in #5, #6
Ten weeks	361.0	320-412	45-63	122-136	127-132 #8	76-89	molting in #5, #6
Twelve weeks	442.0	381-469	60-62	126-138	143-152 #4, #5	84-93	molting in #6, #7
Fourteen weeks	484.0	424-569	41-67	118-133	125-165 #5, #6	76-113	molting in #7, new #7
Eighteen weeks	541.0	494-573	57-66	(molting #8)	148-166 #5, #6	87-92	molting in #6, #7, #8
Twenty-four weeks	660.0	601-768	59-63	-	161-165 #7	84-97	finishing #8 molt
Twenty-six weeks	665.5	595-693	50-66	-	-	87-100	molt complete for primaries except #9 and #10
Twenty-eight weeks	768.5	720-817	59-62	(primary #9) 148-153		98-99	#9 and #10 not molted

Plummage Characteristics and Relation to Age

Data covering weights, feather growth and molt of young penned birds appear in table 1. From birth through 28 weeks all primaries except numbers 9 and 10 were molted. In some individuals molting of primaries one through eight was completed by 26 weeks of age, in late May or early June. At 28 weeks the young had reached weights of 720 to 817 grams.

De Costa (1953) indicated that the young began to molt their juvenile plummage in late February and continued through March and April. About mid-March young crested tinamous had changed their breast feathers and had begun to molt their crest plumes. Crest feathers were lost one at a time, until replacement was complete by May. Her explanation of the crest molt helps explain the variation in young crest measurements noted in table 1.

These preliminary weight and molting data should aid in aging juvenile crested tinamous collected in the wild and in determining nesting phenology. From a few observations, a complete molt of primaries in adults seemed to be underway by late May, with replacement of primary 10 being in progress or completed by this date.

Sexing

Pen and field research disclosed the need for distinguishing between the males and females of crested tinamous which look much alike externally. Females are said to be slightly heavier than males but visual comparison of individuals, even in pens, is a very uncertain method of distinguishing between the sexes. A copulatory organ which measures 5 to 10 mm. in length during the breeding season distinguishes the male from the female, and a method was developed to ascertain its presence. By gentle pressure, both downward and forward, on the sides of the cloacal opening, the organ can be extruded, rising from the center of the opening and pointing forward (figure 3). It is pink, fleshy, and rounded, tapering to a conical point. Females do have a very small fleshy projection at the posterior edge of the cloaca but it cannot be erected by pressure.

Differences in crest feather length proved of small value as a method for sexing. Adult male and female crests measured from 20 to over 85 mm. in length, and a considerable overlap occurred in crest lengths for both sexes.

Habitat

Cover Preferences

Crested tinamous thrive in brushlands either in arid desert steppes of western Argentina or in semiarid habitats of the central and eastern ranges which are composed mainly of brush, grass and trees. In Patagonian habitats these tinamous do well in low brush-grass areas even close to sea level. Tall, dense grass stands are avoided as are the thickest stands of tall brush characteristic of the higher rainfall zones. The most arid desert areas contain almost no grass and only scattered brush. Here crested tinamous are

Figure 3. Cloacal sexing shows male penislike structure extruded approximately five millimeters.

the sole representatives of their group occurring in these ecologically harsh situations. Water is lacking in many desert areas, but this has not been a limiting factor for crested tinamous.

Cover preferences for night roosting are areas with little vegetation in terrain that is flat or contains low ridges. Preferred feeding cover includes brushy, herbaceous vegetation at the edges of tree stands or agricultural fields. Following early morning feeding these tinamous tend to seek shade under brush or similar cover where they rest or dust.

Figure 4 depicts the extent of arid and semiarid brushland ranges in Argentina with comparable brushland areas of the United States and Mexico. According to Morello (1958), from the botanical standpoint brushlands in Argentina extend from latitude 24°35' S. to 44°20' S. near the center of Patagonia. The subspecies albida, elegans, and patagonica occupy portions of these brushlands extending from sea level to about 6,000 feet elevation. Rainfall is generally less than 8 inches a year, as low as 3.8 inches or less some years in the range of albida, but up to 22 inches in La Pampa Province. With low rainfall, the dominant plants of most Argentine brushlands are resinous evergreen bushes of the family Zygophyllaceae which contains four subspecies of creosote bush (Larrea) and several races of Bulnesia, locally called retamo. Distribution of Larrea divaricata in the United States, after Benson and Darrow (1954), is shown in figure 5. Prickly pear cactus (Opuntia spp.), similar to that in the United States, is common and widespread in Argentina.

Figure 4. Regions of North and South America with similar flora, for example Larrea divaricata which is found in greatest densities in the United States, Mexico, Chile and Argentina.

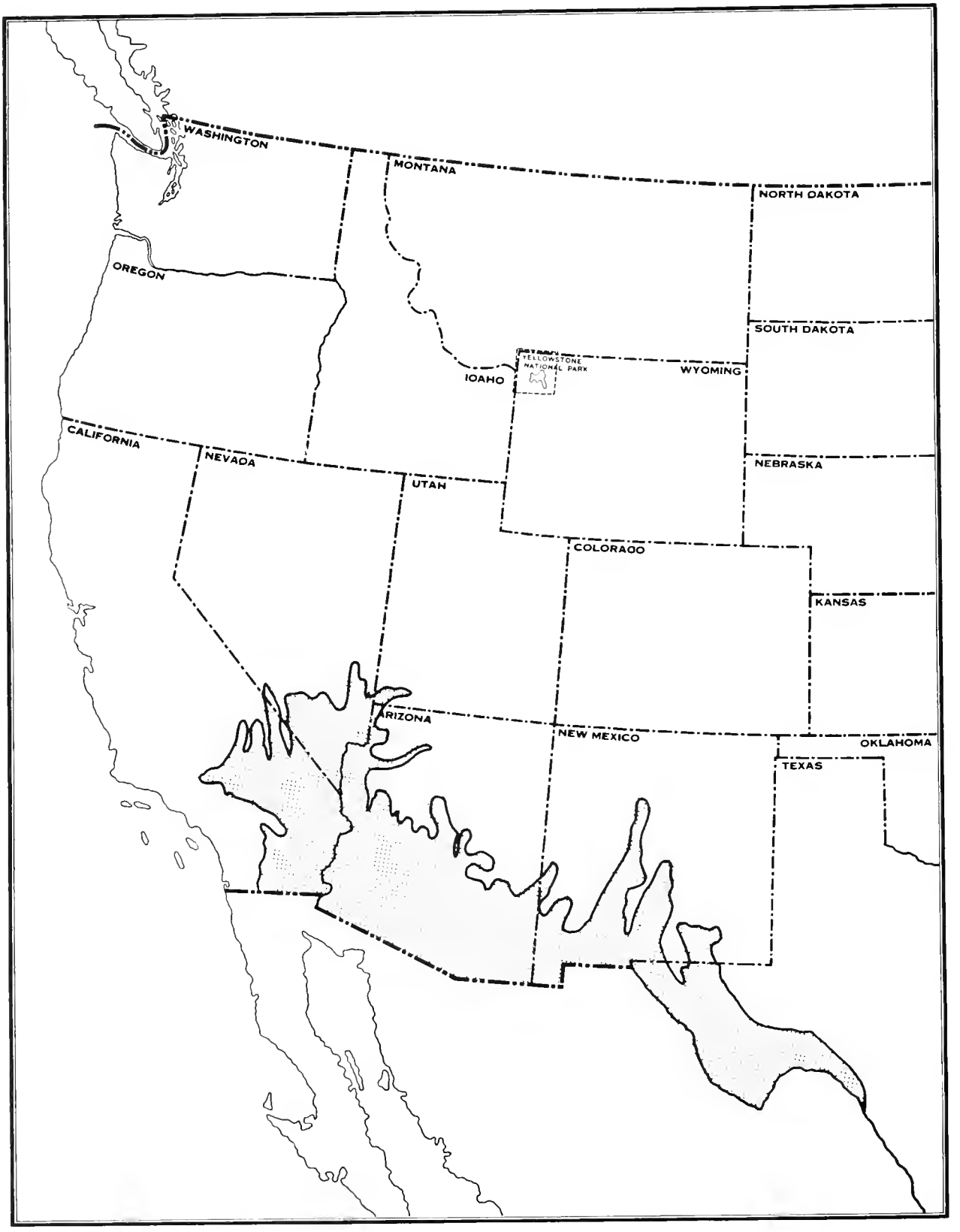


Figure 5. Approximate distribution of creosote bush, Larrea divaricata in the Southwest.

Other desert brush vegetation of the southern United States which also thrives in Argentine habitats of the crested tinamous includes the following genera: Condalia, Atriplex, Lycium, Berberis, Cercidium, Ephedra and Prosopis. In general, distribution of creosote bush (Larrea divaricata) in the United States overlaps that of the above seven genera. These desert brush species appear in California, Nevada, Utah, Arizona, New Mexico and Texas, mainly in the more southern arid and semiarid areas.

In addition to Larrea spp. and Bulnesia spp., the most prominent brushland subdesert vegetation in the ranges of the crested tinamous albida and elegans include the following: mesquite (Prosopis spp.), lote bush (Condalia sp.), saltbush (Atriplex spp.), Plectrocarpa sp., Monttea sp., palo verde (Cercidium spp.), barberry (Berberis spp.), Lycium (Lycium spp.), Mexican tea (Ephedra spp.), Zuccagnia spp., Suaeda spp. and Allenrolfea sp. Cactus scrub brush types include Trichocereus spp. and Cereus spp., with Opuntia spp. very common in the more arid zones. In semiarid open woodlands of crested tinamou range one finds trees of Prosopis, Celtis, Acacia and Geoffroea.

Grasses in the arid to semiarid areas include genera such as Stipa, Aristida, Festuca, Melica, Bromus, Piptochaetium, Bouteloua, Setaria, Trichloris, and Sporobolus, to mention the most dominant types. Understory herbaceous plants include more genera, some of which are very common to the brushlands of the western United States. Included are Croton spp.; Solanum spp.; Russian thistle, Salsola spp.; filaree, Erodium spp.; Mulinum spp.; Menodora spp.; Boerhavia spp. and members of the Malvaceae family, the mallows.

Patagonian crested tinamous, living in the cool steppe climates of Chubut and Santa Cruz Provinces, are not associated with many of the brush types found further north in Argentina. As one travels south Bulnesia and two species of the creosote bush (Larrea), found so commonly in more northern crested tinamou ranges, are missing. Instead, dwarf-like shrubs are more common, often being no more than three feet in height with low to medium-height grasses and other herbaceous plants mixed into the understories. Grasses such as Bromus spp. appear more plentiful and vigorous in Patagonia than in northern areas. Trees, except along watercourses, are not common in this cool steppe area. Shrubs such as Berberis spp. and Lycium spp. are scattered over the range. Preliminary food habit studies showed that Patagonian crested tinamous utilize both for food. Filaree (Erodium cicuta) is present along with Silia gracilis, both of which were avidly taken by crested tinamous during summer months when rainfall was scarce.

Referring to figure 6, Ragonese (1963), Cabrera (1959), Morello (1958), and the U.S.D.A. Foreign Agricultural Service (1958) indicate the natural vegetation of Argentina as well as the range of the Patagonian steppe areas. Except for central Neuquen and Rio Negro Provinces, this steppe extends as far north as western Mendoza and San Juan Provinces. Flat areas surrounding Malargue in southwestern Mendoza Province have an elevation of 4500 to 5000 feet and good populations of crested tinamous occur there. Olrog (1963) identified these birds as E. e. elegans. Vegetation in this northern extremity of the Patagonian steppe has been noted by Roig (1960) and by personal observations to include the following more dominant plants: Larrea sp., Larrea nitida, Ephedra ochreata, Berberis sp., Grindellia sp., Senecio, Tweedia brunonis, Mulinum spiniosum, Prosopidastrum sp., Euphorbia sp., and Lycium sp. Typical grasses are Festuca pallescens and Pleurophora patagonica.

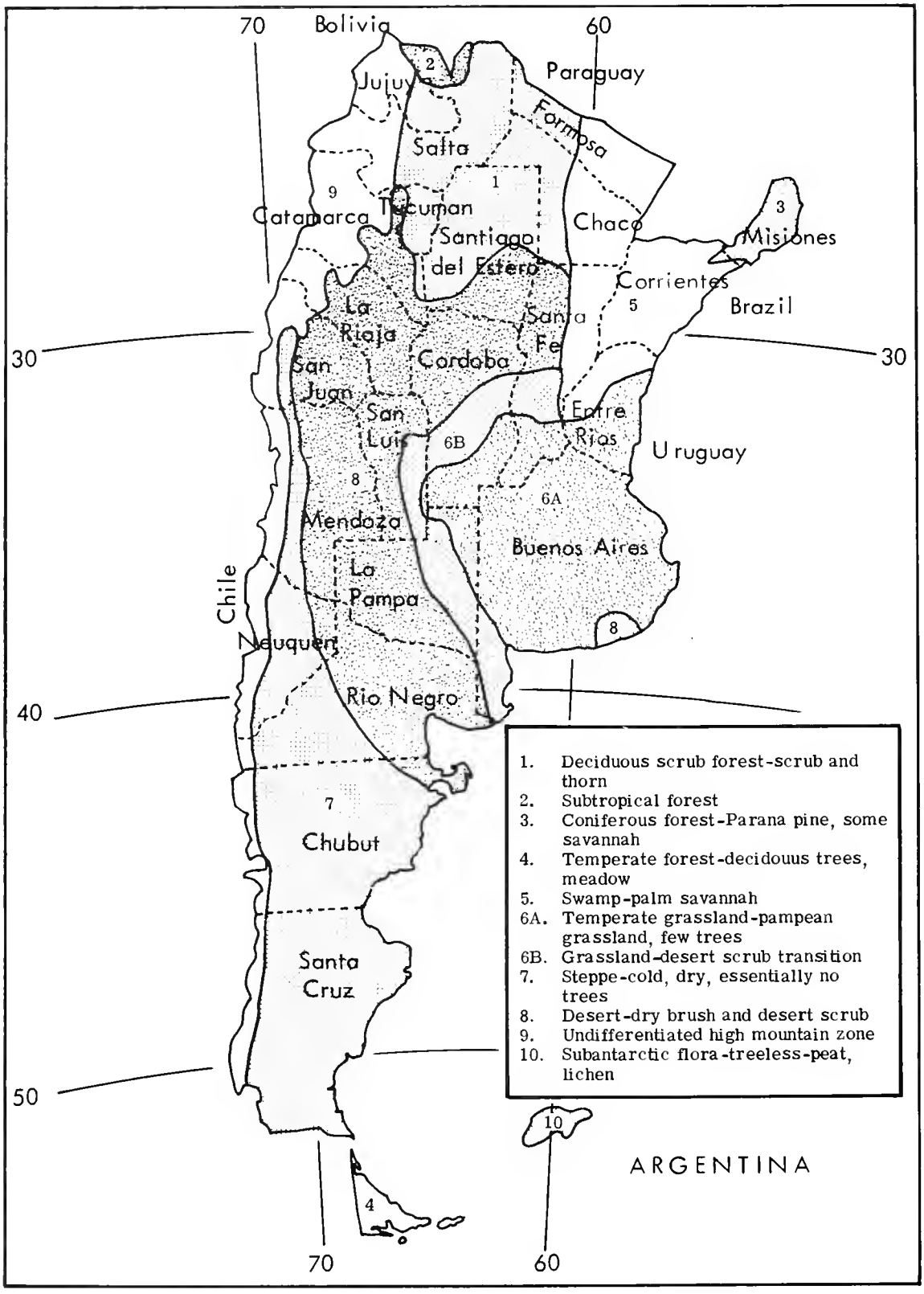


Figure 6. The natural vegetation of Argentina.

Malargue appears to be isolated by an extensive pampa containing pampas grass, Cortaderia araucana, from San Rafael, La Tosca, San Carlos, Campo Los Andes, Tunuyan, Manzano, Potrerillos, Mendoza and Villavicencio north into San Juan Province. These latter areas support one of the largest populations of crested tinamous in Argentina. These areas Olrog (1963) described as also being in the Patagonian ornithological zone following Cabrera's (1965) map description of Argentine phytogeography (see figure 6). Elevations in these cooler brushland areas range from 3,000 to 5,500 feet and the vegetation is similar to that listed for E. elegans elegans.

Where agricultural clearings have resulted in the removal of brush habitats, crested tinamous do penetrate the field edges but are more likely to utilize brush edges wherever any have been left. Road edges in agricultural or brush areas are preferred for feeding as well as dusting by this tinamou. If large areas are cleared for wheat this usually results in a much lower population of birds; they seem to seek out the more weedy, low grass, brush or tree areas surrounding wheat lands. La Pampa Province has a fair amount of agricultural land and where crested tinamous have been studied they have been seen in the following situations:

Habitat	Number birds observed
Cornfields	13
Brush	11
Woodlands	11
Maize field	2
Ploughed fields	5
Corn-alfalfa field mixed	2
Grass-alfalfa field	1

Five crested tinamou broods from these groups were seen in corn or cornfields mixed with alfalfa (Rumboll-Bump notes). Although it is believed agricultural clearing has not enhanced crested tinamou habitat anywhere, it seems able to withstand more habitat changes than other tinamous studied in Argentina. At least 90 percent of prime crested tinamou ranges or habitats in Argentina today are located on livestock ranching areas, as shown in figure 7.

Figures 8 through 19 illustrate crested tinamou habitats in Provinces from La Rioja southward through San Juan, Mendoza, San Luis, La Pampa, Neuquen, Rio Negro and Chubut. These photographs depicting cover preferences in Argentina represent a climatic and vegetative progression from north to south, moving from arid and semiarid to midlatitude steppe desert type habitats as found in Patagonia.

Desert brush habitat conditions in the United States analogous to those of the crested tinamous in Argentina would range from southwestern Texas in the Chihuahuan Desert west through similar areas of New Mexico, the southeastern corner of Arizona, the Arizona Upland Desert, possibly the Yuman Desert, southern Nevada, extreme southwestern Utah, and the Colorado and Mohave Deserts in southern California.

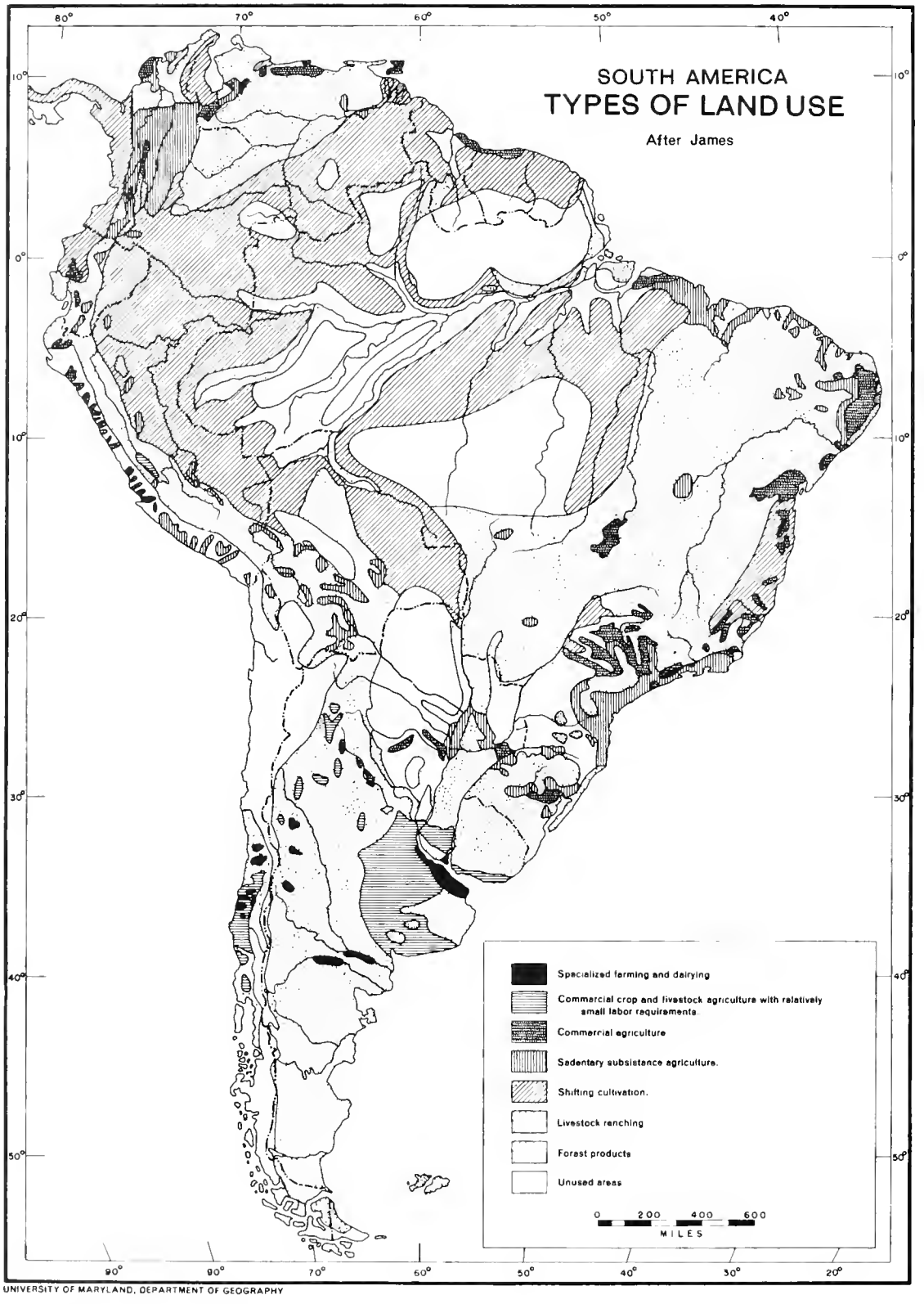
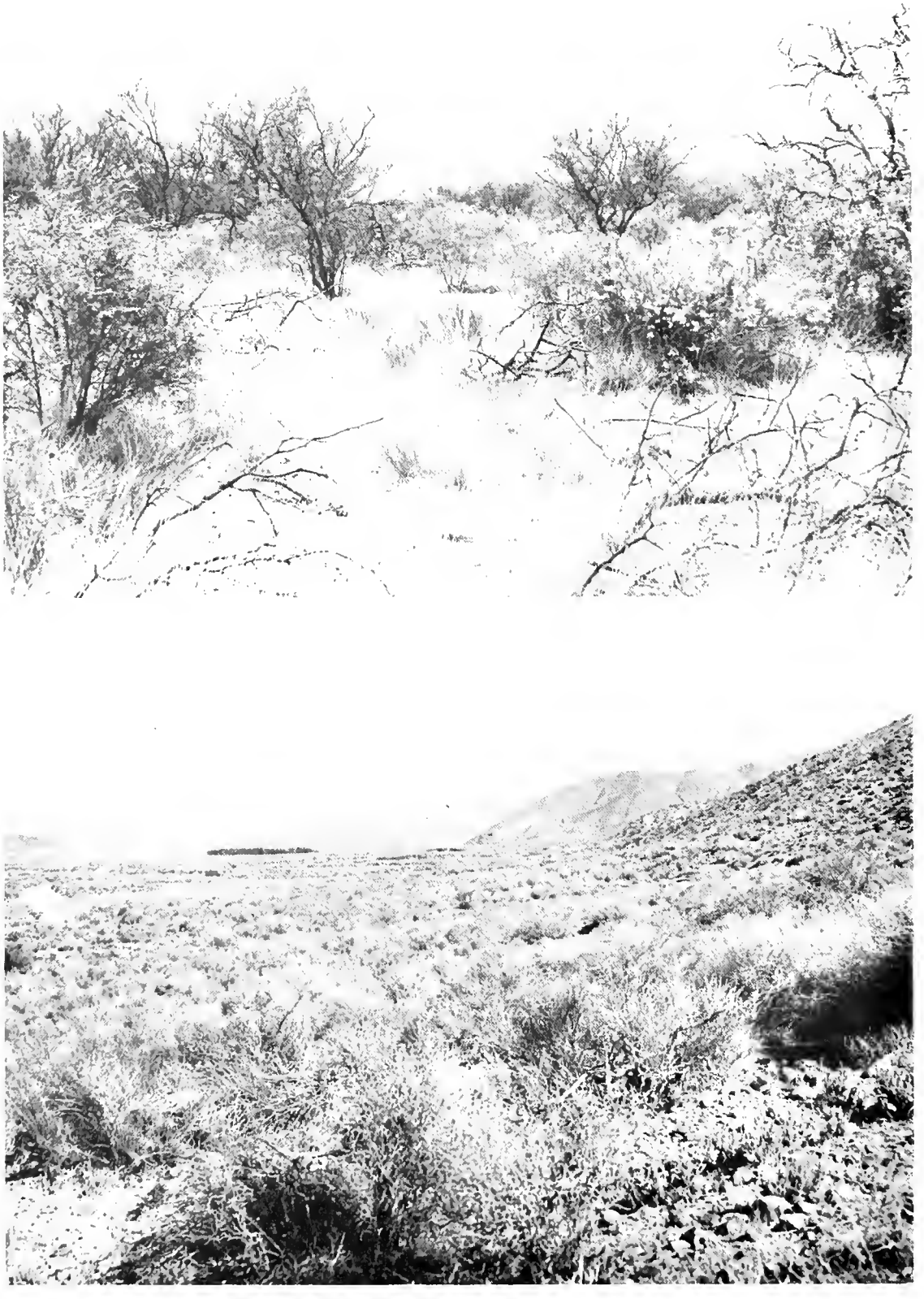


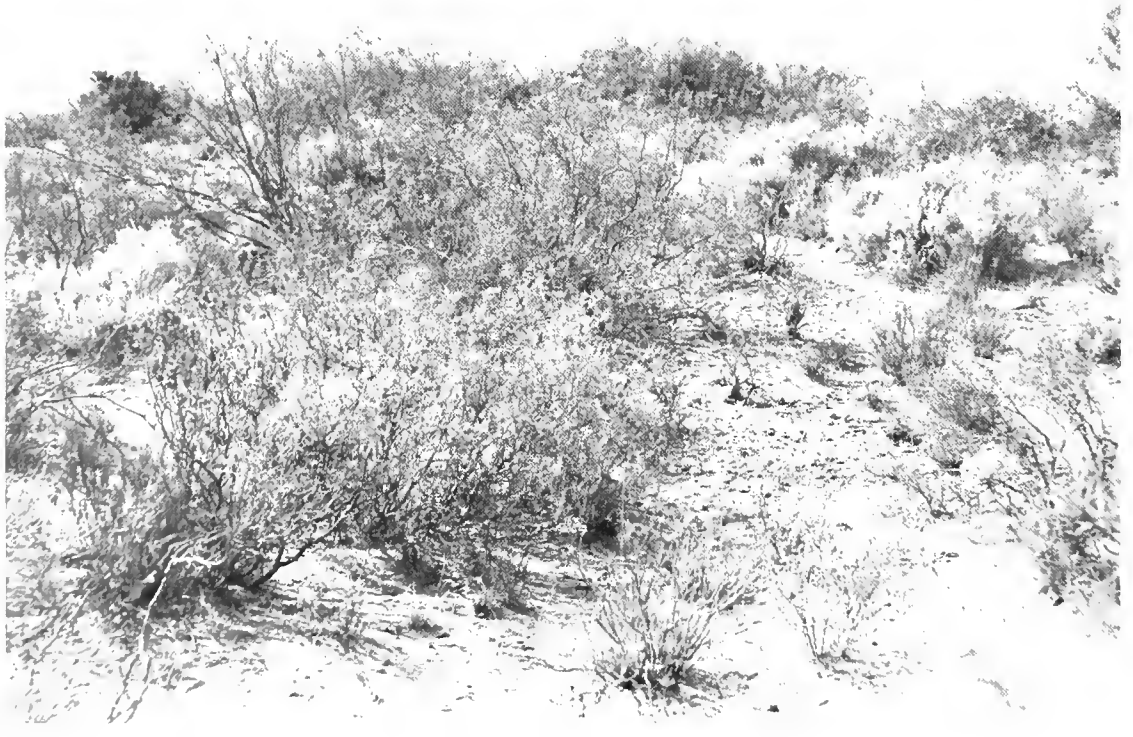
Figure 7. Types of land use in South America (Van Royen, 1954).

Figures 8-9. Cover types supporting crested tinamous in San Juan Province.



Figures 10-11. Cover types supporting crested tinamous in San Luis (top) and Rio Negro (bottom) Provinces.

Figures 12-13. Cover types supporting crested tinamous in La Pampa Province.



Figures 14-15. Cover types supporting crested tinamous in Mendoza Province.

Figures 16-17. Cover types supporting crested tinamous in Neuquen Province.

Figures 18-19. Cover types supporting crested tinamous in Chubut Province.

Further north in brushlands of the Great Basin Desert elegans or patagonica subspecies might find some suitable habitat conditions, disregarding colder temperatures and high snowfall conditions. These same conditions would exist east of the Rocky Mountains from Oklahoma, Colorado, and Kansas into Nebraska. Although not emphasized in this report, the islands of Lanai, Molokai, Maui and Hawaii would probably have areas of brush, grass and scattered trees where elegans elegans would find useable habitat while not facing the more severe climatic conditions found in some of the northern continental States mentioned above.

Topography and elevation

Flat, sloping alluvial plains up to the base of mountains, and wide-mouthed arroyos along with low ridges are inhabited by crested tinamous. From the Atlantic ocean on the eastern edge of Argentina crested tinamou races are found from sea level rising gradually to the higher elevations as they extend west to the Andes. In the northern Argentina Provinces of Tucuman, Catamarca and La Rioja, prime crested tinamou habitat ranges in high, wide valleys from 2,000 feet to about 4,000 feet. In the range of albida the terrain varies from about 2,000 feet in elevation to over 4,000 feet. Further south and east, elegans elegans can be found from sea level to almost 6,000 feet in the upper valleys of Mendoza Province. Patagonian crested tinamous thrive from sea level to about 2,500 feet elevation, the higher populations being found in areas from sea level to 2,000 feet.

Soils

Soils in western portions of the ranges of crested tinamous include sierozems and desert types while central areas and southeastern ranges contain chestnut and brown desert soils, as noted by Van Royen (1954) in figure 25. This map indicates soils in our Southwest are similar to those in crested tinamou ranges of Argentina. In higher rainfall zones occur chernozems, reddish chestnut, rendzinas and related soils of the tropics. A considerable amount of the arid desert soils have extensive alkaline rivers and saline playas. In general, soil texture can be described as sandy or gravelly over much of the habitats of albida, elegans and patagonica. Eastward in higher rainfall areas sandy soils are most prevalent, with a few containing alkaline and saline soils in the bottomlands.

Papadakis, Calcagno, and Etchevehere (1960), soil scientists of Argentina, have recently adopted the newer approximations of soils stemming from earlier classification into the great groups. Their report on the soils of Argentina follows the numbering for the 6th approximation (rev. January 14, 1958) of the United States Soils Survey Division. They have divided Argentina into regions of eleven soil groups, four of which occur in the habitats of Eudromia elegans ssp. These four regions are:

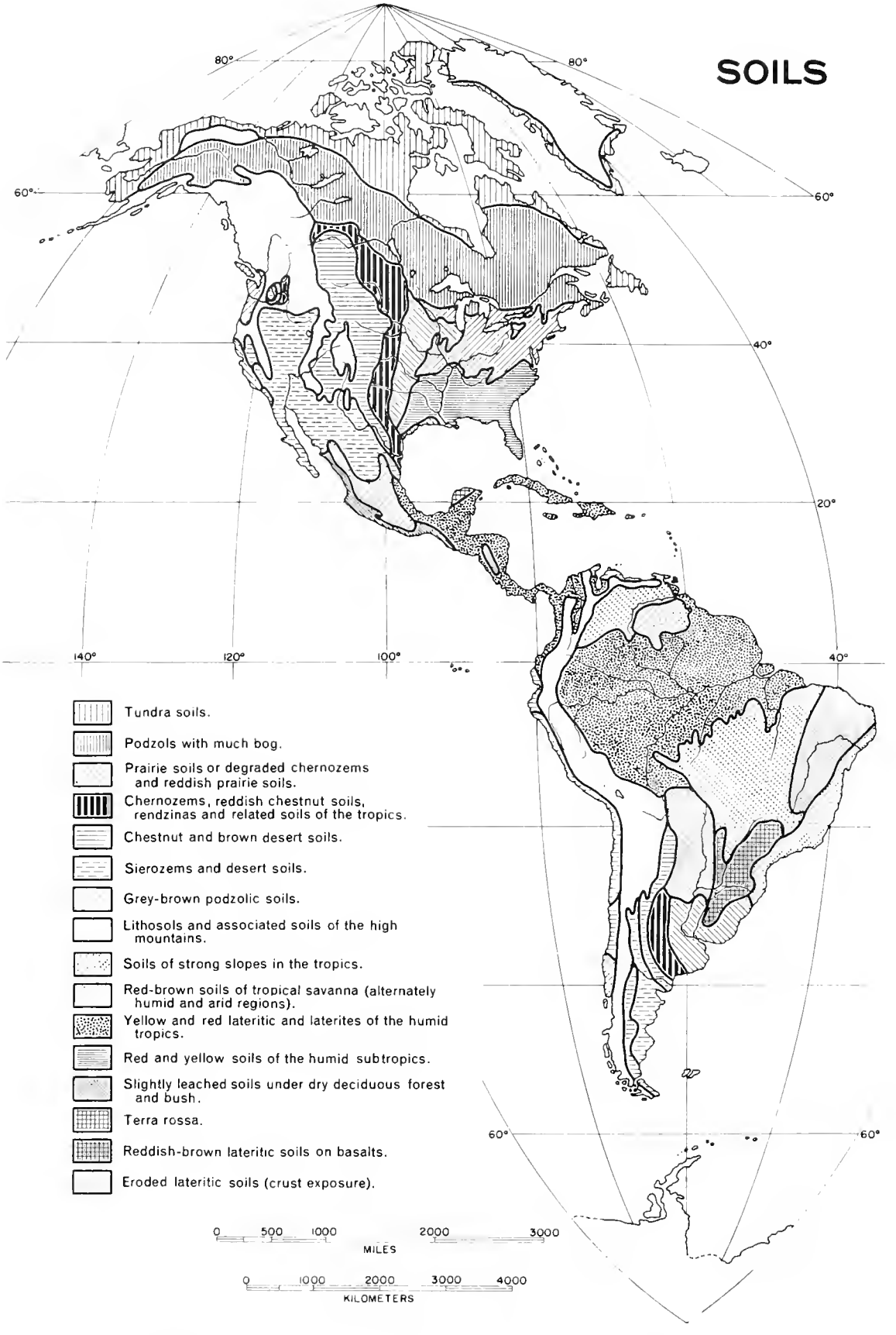


Figure 20. General soil types for North and South America, after Van Royen (1954).

V. Pampean (grassland)

Soils - Chestnut soils without textural B on sandy material. A few saline and alkaline soils in the bottomlands.

Precipitation - Annual rainfall 200 to 800 mm.

Vegetation and land use - Grasslands, wheat, alfalfa and livestock ranching.

Crested tinamou subspecies occurring in this soil range - E. e. elegans and multiguttata.

VI. Semi-arid regions with brown soils

Soils - Brown soils without textural B on sandy materials with naturally consolidated sand dunes, saline and alkaline soils; saline lakes encountered in the bottomlands.

Precipitation - Annual rainfall 300 to 600 mm.

Vegetation and land use - Open thorny woodland with wheat and alfalfa in moister areas; in drier parts no crops without irrigation; livestock ranching.

Crested tinamou subspecies occurring in this soil range - E. e. multiguttata, elegans and riojana.

VII. Reddish brown soils

Soils - Reddish brown soils without textural B and considered as intergrades to desert sands. Bottomlands have many gypsisols, alkaline and saline soils, with extensive saline playas.

Precipitation - Annual rainfall 300 to 500 mm.

Vegetation and land use - Open thorny woodland and many cacti. No crop is produced without irrigation, which include grapes, olives, and cotton. There is livestock ranching.

Crested tinamou subspecies occurring in this soil range - E. e. riojana and magnistriata.

VIII. Desert soils

Soils - Desert soils with textural B often covered by a desert pavement. Desert sand is the dominant soil in the middle parts of Catamarca, La Rioja, San Juan, Mendoza and Rio Negro Provinces. In all of these parts there is encountered saline, alkaline, gypsisols and coloisols in the bottomlands. In the valleys of rivers that cross the Patagonian steppe many humid meadow soils are present but they are not very acid.

Precipitation - 80 to 300 mm.

Vegetation and land use - Desert shrub, thorny, very open with many cacti. In the Patagonian desert, shrubs have the height of herbs and are mixed with grasses. Livestock ranching is the predominant land use.

Crested tinamou subspecies occurring in this soil range - E. e. intermedia, riojana, albida, elegans, devia and patagonica.

Climate

Climates of North and South America are depicted in detail for comparison in figure 26. Table 2 considers from available Argentine weather station records the mean maximum and mean minimum temperatures for January and July, along with the very highest and lowest temperatures for the general ranges of the crested tinamous, Eudromia elegans ssp. Annual rainfall and main periods of rainfall are also listed in this table. Within the ranges of eight subspecies of the crested tinamous there is considerable variation in temperatures and in the amounts and seasons of precipitation and snowfall.

Snowfall records for crested tinamou ranges are sketchy. Snow is not common in these ranges except in certain cold steppe areas of western Argentina, but where it has occurred to depths of 6 inches for a week or so, coupled with mild freezing temperatures, it has not adversely affected the birds. Where snow has lain on the ground for as much as 60 days, as in 1964 in Chubut Province, tinamou populations were markedly reduced. In general, crested tinamou populations thrive best in arid to mild climates without heavy or extended periods of snow. Hail storms are very common during summer months in western Argentina, and although some young and adults have been reported killed by unusually large hail this does not seem to have adversely affected the populations.

In the general range of crested tinamous mean maximum summer temperatures do not exceed 97° F. in the northern latitude and reach only 70° F. in southern Patagonia. Mean minimum temperatures for winter months range from 28° to 32° F. in the north to 25° F. at 4,652 feet elevation in Malargue, Mendoza Province, and 26° to 27° F. in the southernmost Patagonian crested tinamou ranges. Highest temperatures recorded were 114° F. in the north, 110° F. in the west-central region and 96° F. in southern Patagonia. Lowest temperatures ranged from 10° F. in the north to minus 10° F. at Malargue and to only 1° F. in the southernmost habitat of Santa Cruz Province, Patagonia. A short distance further north in Patagonia low readings of minus 1° and minus 9° F. were recorded in Chubut Province. Oceans and precipitation have a moderating effect upon low temperatures in the southern Patagonia areas.

Seasonal precipitation in crested tinamou ranges is inclined toward a summer pattern in the northernmost Provinces, a spring and summer pattern in west-central provinces and a winter pattern in Patagonian ranges. Rainfall occurs in central and eastern Argentina over three or more seasons, with some precipitation recorded in every season. Whereas only spring, summer and fall are indicated in table 2 as being the main rainfall period, in most cases winter precipitation varies from an inch to about 3.5 inches in a few cases.

Figure 21. Climatic regions of North and South America as modified from Van Royen (1954).

Table 2. Argentine weather information in the range of the crested tinamous, Eudromia elegans ssp., from northern Catamarca Province south into Santa Cruz Province of Patagonia[a].

Province	Weather Station	Elevation (feet)	Temperature °F. Mean maximum (Jan.)	Mean minimum (July)[b]	Highest temp.	Lowest temp.	Annual rainfall (inches)	Period of rainfall	Mean days with frost
Catamarca	Andalgala	3517	92	36	108	20	12.5	summer	17.1
	Tinogasta	3941	91	28	108	7	6.8	summer	73.0
La Rioja	Chepes	2159	92	40	110	10	15.2	spring-summer	10.0
	Chilecito	3839	92	35	108	16	8.9	summer	25.5
	La Rioja	1411	97	37	114	15	12.1	summer	16.0
San Juan	Jachal	3822	91	32	107	16	4.4	summer	58.4
	San Juan	2067	94	34	111	18	3.5	spring-summer	27.9
Cordoba	Bell Ville	426	86	39	109	12	32.8	all year	23.1
	Cordoba	1394	88	39	113	16	28.8	spr.,sum.,fall	16.8
	Huinca Renanco	594	93	37	111	11	23.5	spr.,sum.,fall	32.2
	Villa Dolores	1867	92	40	112	17	24.0	spr.,sum.,fall	10.4
Santa Fe	Casilda	236	88	41	107	19	37.8	all year	15.3
Buenos Aires	Azul	433	86	37	104	19	33.6	all year	42.0
	Bahia Blanca	236	88	38	108	16	22.0	" "	29.6
	Balcarce	371	85	38	105	23	33.3	" "	22.9
	Coronel Suarez	768	86	36	106	17	29.1	" "	41.8
	General Villegas	384	91	36	109	12	27.7	" "	37.1
	Trenque Lauquen	312	89	36	-	-	29.0	" "	-

(a) From "Estadisticas Climatologicas" Servicio Meteorologico Nacional, Buenos Aires, Argentina, Publication No. 3, 1941-1950, and Publication No. 6, 1951-1960.

(b) Seasons are the reverse of those in the United States, i.e., July in Argentina is a mid-winter month.

Table 2. Cont'd.

Province	Weather Station	Elevation (feet)	Temperature °F. Mean maximum (Jan.)	Mean minimum (July)	Highest temp.	Lowest temp.	Annual rainfall (inches)	Period of rainfall	Mean days with frost
San Luis	Coronel Pringles	1598	88	33	106	8	26.9	spr.,sum.,fall (also 1-2" win.)	54.4
	Mercedes	1686	91	35	108	15	21.5	" " "	28.6
	San Luis	2349	89	37	110	15	21.2	" " "	23.4
	Union	1220	94	32	108	8	16.5	" " "	57.5
Mendoza	Colonia Alvear	1526	91	34	106	14	13.0	spring-summer	40.8
	La Paz	1660	93	33	110	13	11.6	" "	37.4
	Malargue	4652	86	25	100	-10	7.8	fall-winter	129.1
	Mendoza	2713	86	38	101	21	9.3	spring-summer	13.9
	San Carlos	3084	86	26	99	7	13.8	spring-summer	90.0
Neuquen	Chos Malal	2782	87	34	103	12	10.5	fall-winter	57.6
	Las Lajas	2339	84	31	103	6	8.6	" "	85.3
La Pampa	General Acha	781	90	34	108	14	19.3	spr.,sum.,fall	50.2
	General Pico	463	90	37	113	13	26.9	" " "	38.7
	Guatrache	577	90	33	112	14	23.3	" " "	50.2
	Santa Isabel	1050	92	31	108	6	13.4	" " "	70.3
	Santa Rosa	620	89	35	114	10	24.3	" " "	39.5
	Victorica	1024	93	35	111	14	22.0	" " "	42.0
Rio Negro	Choele Choel	430	90	34	109	14	16.3	all year	49.2
	Cipolletti	869	87	32	103	13	8.2	" "	52.8
	General Conesa	197	88	33	103	9	10.5	" "	39.2
Chubut	Comodoro Rivadavia	200	78	38	99	22	7.5	sum.,fall,winter	21.6
	Esquel	2575	70	26	92	-9	16.6	all year-fall,winter	121.4
	Sarmiento	879	76	32	101	-2	5.1	heaviest fall,winter	53.3
	Trelew	127	83	35	104	13	7.1	all year	47.2
Santa Cruz	Gobernador Gregores	1174	70	28	96	1	6.3	sum.,fall, winter	93.6
	Lago Argentino	722	65	28	83	13	8.0	all year	96.4
	Perito Moreno	1407	69	27	91	1	4.6	sum.,fall, winter	92.0
	Santa Cruz (Puerto)	39	69	29	95	10	7.3	all year	88.0

This is especially true for the Provinces of La Pampa, San Luis and Cordoba. Their winter precipitation was not shown as dominant since it was much less than the amounts falling in spring-summer-fall.

Climate within the general ranges

Climacurves depicting weather conditions over the general ranges of the crested tinamou, Eudromia elegans ssp., are presented in figures 22 and 23. Those for distinct species are figures 29 through 34. Outside boundaries of the shaded areas indicate upper and lower limits for mean maximum and mean minimum temperatures in relation to precipitation for the four seasons. Dotted lines inside the shaded smoothed curves represent the approximate upper and lower mean temperature limits for more than 90 percent of the 55 Argentine stations used. These Argentine weather stations represent those available in Provinces of the crested tinamou range, from northern Catamarca south to Santa Cruz Province.

These four general curves can be used to plot by interpolation United States stations not covered in detail in this report and which are outside the seasonal precipitation amounts noted in the three selected subspecies ranges. This would apply to Stateside stations having annual rainfall of 20 to 35 inches annually, and to the higher rainfall zones occupied by crested tinamous of the subspecies elegans, multiguttata, riojana, and magnistriata.

Climate within the ranges of three selected subspecies

The three subspecies of crested tinamous emphasized in this report thrive in desert, semiarid and cool steppe type climates. Temperatures, rainfall, periods of precipitation, snowfall and freezing temperatures are variable within the three subspecies ranges. Climacurves depicting native ranges are presented for each of these, and compared with selected United States stations. These climacurves cover the four seasons, with smoothed curves representing upper and lower limits of mean maximum and mean minimum temperatures in relation to the average amount of precipitation falling for each station and in each season. Shaded areas represent climatic ranges of the subspecies within their native areas; U. S. stations are identified by perpendicular lines.

Important climatic differences of each subspecies range are considered below. The northernmost subspecies, albida, in San Juan Province is treated first; then elegans elegans southward and southeast in Mendoza, San Luis and La Pampa Provinces; and finally patagonica, the southernmost subspecies, occurring closest to the Antarctic in Chubut and Santa Cruz Provinces.

Eudromia e. albida -- This subspecies lives in desert areas of San Juan and perhaps portions of other nearby Provinces where summer temperatures are hot, spring or summer precipitation amounts to 3.5 to 4.4 inches, the total for the year. In some years in areas such as Matagusanos just north of San Juan City rain does not fall, and for much of the range in most years open water is not available to these tinamous. In southern San Juan Province, Wetmore (1926) collected two specimens suspected as being Eudromia e. albida from Canada Honda, where the annual rainfall is reported as only 3.4 inches and snowfall is not common at this 2,000-foot elevation. Further north at San Juan Jachal at 3,822 feet elevation, still in the suspected range of albida, some snow does occur and the coldest winter month (July) has a mean temperature

of only 32° F. Mean maximum summer temperatures nearest the best albida ranges extend from 91° to 94° F., only slightly warmer than temperatures found in the northern range of elegans in Mendoza Province. Highest temperature recorded for albida ranges was 111° F., and the lowest, 16° F.

Figures 24 and 25 present climacurves representing desert range of the crested tinamou albida in San Juan Province, and also Chilecito in nearby La Rioja Province. Records of only two weather stations were available in San Juan Province but both are in prime ranges of this subspecies.

Eudromia e. elegans -- Considering only portions of Mendoza, San Luis and La Pampa Provinces, this subspecies thrives over a larger area of arid, semiarid and temperate climatic areas than any other of the races. In northern Mendoza Province habitat, Jocoli shows only 3.3 inches rainfall annually, comparable to the lower rainfall areas just north cited for albida. Prime habitat usually receives between 6 to 12 inches of rain in the spring-summer months in Mendoza Province at elevations ranging from 1500 to 4500 feet. Snow normally does not fall in the range but when it does, not more than 6 to 8 inches persist for more than a few days on the ground.

Hail storms are sometimes violent, occurring during summer breeding months. During the first week in November 1965 between San Rafael and Mendoza two to four inches of hail fell, defoliating many trees as well as knocking most grape leaves from vines in certain areas of each agricultural district. After this deluge of hail, Argentine gauchos reported finding deserted crested tinamou nests as well as some dead young and adults where they had apparently been caught in the open. FGIP biologists found deserted nests in eastern Mendoza Province and watched one male unsuccessfully try to incubate 7 eggs during 20 minutes of hail and rain followed by an additional 20 minutes of heavy rain. This was the first rain for the spring-summer period of that year in this area. A hail storm in Mendoza on January 7, 1967 deposited two to three inches on the ground; this marked the first severe hailstorm of the year. Makeshift heavy-duty tar paper roofs on the Mendoza FGIP pens were perforated so badly that most had to be roofed over with additional tar paper.

Summer mean maximum temperatures in good ranges of this subspecies vary from 86° to 93° F. with a mean minimum temperature of 33° F. recorded in the winter. Highest temperature recorded was 110° F. and lowest 13° F.

The Malargue weather station of southwestern Mendoza Province was not considered for elegans but instead was plotted on the patagonica climacurves. This was done because Olrog (1963) placed this area in his "zones ornitograficas" as being representative of the Patagonian steppe zone. Taxonomically, this area of Malargue is said to have elegans.

San Luis and La Pampa Provinces, centrally located in Argentina, have a milder climate in elegans ranges. Spring, summer, fall precipitation patterns are common although from one to two inches falls during winter months also in San Luis and from about 1 to 1.6 inches in good crested tinamou range of La Pampa Province. Precipitation occurs more or less all year in these two Provinces in the habitat of elegans while nearby Mendoza Province ranges receive rainfall mainly in spring-summer months. Snowfall is uncommon except

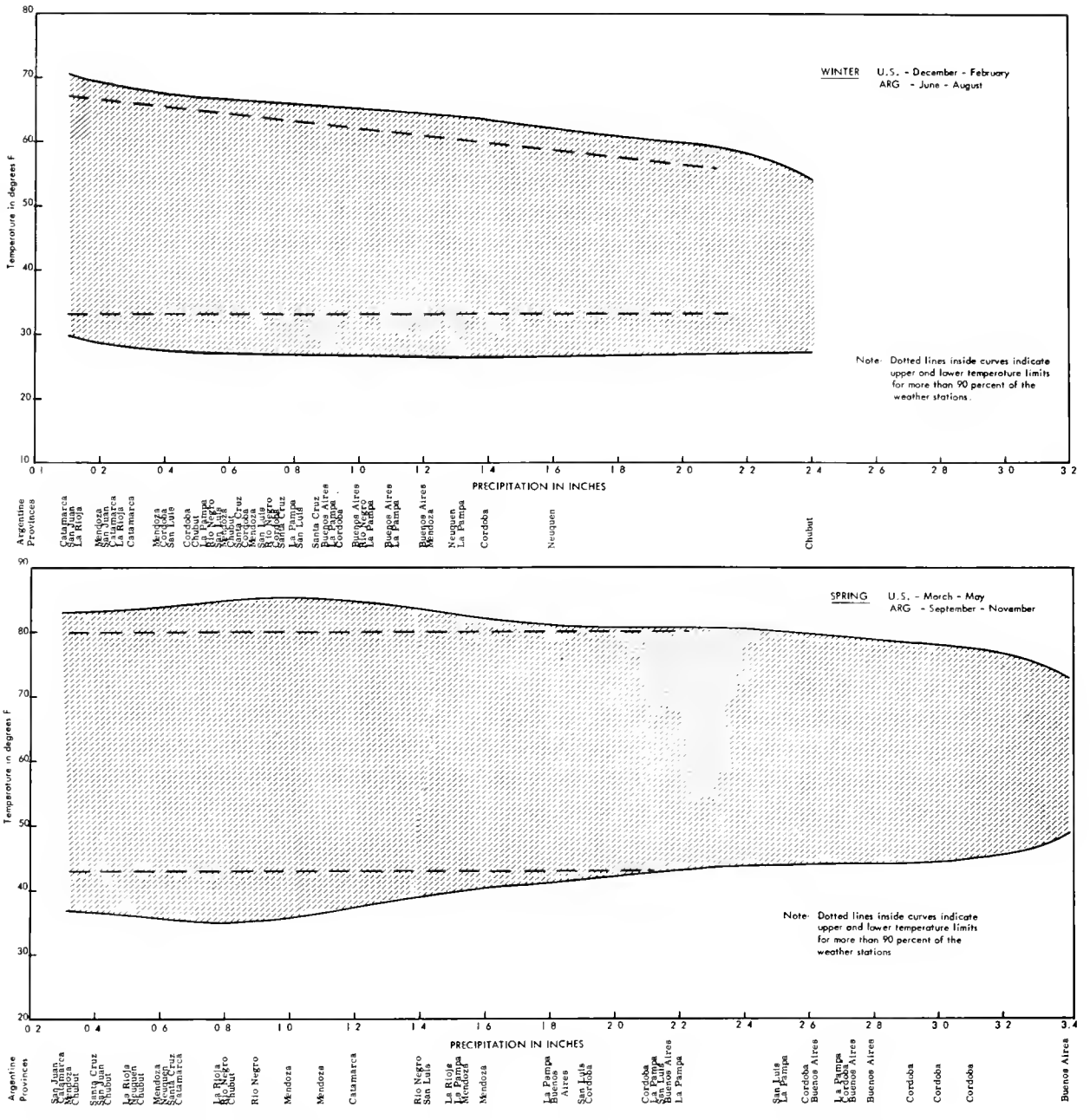


Figure 22. Mean maximum and mean minimum temperatures according to precipitation, by seasons, in the general ranges of the Argentine crested tinamous, Eudromia elegans ssp., including arid, semiarid, temperate and cool steppe climates.

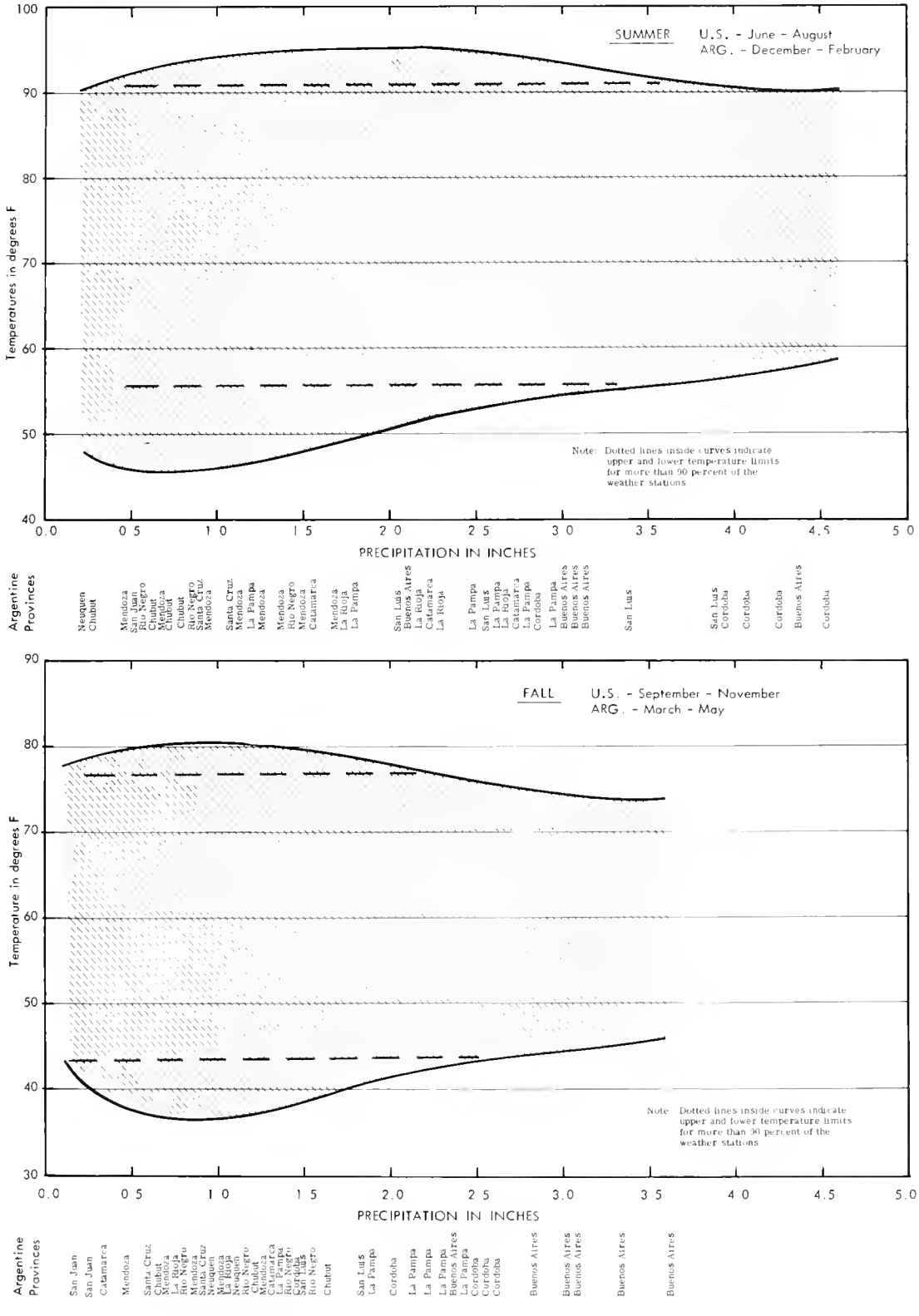


Figure 23, Mean maximum and mean minimum temperatures according to precipitation, by seasons, in the general ranges of the Argentine crested tinamous, Eudromia elegans ssp., including arid, semiarid, temperate and cool steppe climates.

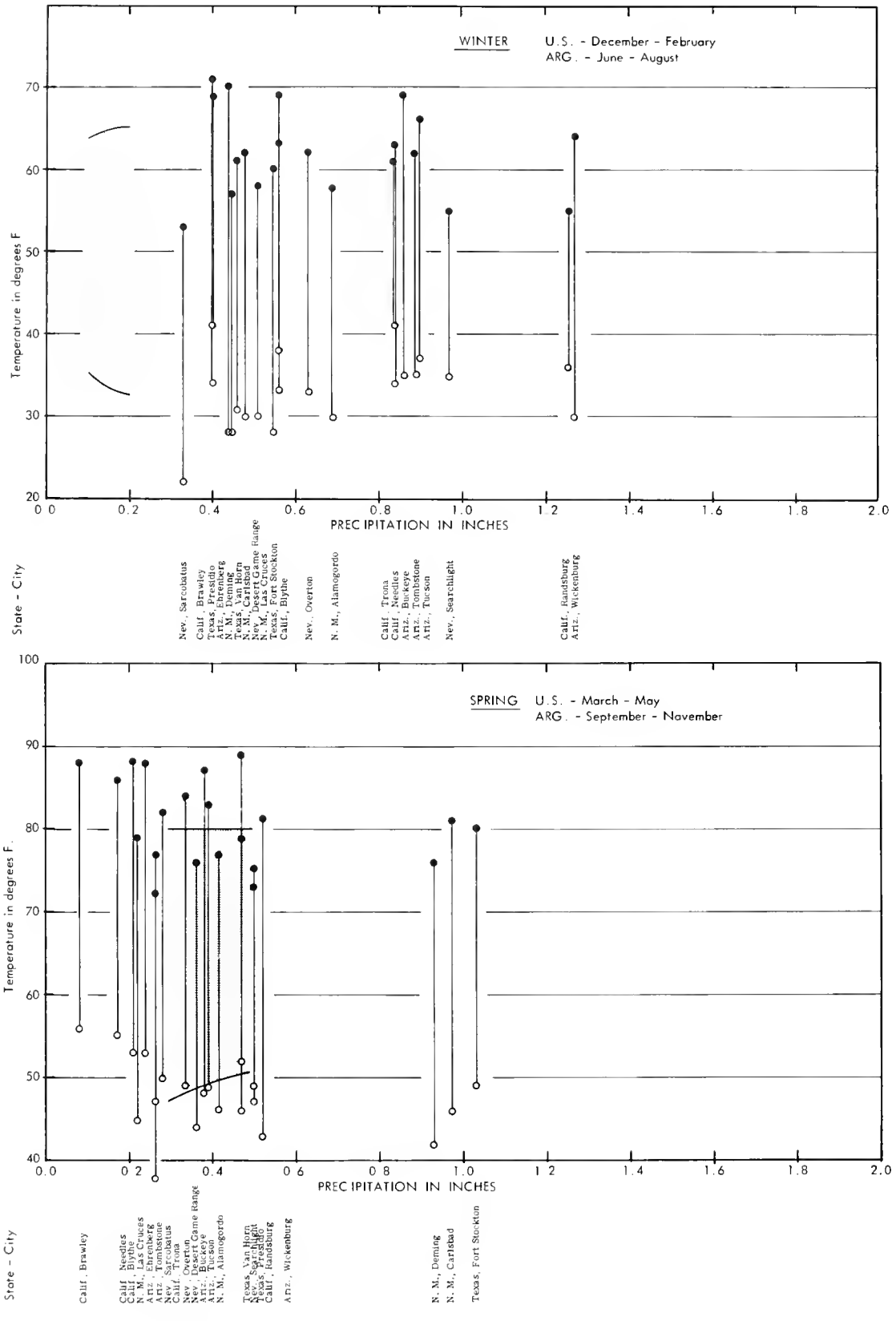


Figure 24. Mean maximum and mean minimum temperatures according to precipitation, by seasons, in the desert climate of the Argentine crested tinamous, Eudromia elegans ablida, as compared to certain desert areas of the United States.

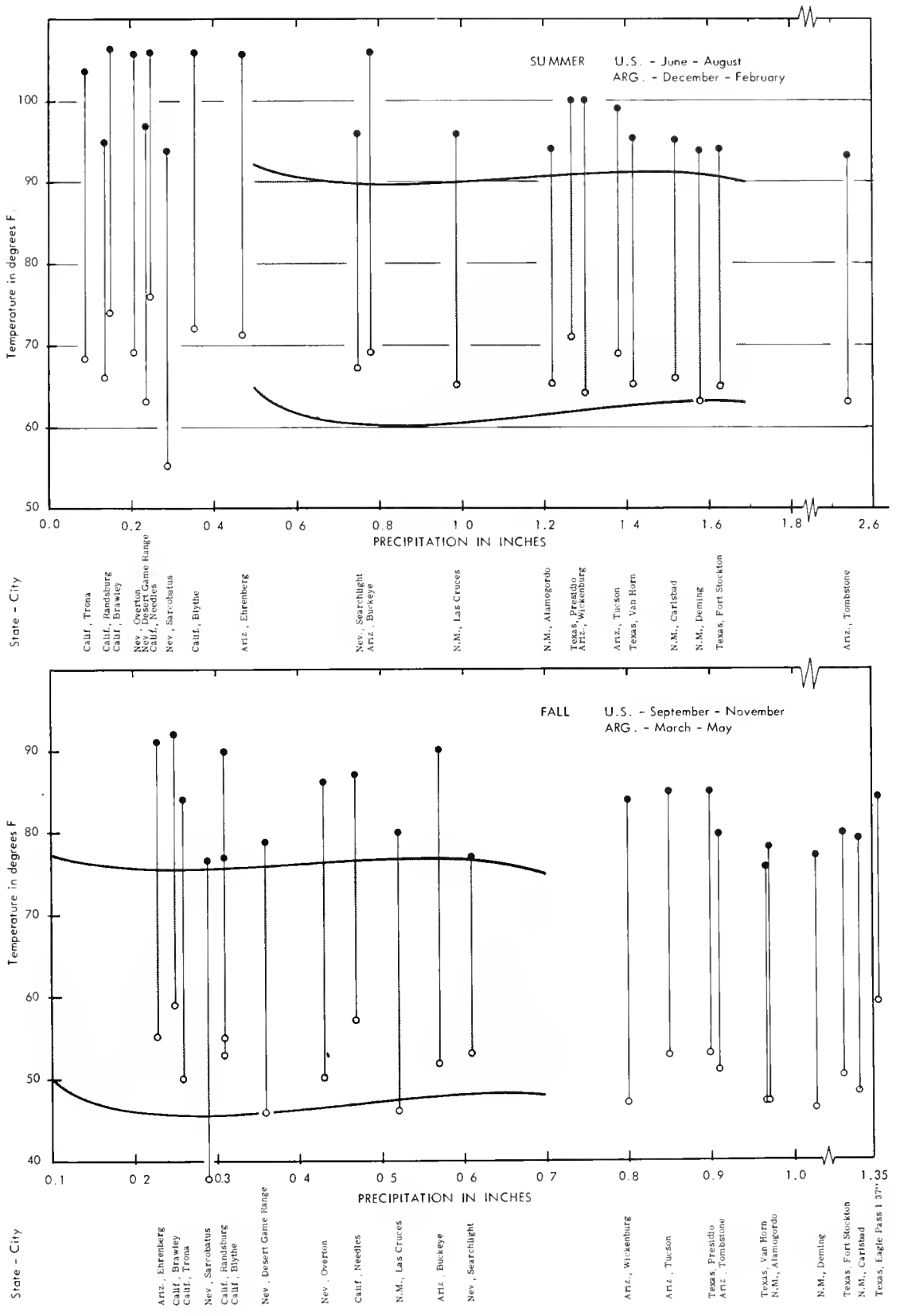


Figure 25. Mean maximum and mean minimum temperatures according to precipitation, by seasons, in the desert climate of the Argentine crested tinamous, Eudromia elegans albida, as compared to certain desert areas of the United States.

for the highest elevations in San Luis but does not amount to more than a slight fall, remaining only a few days on the ground. Summer mean maximum temperatures in San Luis tinamou range vary from 88° to 94° F. with winter mean minimum temperatures extending from 32° to 37° F. The alltime high temperature is 110° F., the low is 8° F., with annual rainfall extending from 16.5 to 26.9 inches.

La Pampa summer mean maximum temperatures range from 89° to 93° F. and winter mean minimums from 31° to 35° F. The highest temperature recorded was 111° F. and the lowest 6° F. Annual rainfall varies between 13.4 inches to at least 22.0 inches. Snowfall is uncommon in this Province where elevation ranges from about 100 to 1050 feet over good crested tinamou habitat.

Climacurves for E. e. elegans ranges in portions of Mendoza, San Luis and La Pampa Provinces are presented in figures 31 and 32. Fourteen Argentine weather stations were available for plotting these curves.

Eudromia e. patagonica -- The southernmost race of crested tinamous inhabits the cool Patagonian steppe zone. This climate extends north from Santa Cruz and Chubut Provinces through the edges of western Mendoza and San Juan Provinces. Climatic regions for Patagonia, according to Koeppe and DeLong (1958), include both the intermediate desert and semiarid continental types.

Rainfall decreases to the south in the Argentine Patagonian steppes as well as along the eastward Atlantic ocean side. In the range of patagonica in Chubut and Santa Cruz Provinces, with elevations from sea level to 2575 feet, precipitation in some areas occurs all year or is sometimes heaviest during summer months. For other areas fall and winter provide the most precipitation. Lowest precipitation was a 4.6-inch annual average at Perito Moreno, then ranged between 5.1 and 7.5 inches further north in Chubut to a high of 16.6 inches at Esquel, on the extreme western edge of patagonica range.

Snowfall is not common over most Patagonian crested tinamou ranges. It does occur at the higher elevations of 2,000 to 4,800 feet near the Andes. Around Gobernador Costa, Chubut Province, in 1964 snow laid 60 days on the ground, while in 1965 there were 31 inches on the ground for 15 days in fair-to-good crested tinamou habitat (field contacts with Ernesto Roco, 1966). According to local residents both this species and another mesa-inhabiting tinamou, Tinamotis ingoufi, were markedly affected but crested tinamou made the most rapid recovery by 1966. This amount of snowfall does not normally occur in the best crested tinamou habitats of Argentina.

Near the small villages of Rio Chico and Comallo in Rio Negro Province, just north of Chubut Province, crested tinamou may be faced with as much as 20 inches of snow during the year at the 2,000 to 2,500-foot elevations. This usually is spread over several months and does not remain long on the ground.

In prime crested tinamou habitat in southwestern Mendoza Province is Malargue, at an elevation of 4,652 feet. It has an annual average of 7.2 days of falling snow with about 7 inches of snow from April to October. It has the lowest winter mean minimum temperature of all stations within crested tinamou range. It averages 25° F. with an alltime low temperature of minus 10° F. There were no local reports that snow adversely affected tinamous

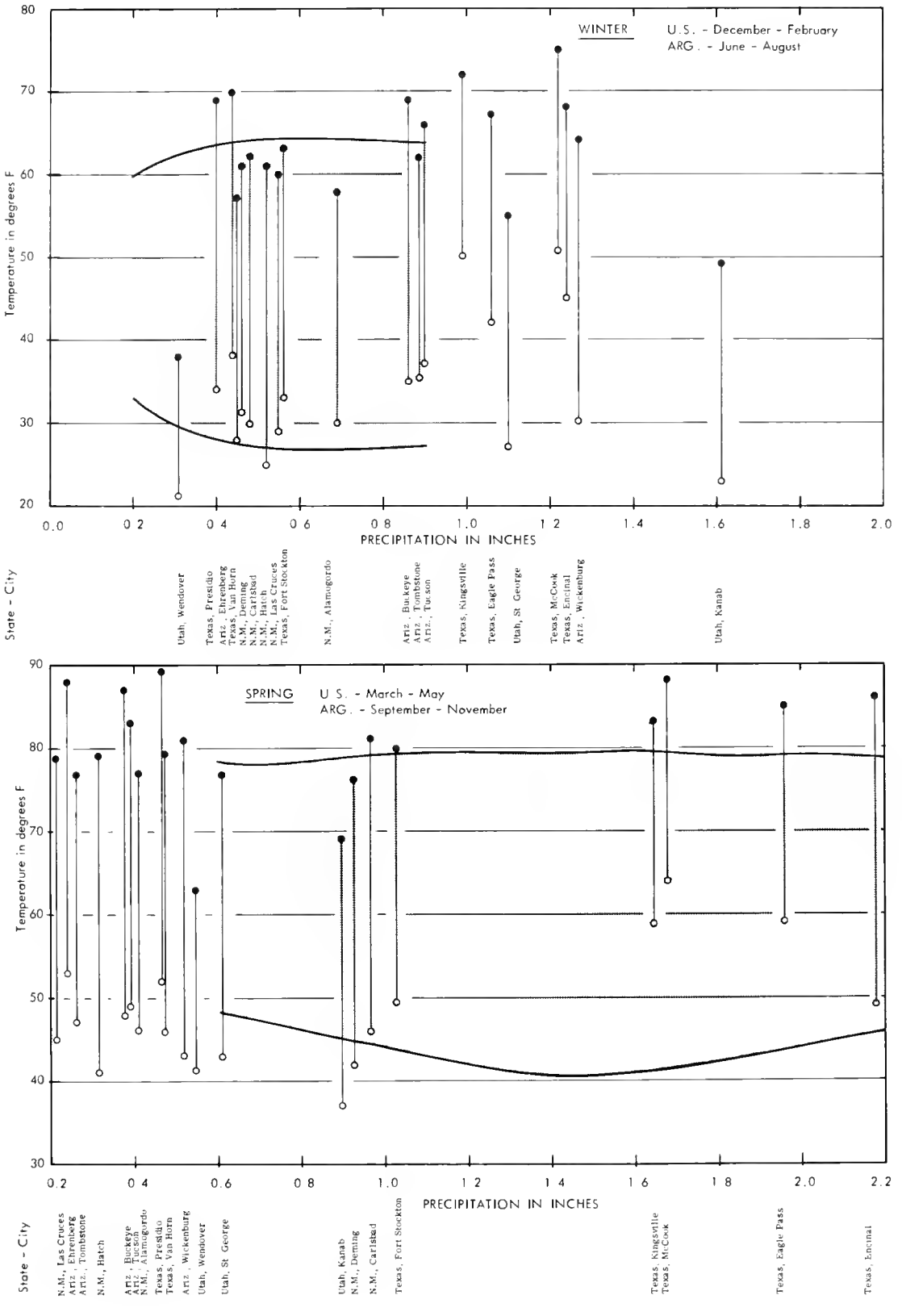


Figure 26. Mean maximum and mean minimum temperatures according to precipitation, by seasons, in the arid and semiarid ranges of the Argentine crested tinamous, Eudromia elegans elegans, as compared to selected areas of the United States.

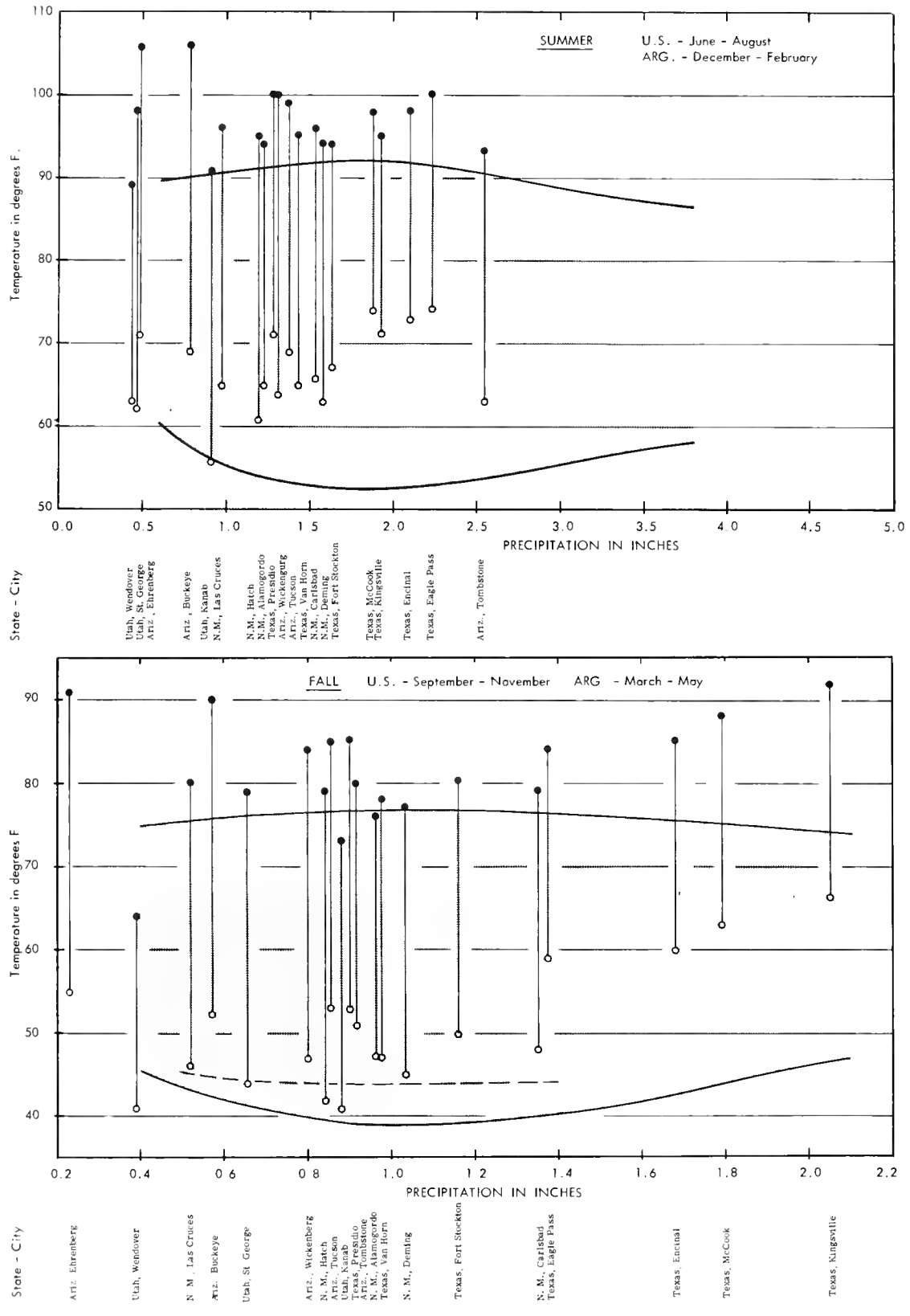


Figure 27. Mean maximum and mean minimum temperatures according to precipitation, by seasons, in the arid and semiarid ranges of the Argentine crested tinamous, Eudromia elegans elegans, as compared to selected areas of the United States.

in the Malargue area, unless larger snowfalls were coupled with freezing temperatures. Rainfall at Malargue averages 7.8 inches annually, falling mainly during the fall and winter. This period is in contrast to other sections of Mendoze Province which receive their rain during the spring and summer.

Antarctic winds blowing from the south do not cease even at night in Patagonia and crested tinamous there tend to roost at the bases of low brush on the north-facing sides, apparently to avoid these cold winds. Chilean tinamous in southern Chile faced with the same constant winds were found also to roost on the north side of brush, being well protected from the southern Antarctic winds.

Summer mean maximum temperatures in Santa Cruz and Chubut Provinces range between 65°F. and 83°F., the latter along the Atlantic coast, while mean minimum temperatures during winter varied between a low of 26°F. at 2575 feet elevation to 38°F. along the coast. The highest temperature recorded was 104°F. along the ocean side of eastern Argentina at Trelew, with an alltime low of minus 9°F. at Esquel in the interior.

Further north at Malargue the lowest mean minimum temperature for winter was 25°F., reaching a mean maximum of 86°F. during the summer. The lowest temperature ever recorded was minus 10°F. and the highest 100°F.

Climacurves for Patagonia crested tinamou ranges are shown in figures 28 and 29. They are constructed from Argentine stations extending from Santa Cruz and Chubut Provinces north into southwestern Mendoza Province, to include ranges inhabited by both patagonica and elegans. A total of 13 Argentine stations was available for plotting and constructing the curves.

Comparisons with stations in the United States

For plotting comparisons of three subspecies of the crested tinamou, 75 United States stations were used to construct climacurves on a three-months basis covering winter, spring, summer and fall. Since seasons are reversed between North America and Argentina, our winter months of December through February fall in June through August in Argentina; a similar pattern holds true for the other seasons.

The 75 selected stations were each plotted in relation to seasonal precipitation, with mean maximum temperatures shown as black circles and mean minimum temperatures as white circles, the circles connected by a black line. Specific climacurvic comparisons are shown in figures 24 through 29.

Climacurvic comparisons of Argentine ranges to those of the United States stations, in regard to three subspecies of crested tinamou, indicate the following:

Eudromia e. albida -- Mean maximum temperatures during spring, summer and fall average 5° to 15° F. hotter than those in Argentina. Mean minimum temperatures are comparable except for winter and spring being slightly colder.

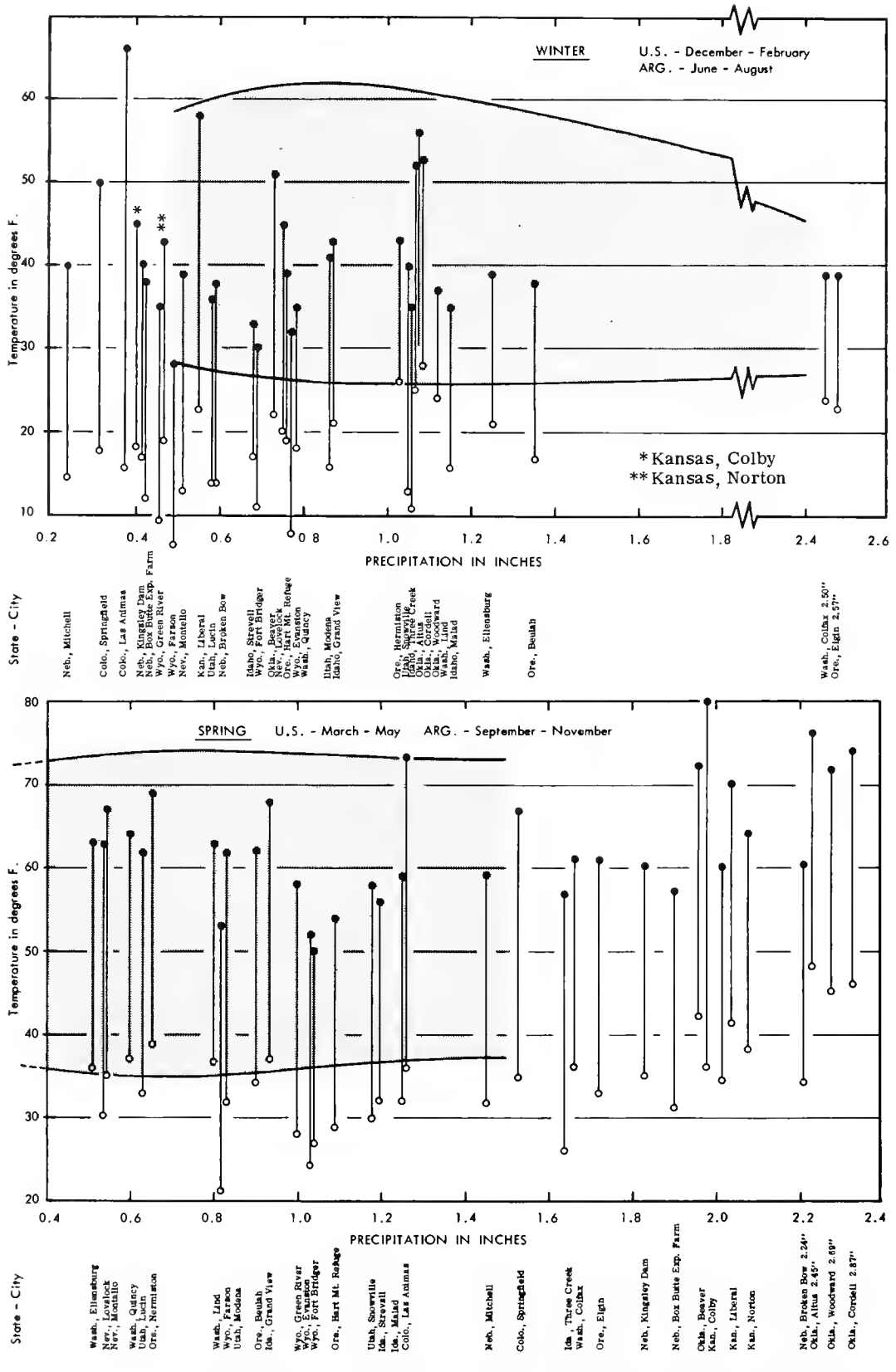


Figure 28. Mean maximum and mean minimum temperatures according to precipitation, by seasons, in the ranges of the Argentine crested tinamous, E. e. patagonica and elegans inhabiting the cool Patagonian steppe climate as compared to cold desert, high snowfall and other selected areas of the United States.

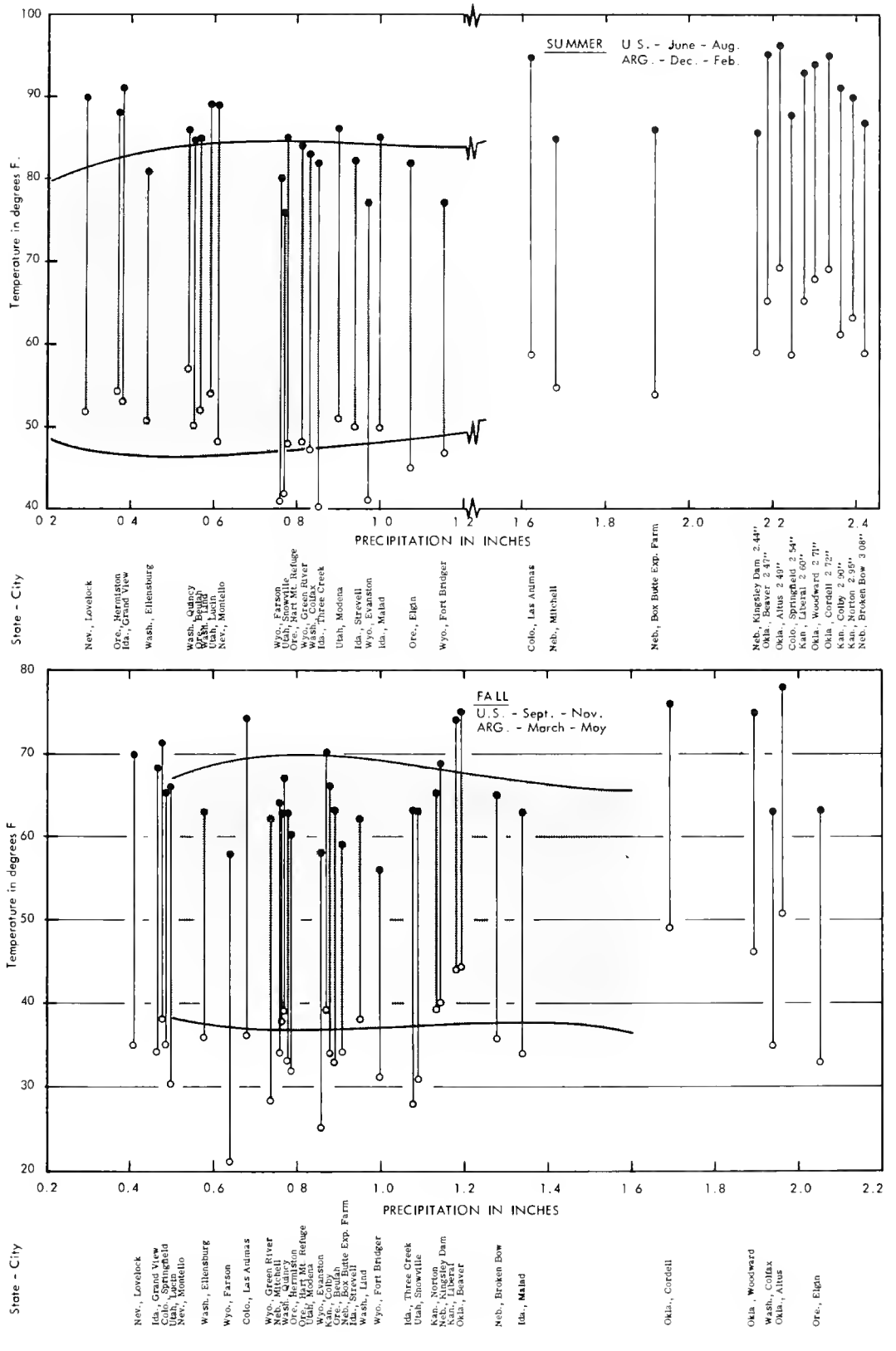


Figure 29. Mean maximum and mean minimum temperatures according to precipitation, by seasons, in the ranges of the Argentine crested tinamous, E. e. patagonica and elegans inhabiting the cool Patagonian steppe climate as compared to cold desert, high snowfall and other selected areas of the United States.

in most of the 21 United States stations. Spring and summer precipitation is lower in some hot desert areas of California and Nevada. Snowfall would be considered uncommon in both the United States stations and the albida range in Argentina.

Eudromia e. elegans -- Mean maximum temperatures and mean minimum temperatures for 20 U. S. stations are similar to those temperatures occurring in Argentina in the Eudromia e. elegans ranges. Also, precipitation patterns and amounts are similar although some stations in Texas, New Mexico, Arizona and Utah report less rainfall during March through May than the spring season in Argentina. Snowfall may occur but does not normally remain for extended periods. Only at one station of higher elevation in Utah, having 29 inches of snowfall annually, might the crested tinamou experience trouble.

Two female crested tinamous acquired by the New Mexico Game Department for their Carlsbad game farm experienced low temperatures of minus 18° F. for about one week in the mid-1950's with no ill effects noticed. Tinamous of this subspecies and albida shipped from Argentina under the FGIP have not been noticeably affected, through 1967, by low freezing temperatures on the Nevada Fish and Game Department bird laboratory at Yerrington, Nevada.

Some of the highest populations of elegans elegans are located in the oasis desert country of Mendoza Province in western Argentina. Jaeger (1961) indicates that the closest climatic analogues for this Argentine area are in the Arizona Upland Desert (Tucson) which has mild winters, hot summers and a preponderance of summer rain.

Eudromia e. patagonica and/or e. elegans -- Mean maximum temperatures do not appear to be a problem at the 34 United States stations plotted on the Argentine seasonal climacurves. Mean minimum temperatures in winter for three-fourths of these stations extend from an average of about 5° F. to 16° F. below, the lowest temperatures shown for Argentina stations. Rainfall patterns in the comparisons are similar but spring and summer seasons in Oklahoma, Kansas, and Nebraska receive noticeably more moisture than Argentine stations plotted. Snowfall is much heavier in several States and this, coupled with freezing temperatures over a considerable period, would appear detrimental to crested tinamous which have not fared well under similar conditions in Argentina.

Director Mel Steen, Nebraska Fish and Game Department, indicated (personal correspondence, 1968) that crested tinamous shipped by the FGIP from Chubut Province seem to have wintered well in their southern Nebraska game farm when kept in the open with only a box to crawl into for shelter. If the crested tinamous can hollow a suitable roost in the ground, freezing temperatures would not seem too drastic a hazard except where blizzards or snowfall cover extensive ground areas for periods longer than a few days.

Figure 35 presents climatic areas which might be suitable for the three races of crested tinamous in western United States. Questionable areas, namely those normally experiencing extreme freezing, high snowfall and blizzard conditions, are noted by a question mark near the area delineated on the map. Although not marked with a question mark, there are areas in the United States where precipitation does not fall during the late spring or summer

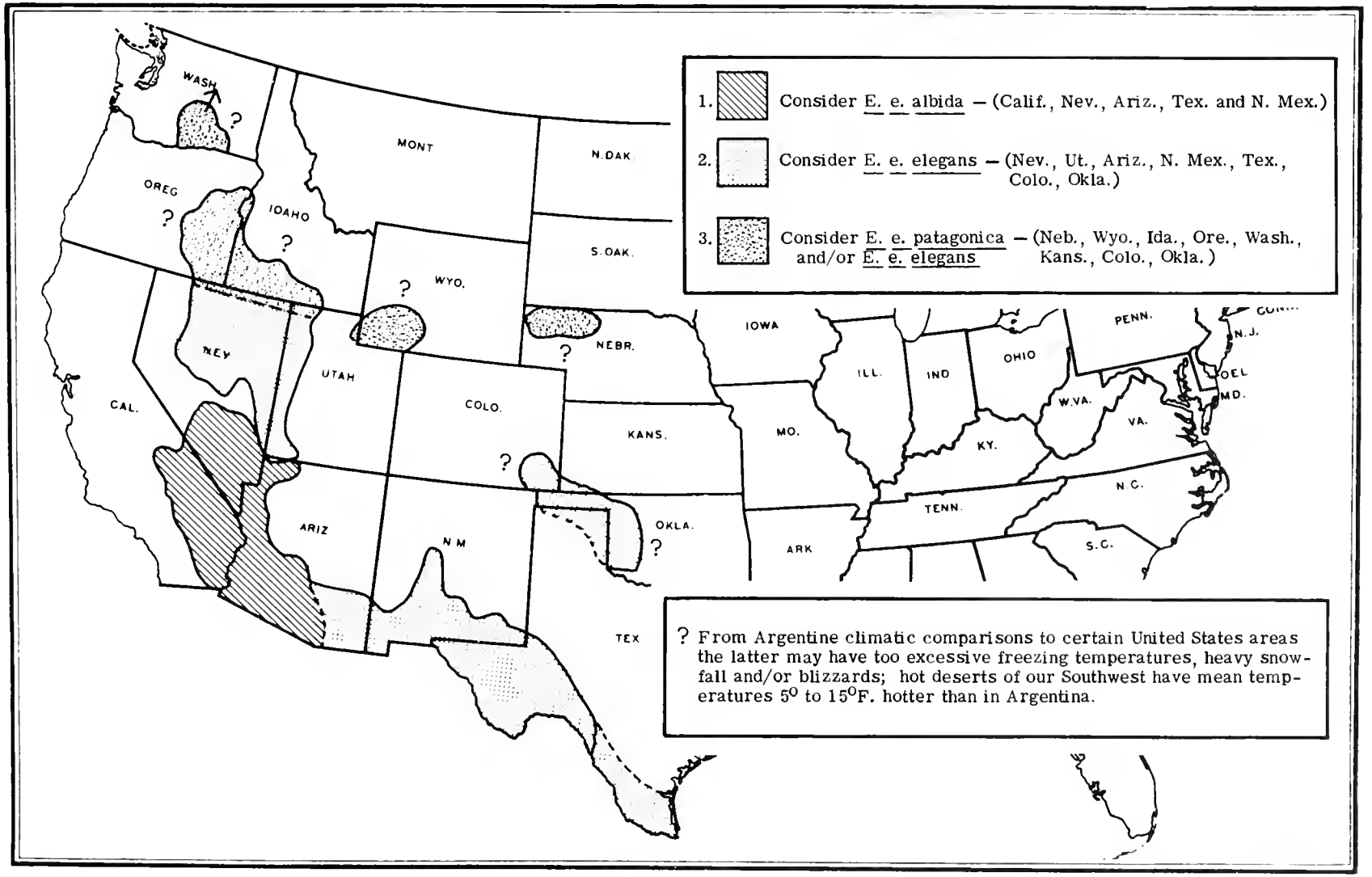


Figure 30. Selected climatic regions of the United States considered for crested tinamou experimental liberations.

breeding period as it does in Argentina. These will provide ecological differences to be watched closely by biologists. Another difference bearing close observation, noted on the climacurves but not with a question mark on the map, is in those areas with mean maximum temperatures in spring, summer and fall much hotter than their Argentine counterparts. These areas, and those with even higher temperatures, may have an important bearing on the survival of crested tinamous, as compared to cooler breeding season temperatures in Argentina over all of their various ranges.

Food and Water

In our searches for a desert game bird to fill vacant niches or to complement existing desert or semiarid game bird populations in the United States we were elated to discover the hardiness of Argentine crested tinamous and to determine some food and water tolerances that enable this tinamou to survive so well in the deserts. For any game bird to survive exceptionally well under desert conditions it must eat portions of a wide variety of available plant and/or insect material and preferably be able to survive without direct water. Crested tinamous eat an assortment of vegetative parts such as leaves, twigs, flowers or their buds, seeds and fruits of weeds, grasses, brush and tree products, plus a small amount of insects. Direct water is often unavailable in their ranges; where water does occur it is shown little interest, the birds' water requirements apparently are taken care of metabolically in the vegetable matter they eat. Food and water requirements of crested tinamous enable them to live and thrive in many desolate areas of Argentina where no other tinamous can be found today. Only the closely related rheas, Rhea sp., with similar food and water requirements are found with crested tinamous in the most arid habitats (Olrog, 1968).

Crested tinamous find their food by searching the ground in washes, along arroyos, or over the flatter areas at the bases of brush or other vegetation in which windblown parts might become lodged. They are very adept at jumping to take leaves of plants as well as flowers and fruits not yet fallen to the ground. In general these tinamous do not scratch the ground much in search of food, except with their bills. They continually peck away at what particles can be gleaned from the surface. Only a small amount of grit appears in their crops.

Feeding periods are similar to those of other desert game birds in that feeding is accomplished early in the morning, usually finishing by 8 a.m. in the summer months, and beginning again in the afternoon about 4 or 5 p.m., continuing until dark. If any feeding is done during the mid-daylight hours it is in the close vicinity of brush where the birds habitually rest and dust during periods of highest temperature. During winter with its cooler daytime temperatures the birds feed later in the morning and earlier in the afternoons. Journeys for water are not needed since the birds use little, if any, direct water and in most arid and semiarid areas streams or tanks of water are not available.

Nesting males are inclined to feed in the mornings before 10 a.m. and again in late afternoon. A male collected during the breeding season on November 27 contained a full crop weighing 20 grams. Three days later the crop, dry, weighed only six grams. This indicates the amount of vegetable moisture in a crop obtained from the most arid desert area in San Juan

Province. No insects were in the crop. It contained leaves, spines, seeds and flowers of the following: creosote bush, Larrea spp., more than 50 seeds plus 6 percent flowers; spiderling, Boerhavia paniculata?, 16 percent; a spurge, Euphorbia sp., 15 percent; retamo, Bulnesia retamo, 12 percent; palo verde, Cercidium sp., 11 percent; pricklypear cactus, Opuntia sp., 8 percent; and miscellaneous plant material unidentified, 32 percent. Cacti, including thorny parts, are commonly taken by crested tinamous and their gizzards oftentimes will have numerous small thorns imbedded in the walls.

Between 1964 and 1967 attempts were made by the FGIP to collect seasonally as many crested tinamous as possible to determine their food habits. A total of 119 birds was collected in the western portion of the ranges. Table 5 presents their seasonal food habits as identified by Dr. A. Ruiz Leal, University of Cuyo, Mendoza, Argentina. Dr. Leal also kindly attempted a more complete identification of 26 crops from La Pampa Province collected by Dr. Bump, which were partially identified earlier through the courtesy of Dr. Guillarmo Covas of Estacion Experimental Anquil, La Pampa Province. These crops are not included in the seasonal analysis of 119 crops but are referred to separately in this section.

Only three young birds were collected as it was the policy not to collect small birds in hopes that these could be trapped for eventual shipment to those States requesting tinamous. One young bird weighing 299 grams, collected near La Totora, San Luis Province, had eaten fruits, flowers and seeds of Evolvulus sp., morning glory family; a couple of pieces of wood; some fruits and seeds of a legume; and 35 black ants. Two other small birds collected together in eastern La Pampa Province at 9:30 a.m. had only a few legume seeds in their crops. Wetmore (1926) reported that examination of the crop and alimentary tract of a crested tinamou chick disclosed the unmistakable odor of dung of the adult and hypothesized that it was probably eaten to supply either moisture or partly digested vegetable food, in an area where succulent vegetation was scarce and water absent. Adult crops collected showed in general a much larger proportion of vegetable matter than insects throughout the year. Slightly more insects were taken in spring and fall than in other seasons.

Protein content of desert plants is usually high, and to determine the extent of protein in foods eaten by several subspecies of crested tinamou, "Cargill" food company in Buenos Aires kindly analyzed crops of five tinamous from San Juan and Mendoza Provinces for us. These five birds were collected during spring and summer seasons and their crops contained 25.68 percent protein. Annual rainfall in the collection areas ranged between 3.5 and 10 inches, occurring either during summer or spring and summer.

Nowhere are these tinamous dependent upon agricultural crops although where good brush cover exists next to cultivated fields some use can be expected. Fallow fields in particular are utilized for feeding on weeds, such as Solanum sp., a nightshade, and Russian thistle, Salsola sp., but in general grains of cultivated crops are bypassed for weed, grass and woody plant vegetation in the more wild brush areas.

Crested tinamous collected at the last hour before sundown had a greater amount of food in their crops than those collected early in the morning up to 8:30 a.m. One bird shot at 6:10 p.m. on August 3 had eleven varieties of plant food in its crop. Composition was 90 percent leafy plant material

and one Orthoptera insect. Weight of the contents was 19 grams while two others collected late in the day on May 5 and May 27 weighed 20 grams each, wet weight. Both contained about 98 percent vegetable material, with 10 and 11 types of plants represented for each crop. Table 5 shows 39 plant families were found, with the following most commonly represented: 1. Leguminosae; 2. Solanaceae; 3. Zygophyllaceae and, in decreasing use, the following families: Cactaceae, Gramineae, Compositae, Euphorbiaceae, Malvaceae and Rhamnaceae. Of insects eaten, black ants were taken most frequently, followed by grasshoppers and beetles but insects made up less than 10 percent of the annual seasonal foods utilized.

Bump and Bohl (1965) earlier noted preliminary food habits for crested tinamous which surprisingly included creosote bush seeds plus buds and flowers from Larrea divaricata and Larrea cuneifolia. No North American game bird has been reported taking this resinous plant's seeds or flowers. Martin, Zim and Nelson (1951) and Benson and Darrow (1954) indicate that this bush is fed upon only by a few species of insects and occasionally a jack rabbit. By far the greatest seasonal use of Argentine creosote bush seed was during spring when it was found in 24 crops, and in winter in 26 crops. In summer and fall the seeds and flowers were found only 9 times in the specimens examined. This particular plant did not make up more than eight percent of the total plants eaten. While the volume of seeds taken was not high, creosote bush was not eaten accidentally as it appeared so consistently in the crops.

Figure 5, after Benson and Darrow (1954), shows distribution of creosote bush, Larrea divaricata, in the Southwest, and lists other desert plants in the range of this bush. Representatives of all these genera occur in crested tinamou ranges of Argentina also. Some of these genera utilized in the crested tinamou diet, which occur in both our Southwest and Argentina, include pricklypear cactus, Opuntia sp.; mesquite, Prosopsis sp.; palo verde, Cercidium sp.; joint fir, Ephedra sp.; filaree, Erodium sp.; nightshade, Solanum sp.; Russian thistle, Salsola sp.; barberry, Berberis sp.; vetch, Vicia sp.; spurge, Euphorbia sp.; and bromegrass, Bromus sp.; along with two genera of the Malvaceae family, mallow, Lecanophora sp., and globemallow, Sphaeralcea sp. One bird collected in a rather heavy alkaline area had eaten leaves of seablite, Suaeda divaricata, a plant also found in western United States but not reported in the diet of any native game birds.

Concerning 26 crested tinamou crops collected from eastern La Pampa Province, foods were of the same genera as those represented in the 119 crops analyzed, with three genera appearing for the first time. These were wheat, Triticum sp.; a grass, Agropyron sp.; and a legume, Cassia. Of these 26 crops none was collected in the spring.

The three dominant plant families that appeared in summer, fall and winter were Gramineae, Leguminosae and Solanaceae. At least four grass genera appeared 17 times during fall and winter but only twice in the summer; legumes representing eight-plus genera appeared 13 times in summer and fall and three times in winter. The single genus, Solanum, appeared 13 times in summer and fall and was not found in winter-collected crops. Genera of seven other plant families were recorded for these 26 crops but each did not appear more than one or two times during the three seasons these crops were collected. Most tinamous from which crops were collected were of either the subspecies Eudromia e. elegans or multiguttata.

Since much of eastern La Pampa contains wheat, corn and barley fields, these grains appeared more in the crop samples than were noted in crops from the more typical brush habitats of crested tinamous. Wheat, Triticum sp., made its first appearance in crops analyzed but was represented in only a few crops. Insects occurred in greatest numbers in fall and to a lesser extent in summer. Where insects were in the crops, beetles of small to medium sizes were most common, followed by grasshoppers and black ants. One bird ate a small green worm and another, two weevil larvae. Overall, insects did not comprise much of the total food diet of crested tinamous in eastern La Pampa. This also was the case with crops analyzed in western Argentina.

Crops collected in Chubut Province, Patagonia, had foods similar to those collected further north and east in Argentina. Fruits of filaree, Erodium sp., comprised 70 percent of the contents of three crops. These also contained legume leaves, plant particles of Compositae, and fruits and seeds of barberry, Berberis sp. Four other crops contained more than 90 percent each of wolfberry fruits, Lycium sp.; Solanaceae; and seeds from Bromus brevis and Bromus macranthus. A crested tinamou collected near Cushamen, Chubut Province, added another genus from the Compositae family. The crop was fairly full of the flowers of Taraxacum officinale, dandelion. All these crops were collected on the western half of Patagonia near the Andes.

Crested tinamous have large caeca which are immense in proportion to the overall size of the birds. The external surface is divided into many lobular projections near the base, tending to disappear at the free ends. Figure 31 illustrates the caecum size with the conical lobulated tubes from a specimen collected in San Juan Province. Wetmore (1926) measured one caecum that was roughly 130 mm. long by 25 mm. in diameter and another 125 mm. long by 22 mm. wide. Extended, one of the tubes of these caeca would amount to five inches in length. Of all the tinamous, only in the crested is the extremely large caecum found, which has probably enabled it to survive in deserts of Argentina without direct water and with only arid vegetation as a supplement to its water needs.

While it is not unusual for Gambel's quail, California quail and Harlequin quail to have their water requirements provided through feeding on succulent vegetation and insects, Bartholomew and Cade (1963), none of their diets contain the variety nor the quantity of plant material taken by crested tinamous.

Table 5. Seasonal food habits of 119 crested tinamous, Eudromia elegans ssp., based on crops collected from Argentina, 1964-1967.

Foods	Parts eaten	Number times appeared in crops			
		Spring	Summer	Fall	Winter
Plant					
Acanthaceae	seeds and fruits	1			1
Amaranthaceae					
Amaranthus sp.	one plant			1	
Gomphrena sp.	roots, pieces of roots, flowers			1	2
Anacardiaceae					
Schinus polygamus	leaves				1
Asclepiadaceae					
Philibertia gilliesii	1" long green fruit			1	
Tweedia brunonis	small twigs, leaves, pieces of small twigs	1	1		3
Berberidaceae					
Berberis grevilleana	seeds		1		
Berberis sp.	seeds, whole fruits		3		
Bignoniaceae	one seed	1			
Boraginaceae					
Heliotropium mendocicum	root tubers, fruits	3		4	2
Pectocarya sp.	young plants				1
Cactaceae					
Echinopsis sp.	entire fruits, pieces of flowers				2
Gymnocalycium sp.	whole flower				1
Opuntia glomerata	small and large fruit parts				1
Opuntia sp.	small twigs, seeds, flowers, fruits	5	1	1	11
Pterocactus tuberosus	big pieces of twigs			1	
Capparidacea					
Atamisque emarginata	leaves, small twigs, flower buds, fruits	3			11
Caryophyllaceae	small twigs with leaves			1	
Gilia gracilis var.	fruits and seeds		1		
Paronichya brasiliana	ends of small twigs			1	
Silene sp.	fruits and seeds (whole capsules)	3	1		

Table 5. Cont'd.

Foods	Parts eaten	Number times appeared in crops			
		Spring	Summer	Fall	Winter
Plant					
Chenopodiaceae					
Atriplex sp.	young vines, leaves			1	1
Chenopodium sp.	small twigs, fruits, leaves			1	
Salsola kali	plants, pieces of small twigs (tender ends)	1			2
Suaeda divaricata	leaves	1			
Compositae					
Bidens sp.	fruits	1			1
Gnaphaphalium sp.	ends of inflorescence	1			
Hyalis argentea	tender leaves, young vines				4
Parthenium hysterophorus	roots, leaves, young plants, vines				4
Porophyllum obscurum	whole floral capsules	2			
Proustia ilicifolia	flower, leaf parts			2	
Psila tenella	ends of small twigs with leaves			1	
Thesperma megapotamicum	small twigs with leaves				1
Thymophylla belenidium	ends of small twigs, ends of tender vines				2
Verbesina enceliodes	inflorescence, pieces of root and small twigs	2		1	3
Convolvulaceae					
Cressa truxillensis	small twigs			1	
Dichondra repens	leaves			2	
Evolvulus sp.	fruits, spoiled flowers, seeds, leaves, ends of small twigs	1	1	1	
Cruciferae					
Descurainea sp.	whole plants	2			1
Eruca sativa	flowers, pieces of leaves			1	
Lepidium sp.	small twigs with fruits, flowers, seeds	1	2		
Ephedraceae					
Ephedra sp.	small piece of young twig				1
Ephedra ochreata	two fruits		1		
Euphorbiaceae					
Croton sp.	--	1			
Euphorbia portulacoides	fruits and seeds--entire fruit	1		1	
Euphorbia serpens	small twigs, leaves, fruits			1	1
Euphorbia sp.	plants and vines with leaves, small twigs and plants, fruit	4	2	1	1

Table 5. Cont'd.

Foods	Parts eaten	Number times appeared in crops			
		Spring	Summer	Fall	Winter
Plant					
Fungi					
Cyathus sp.	flower parts	1			
Tylostoma sp.?	whole individuals	1		2	
Geraniaceae					
Erodium circutarium	fruits, leaves, young plants		6	1	1
Gramineae	flowers	5	1	1	
Bromus brevis	fruits, seeds	4	6	5	1
Bromus macranthus	seeds	1	1	2	
Bromus sp.	one fruit	1			
Cynodon dactylon	pieces of young vine				1
Eragrostis sp.	pieces of flowers			1	
Hordeum stenostachys	three seeds			1	
Hordeum vulgaris?	grains			2	
Poa sp.	seeds	1			
Schismus barbatus	flowers, leaves, young plants		1		3
Zea mays	grains			2	
Hydrophyllaceae					
Phacelia artemisioides	small twigs, leaves, fruits and seeds	1	1		1
Phacelia artemisioides affinis	small twigs with leaves				1
Phacelia sp.	young plants, pieces of young twigs with fruits, seeds		2		
Leguminosae					
Adesmia sp.	flowers	1			
Caesalpinia sp.	twigs and leaves				1
Cercidium australe	seeds, flowers, buds	12		2	6
Geoffroea decorticans	leaves, follicles				6
Hoffmanseggia sp.(andina?)	leaves, seeds		2	1	2
Medicago hispida	leaves, small twigs, fruits, seeds	13		2	
Medicago sp.	pods, leaves, seeds		5		
Melilotus sp.	pieces of leaves and seeds		1		
Mimosoideae?	leaves	1			
Prosopidastrum globosum	various fruits		1		
Prosopis alpataco	pods, leaves, fruits, seeds	2	3	6	3
Prosopis sp.	leaves, flowers, seeds	2			
Prosopis torquata	seeds, leaves, fruits				6
Vicia sp.	seeds, pods, fruits, greens	5	2		
Zuccagnia punctata	fruits				1

Table 5. Cont'd.

Foods	Parts eaten	Number times appeared in crops			
		Spring	Summer	Fall	Winter
Plant					
Liliaceae or Amaryllidacea	roots, bulbs, seeds	3	1		
Loranthaceae					
Psittacanthus cuneifolius	leaves	1			
Malvaceae					
Lecanophora diversifolia	leaves	2			
Lecanophora ecristata?	flower parts	1			
Lecanophora heterophylla	leaves			1	1
Lecanophora sp.	flower and fruits	1			
Sphaeralcea miniata	leaves, flowers, buds, fruits tender vines	4		1	4
Sphaeralcea sp.	leaves			1	
Nyctaginaceae					1
Boerhaavia paniculata	leaves, small twigs, seeds, small pieces plants and fruit	2			6
Bougainvillea sp.	--	1			
Bougainvillea spinosa	leaves, flowers, fruits, seeds	1	2	1	
Oleaceae					
Menodora decemfida	pieces of small twigs, seeds			1	2
Polemoniaceae					
Gilia gracilis var.	fruits and seeds		1		
Silia gracilis	pieces of small twigs with fruit, whole capsules and seeds	2			
Portulacaceae					
Portulaca sp.	a small tubercle				1
Ranunculaceae					
Clematis denticulata	leaves			1	
Rhamnaceae					
Condalia microphylla	leaves, fruit	1		5	4
Rosaceae					
Acaena sp.	fruits	1			
Margyricarpus setosus	fruits	1			
Santalaceae					
Arjona sp.	whole small twigs with fruits and seeds		1		
Sapindaceae	seeds				1

Table 5. Cont'd.

Foods	Parts eaten	Number times appeared in crops			
		Spring	Summer	Fall	Winter
Plant					
Solanaceae					
Lycium chilense	leaves, flowers, fruits	1		2	5
Lycium sp.	leaves, flowers, fruits, seeds	19	7	7	7
Nicotiana acuminata	fruits	2			
Solanum euacanthum	seeds	2			
Solanum physalidicalyx	fruits			1	
Solanum sp.	fruit and seeds	1	1	1	
Sterculiaceae					
Ayenia sp.	small twigs with leaves				1
Ulmaceae					
Celtis sp.	fruits, leaves	1			1
Umbelliferae					
Mulinum spinosum	flower parts		1		
Verbenaceae					
Acantholippia seriphioides	tender small twigs				1
Glandularia sp.	pieces of small twigs				1
Glandularia sp.	inflorescence	1			
Lippia turbinata	inflorescence			1	
Pitraea? sp.	flower part			1	
Verbena seriphioides	parts of leaves	1			
Verbena sp.	fruits and seeds	1	1		
Vitaceae					
Vitis vinifera	seeds	3	2	1	1
Zygophyllaceae					
Bulnesia retamo	fruit, flowers, leaves	6		1	2
Bulnesia schickendantzii	fruits	1			2
Bulnesia sp.	fruits				5
Larrea divaricata and *cuneifolia*	fruit, flower buds, seeds, and some leaves	17	3	5	17
Unidentified	fragments of flowers, pods, leaves, fruits, seeds, twigs	14	1	3	

Table 5. Cont'd.

Foods	Parts eaten	Number times appeared in crops			
		Spring	Summer	Fall	Winter
Animal					
Coleoptera	beetles	3	1	3	1
Tenebrionidae	ground beetles	1			
Rhynchophora	snout beetles		1	1	
Hymenoptera	black ants	10	3	4	
Lepidoptera	butterfly chrepolis			1	
Orthoptera					
Acrididae	grasshopper, whole and parts	3	3	7	3
Miscellaneous	small stones, rocks, sand - whole pieces	6			2
	wood - piece		1		
	mammal bones - small piece; 3/4 inches long	1		1	
	paper - pieces	1			1
	bird egg shell - pieces	1			

Figure 31. An extracted lobulated twin-lobed caecum of a crested tinamou, lower left, measures almost five inches in length.

General Habits and Behavior

Movements

Present knowledge of crested tinamou movements does not indicate that they are migratory in any part of their Argentine ranges. They do cover large distances in search of food but once feeds are located in sufficient quantity they appear to live in localized situations where they can be relocated day after day, if not overly disturbed. Walking is their preferred method of movement, in either small groups or fairly large winter flocks. Flying is usually resorted to only when they are approached so suddenly that they cannot run fast enough to elude the pursuers. Their first reaction to an observer is to either stand still, drop closely to the ground or to move away.

Then pursuit must be very rapid to overtake or flush them. Although they appear tame at times, usually the only signs of their actual presence in the more desolate desert areas of Argentina are their tracks. These are found in rock-free or sandy bottoms of washes and arroyos or in flat or alluvial plains over which the birds are fond of feeding. It is not uncommon to find birds, pursue them on the ground, and then not to sight them again as they continue to run ahead through the brush cover. Dogs soon lose their scent in the more arid areas.

Concerning their spring movements, for several years call counts were run over ten-mile strips in Mendoza and San Juan Provinces. During one count some 19 birds were seen scattered along the route near Tunuyun, Mendoza Province, and appeared fairly tame when seen feeding or even dusting along the road edges. However, upon return to this area just a week later only three birds were seen. These were very wild and furtive as they ran into the brush long before our jeep came near them. Closer examination disclosed tire tracks and shotgun shells off the road, indicating that illegal spring shooting had probably decimated their numbers along the road and the remaining few had become very wild. A natural aftermath of this type of harrassment is that crested tinamous become wary very quickly and tend to establish themselves deeper into brush areas for protection.

Crested tinamous prefer brush for their living areas. It is interesting to have observed that although they were seen commonly along roadways, both pavement and dirt, it was extremely rare to find a bird killed by moving cars, trucks or buses. Their tendency to remain along the brushy sides of the road or to cross only occasionally, without flying, tends to keep road deaths to a minimum.

Crested tinamous leave their roosts early in the morning and feed until the sun becomes fairly strong, when they gather around brush or other cover to rest and dust. More movement occurs in middle daylight hours if the weather is cooler. By late afternoon the birds are again moving over the flat areas, washes and arroyos looking for food, this movement lasting to almost dark. In small groups or large, the size depending upon the season of the year, the birds roost in open areas until the following morning.

Flight

Crested tinamous fly directly, less vigorously and more slowly than pheasants, but often times take off with so little noise that distance can be placed very quickly between them and their pursuer. At close distances the noise created by beating wings or occasionally a soft call of fright is all that can be heard. Flights, depending upon the wariness of the birds, may be 100 feet or more and may continue from short distances to more than 300 yards. After either short or long flights the birds are difficult to relocate. They do not "tower" but take off and fly low, not wavering in their direction unless tall brush or trees are in their path when they may swerve upward or around these obstacles. In flight they tend to beat the wings rapidly every 20 to 30 meters, as described by Godoy (1963). Liebermann (1936) notes that crested tinamous are excellent walkers and that flight is unusual.

Once airborne this tinamou flies much better and further than one would normally expect. Gardiner Bump reports that in La Pampa Province six birds, after being followed for about a mile with a jeep, flushed and flew 1200 feet to thick weeds 20 inches high. In a series of flights caused by dragging a rope over fallow fields one crested tinamou flew 1000, 500, 60 and 65 feet in four flushes for a grand total of 1625 feet. All of these flights began at least 130 feet in front of the dragged rope.

Wariness

Hunting makes crested tinamous extremely wary and although in some provinces of Argentina they are pursued throughout the year, they manage to persist today because of this wariness in a habitat that is utilized to the utmost in hiding from their enemies. During the breeding season they are not overly wary but upon being approached closely by a horse or vehicle any bird seen along a road will do one of the following: stand very erect, ready to move into the closest cover; walk half-way behind the nearest weed or bush and peer around the cover; flatten itself on the ground where it blends well with the soil and cover, or bow its head abruptly out and downward almost to its feet, often walking or slinking away or running low through the brush.

With the many male calls given only during the breeding period it would appear easy, at first thought, to catch sight of or to flush these birds by rushing or slow stalking. Wetmore (1926) indicated that he was able by careful stalking to work close to whistling males but that he seldom saw them. Near El Maiten, Chubut Province, the author with a Labrador retriever tried unsuccessfully to collect males which were calling from several grassy areas near a river. None were seen nor flushed, following persistent crisscrossing of the area, and the calling resumed within 30 minutes of our leaving the immediate vicinity. This indicated the birds had not left but that their odor had simply eluded the dog. In collecting eggs from a nest near Matagusanos, San Juan Province, we found the male had sneaked away as we approached and, although he did not flush far, a search with the dog did not again locate him. Young birds of the year are not as wary as adults but travelling with the male parent and later in larger groups with more adults soon teaches them traits that have allowed the crested tinamou to persist so well over the years in Argentina.

Resting and Roosting

The hours of full sunshine, usually after 8:30 a.m. until about 3:30 to 4:30 p.m., are spent in the shade. Any of the brush or taller grasses can provide cover under which the birds rest and often dig a dust bowl. Figure 37 illustrates a dust or roost bowl near a desert bush. Birds dusting in these bowls use their wings and feet, often rapidly turning right and left in order to stir up dust which rises through their feathers. Dirt is also thrown over the shoulders by use of the bill.

During rest periods crested tinamous often sun themselves for short periods and then retire again to the shade. If very warm they may spread and droop their wings and settle to the ground, resting on the tarsi. One method of sunning is shown in figure 33 while another common position is to lay on the side with the uppermost wing raised and extended to expose the flank. This is the same position used in taking rain baths during showers. Thomson (1964) describes pigeons as taking rain and sun baths in the above posture.

Figure 32. Rocky but sandy areas in the desert of San Juan Province provide easy digging for crested tinamou dust or roost bowls.

In our Mendoza pens the large brushland tinamou, Nothoprocta cinerascens, also used this position for sunning and was especially enthusiastic in taking a rain bath, assuming this same posture. Pale spotted and canyon tinamous also readily took sun and rain baths in Mendoza pens.

Crested tinamous are ground-roosting birds. In our Southwest game birds do not dig roost bowls but roost on top of the ground or in low bushes or trees where they are exposed to the night temperatures. Digging a roost bowl each night protects crested tinamous from coldness and winds that blow habitually in desert ranges of western Argentina. In Patagonia crested tinamou roosts were usually found on the north side of low brush or grass clumps, apparently for protection against cold southern Antarctic winds which blow both day and night.

The roost bowl is dug separately by each crested tinamou with its feet, the body moving constantly in a circling motion as the feet kick the dirt to the edges to form a bowl. In the wild, new roost bowls usually are dug every night, with 10 to 20 bowls occasionally in close proximity to each other. These are placed in the open on flats, on low ridges, or, more rarely, on lower hillside edges. Figure 34 shows a typical roost bowl photographed at night with an adult roosting low in the bowl. In the breeding season the male nightly digs a roost bowl into which the young chicks can

Figure 33. When taking sun and rain baths the wing commonly is fully raised, exposing the under surface and flanks.

crawl to be protected by him. When they become too large for him to cover all of them some may seek cover under the female, at least in a penned situation.

Earlier mentioned was the fact that the droppings of the crested tinamou, shown in figure 35 , were normally strong or foul smelling. Perhaps for this reason the bird in the wild has learned not to leave droppings at the edge of its roost bowls as do other tinamou species of Argentina. Several droppings are deposited each night at the rear of shallow roost bowls of other genera of tinamou and these roosts are sometimes used again. Never was one dropping of the crested tinamous found in their wild roost bowls. The odor of a dropping would almost surely attract a night predator such as the Argentine fox but the birds apparently reserve their defecation for an area away from the bowl after leaving the roost in the mornings. The same holds true with the nest bowl, the male usually defecating after he leaves in the morning for feeding.

Figure 34. In the wild, crested tinamous nightly dig a separate roost bowl in relatively open brush-free areas.

Breeding

Some tinamous, such as Nothoprocta ornata, live in pairs, as noted by Pearson (1955). It appears that a combination of polyandry and polygyny may exist in the tinamous as a whole. Polyandry describes best the sexual relationship between the female crested tinamou and two or more males, the latter sex solely incubating, brooding and caring for the young. Males set up calling areas where they dig a nest bowl and females in sex packs of 2 or 3 birds visit the calling male for breeding and laying of eggs in his nest. Following laying of the clutch, females leave the male to tend the nest. Some female birds have been found in close range of incubating males, the meaning of their presence not being closely studied.

Thomson (1964) notes that polyandry is rare among birds and few detailed field studies of polyandrous species have been made. Polyandrous breeding habits of the crested tinamous are similar to the Argentine rhea, a flightless ratite.

Approaching the breeding season and in the early stages of nesting, females issue sharp whistle calls, often in answer to already whistling males who have begun to set up their individual territories. Both sexes

Figure 35. Typically large and usually strong smelling droppings of the crested tinamous. These measure one to two inches in length.

have distinctive whistles which in early contacts end in a duet of calling. Early meetings of the two sexes quickly establish the females as the dominant sex, controlling the males through various methods of intimidation. Although at first aggressive, males once intimidated by a dominant female often drop to the ground with their bills touching the earth. This submissive display is brought about by the female's aggressive attitude, a very erect body stance coupled with strong guttural calls and widely-flaired crest feathers as shown in figure 36. Behavior of a more belligerent nature is to wing-flail a closely-approaching male.

The male may have the nest dug before females arrive or it may be constructed after various forms of stimulation. These include the duet calling along with a form of dusting face to face. In this display the female often sets the stage by flitting and dashing about on the ground, ending in a shallowly-made bowl where she turns back and forth, deepening the bowl. All this time the male may be watching or digging in another nearby bowl. He may move into the female's bowl as she leaves, to then continue digging. Shortly after this type of stimulative bowl-digging the male, with or without female assistance, selects the nest bowl, digging in it each day. The female may fit her body into the nest on occasions; the next step is copulation and egg laying.

Figure 36. Adult female crested tinamou intimidates a male bird giving guttural calls as she flares her crest feathers.

As females become receptive the stage is set for copulation. Then the male appears to display more aggressiveness, the female, less dominance. Seeking to copulate with the female, the male will approach closely, ringing the female in tight circles as he rapidly moves around her, his body in an extremely erect position. All during this close circling the male issues a high-pitched twittering call. Should the female attempt to run the male will often grab her by the neck or wing with his bill and spin her around. When the female is ready for copulation she drops to the ground with quivering wings, following which the male mounts her back and in a matter of seconds, preceeded by his treading, copulation is completed. The female remains low to the ground and gives low, nasal-like calls every few seconds. These are very similar to those given by her as she leaves the nest following laying of an egg.

Under penned conditions copulation was most often observed in the late afternoons but also occurred during midday to a limited extent. Pereira (1928) reported that wild-captured young placed on a game farm were ready to breed at 8 months and laid eggs at 9½ months of age.

Nesting

The nesting season of crested tinamous is reported as from September into March for Argentina (Liebermann, 1936). Our observations indicated that the highest number of nests hatched in late November, December and January. Some males and females begin the breeding cycle earlier than the main group and have nests as early as September. These may be well before any spring or summer rains occur. In table 6 is projected the nesting season phenology of crested tinamous in Mendoza and San Juan Provinces, the earliest beginning incubation on October 23 and the latest on January 22. These nests were located at elevations from 2300 to 4500 feet.

Table 3. The nesting season phenology for crested tinamous, Eudromia elegans ssp., in the wild, with clutch sizes and nest locations, in Mendoza and San Juan Provinces.

Subspecies	Date nest found	No. eggs	Estimated start of incubation in the wild[a]	Nest location
E. e. albida	10-25-65	6	10-23	--
	11-6-65	5	11-5	Under Larrea divaricata
	11-23-65	6	--	Cactus area
	11-25-65	5	11-21	Among Larrea cuneifolia, Opuntia
	11-25-65	4	11-23	Under Larrea cuneifolia
	12-19-65	5	No hatch	Under Larrea divaricata, Opuntia
	12-19-65	6	12-14	Under Larrea divaricata
	12-30-65	4	12-27	Under Larrea sp. bush
	12-30-65	5	12-24	Under Larrea sp. bush
	12-30-65	6	12-19	Under Larrea sp. bush
	2-5-66	4	1-22	--
E. e. elegans	11-4-65	6	10-27	--
	11-14-65	12	--	In agricultural field, weeds, Larrea
	11-14-65	7	--	In agricultural field, weeds, Larrea
	11-19-65	7	11-8	Between 2 Suaeda plants
	11-19-65	6	11-6	Near Geoffroea decorticans tree
	11-19-65	4	No hatch	Under Suaeda bush
	11-30-65	6	11-19	Larrea divaricata, other legume bush
	12-9-65	8	12-6	--
	12-12-65	6	--	--
	12-12-65	7	--	--

[a] Back-dated 21 days from hatch to obtain estimated start of field incubation.

Field assistant Rumboll reported from La Pampa four nests with eggs or hatching between January 10 and January 30, while other nests with eggs were found in November and December. On November 13 Bohl collected two young from a brood of five in eastern La Pampa Province that were estimated to be almost three weeks old, which would have them hatching the last week in October.

Considering further the nesting success of crested tinamous, table 5 lists the gonadal development of three subspecies of crested tinamous collected from various Provinces of Argentina. Male and female gonads show their largest measurements from September through February for San Juan, Mendoza, San Luis, Neuquen and Rio Negro Provinces, which coincides well with the nest hatching dates projected in table 4.

In western Chubut Province a male collected November 9 had gonadal development of 29x24 mm. of the right testis and left testis 34x20mm., which indicated an advanced breeding stage comparable at that date to tinamous in more northern Provinces. One female collected with this same male had the largest egg measuring 30 mm. in diameter which again indicated she was at or very near the laying stage. Crested tinamous collected in eastern La Pampa on November 12 and 13 had, for both males and females, gonadal measurements indicating the birds were actively breeding. Two females collected had almost completely formed eggs, with shell layers forming in the oviduct. During the active breeding periods male crested tinamous have a penis-like projection measuring close to 10 mm. in length.

The greater proportion of nests were found after spring rains had started but some birds began nesting before spring or summer rains occurred. Near Desaguadero, Mendoza Province, no spring rain had yet fallen in November when three nests were observed just as the first rain and hail storm began. One nest was collected for its eggs before the storm, and the other two were deserted by males in late incubation.

One of these nests was watched for 40 minutes from a distance of 30 feet while hail fell for 20 minutes followed by 20 minutes of heavy rain. During this time the male attempted to protect the eggs and continue incubation, but he finally left the nest, noticeably water soaked and appearing stunned by the hail. Inside the nest bowl the five eggs were floating in water along with some hail. These eggs were collected and all hatched after three days in our Mendoza incubator but all chicks subsequently died, possibly due to the exposure to cold water and hail.

Nests are usually placed under low bushes, grass clumps or weeds and sometimes have been found among exposed tree roots at the base of trees. Eleven of 21 nests noted in table 4 from arid and semiarid Argentine Provinces were associated with creosote bush, Larrea spp. While grass cover was scarce in the more arid ranges, nests in the higher rainfall areas of the pampas grasslands in La Pampa and Buenos Aires Provinces were more often reported under grass clumps, weeds and brush. Bump and Rumboll reported 11 of 16 nests found in La Pampa Province were under semiarid desert brush. All locations of crested tinamou nests in San Juan Province were under creosote bushes. Another nest location is shown in figure 37 under retamo (Bulnesia retamo). Figure 38 shows a male crested tinamou elegans, on its nest,

Table 5. Gonadal development of crested tinamous in relation to the nesting seasons for Eudromia e. albida, elegans and devia.

Males

Province	Date collected	Weight in grams	Gonadal Development: Right testis Size (mm.)	Right testis Weight (gr.)	Left testis Size (mm.)	Left testis Weight (gr.)
Mendoza	Aug. 3, 1966	731	14x6.5	--	--	--
Mendoza	Aug. 3, 1966	---	13x7	--	--	--
Mendoza	Aug. 3, 1966	783	12x6	--	10x5	--
Mendoza	Aug. 3, 1966	742	12x6	--	10x5	--
San Luis	Aug. 17, 1965	714	12x10	--	10x9	--
San Juan	Sept. 14, 1965	680	26x16	2.85	24x13	2.10
Mendoza	Sept. 16, 1964	---	13x4	--	--	--
San Juan	Sept. 22, 1964	---	20x13	--	19x17	--
Mendoza	Sept. 30, 1965	678	29x18	2.90	29x22	2.85
San Juan	Oct. 7, 1965	656	15x23	2.40	14x28	2.50
Mendoza	Oct. 12, 1964	603	20x12	--	15x8	--
Mendoza	Oct. 13, 1966	704	22x18	--	--	--
Mendoza	Nov. 1, 1964	581	27x17	--	23x16	--
Neuquen	Nov.11, 1966	633	32x19	--	30x18	--
Neuquen	Nov. 12, 1966	769	34x23	--	33x20	--
Rio Negro	Nov. 12, 1966	654	31x21	--	31x19	--
Mendoza	Nov. 14, 1964	671	32x17	4.50	26x17	--
San Juan	Nov. 16, 1966	699	28x20	--	27x18	--
San Juan	Nov. 19, 1965	655	28x19	3.20	30x19	3.00
Mendoza	Nov. 19, 1964	699	28x19	4.00	22x18	3.00
Mendoza	Nov. 19, 1964	---	--	--	28x19	4.50
San Luis	Nov. 21, 1964	648	38x21	6.00	36x21	5.00
San Luis	Nov. 21, 1964	528	21x14	1.00	--	--
San Juan	Nov. 23, 1964	618	30x17	3.50	26x15	2.00
San Luis	Dec. 12, 1965	299 (juv.)	5x3	0.05	5x3	0.05
Mendoza	Jan. 6, 1965	550	25x17	3.50	21x18	3.00
Mendoza	Jan. 7, 1965	626	29x18	4.00	25x17	3.00
Mendoza	Jan. 7, 1965	564	22x16	2.00	21x18	2.00
Mendoza	Jan. 14, 1965	642	14x9	0.50	14x8.5	0.50
Mendoza	Feb. 12, 1965	822	16x9	--	12x8	--

Females

Province	Date collected	Weight in grams	Ova diameters largest first[a]
Mendoza	Aug. 3, 1966	648	4 mm. largest
Mendoza	Aug. 3, 1966	763	5 mm. largest
Mendoza	Aug. 3, 1966	594	2.5 to 2.75 mm.
Mendoza	Aug. 3, 1966	738	3 mm.
Mendoza	Aug. 3, 1966	675	3.5 mm.
Mendoza	Aug. 3, 1966	681	2-3 mm.

(a) Numbers in parentheses indicate number of ova of a particular size.

Table 5. Cont'd.

Females

Province	Date collected	Weight in grams	Ova diameters, largest first
San Luis	Aug. 17, 1965	768	5 and 4 mm.
Mendoza	Sept. 16, 1964	---	2-3 mm., 1 mm. or less (75 plus)
Mendoza	Sept. 16, 1964	---	1.5 mm., little follicle development
Mendoza	Sept. 18, 1965	675	4 mm. (3), oviduct diameter 5-6 mm.
San Juan	Sept. 22, 1965	727	6 mm., 5 mm. (4), others smaller
Mendoza	Sept. 27, 1964	---	4 mm. (2), egg tract enlarging
Mendoza	Sept. 27, 1964	---	4 mm. (2), 3 mm. (4), egg tract white, enlarged
Mendoza	Sept. 30, 1965	792	30 mm., others 9, 5 and 3 mm. and less
Mendoza	Sept. 30, 1965	705	31 mm. (2), 22 mm., 13 mm., oviduct 15 mm. diameter one inch from opening.
Mendoza	Sept. 30, 1965	758	20 mm., others 8, 7 and 5 mm.
Mendoza	Oct. 13, 1966	711	16 mm., 7 mm., 6 mm (2), 3-4 mm. (9)
San Juan	Oct. 13, 1966	779	shot up; oviduct very large
San Juan	Oct. 13, 1966	---	23 and 12 mm.
San Juan	Oct. 18, 1966	722	4 mm.
San Juan	Oct. 18, 1966	796	broken egg shell in cloaca
Neuquen	Nov. 12, 1966	809	19 mm., no shell formed
Rio Negro	Nov. 12, 1966	671	16 and 10 mm.
Mendoza	Nov. 14, 1964	602	6 mm. (2), 5 mm. (2), 4 mm. (3 plus), 25 mm. egg w/o shell in tract
San Juan	Nov. 19, 1965	700	22, 10 and 8 mm.
San Luis	Nov. 21, 1964	835	egg in cloacal opening
San Luis	Nov. 21, 1964	754	20 mm. and less, laying
San Luis	Nov. 21, 1964	661	egg extruded from tract
Mendoza	Mar. 20, 1965	715	1 mm.
Mendoza	Mar. 20, 1965	748	2 mm. largest; 95% smaller
Mendoza	May 5, 1966	638	small follicles
San Juan	May 17, 1965	---	3 mm. (2)

among weeds of a fallow field. Some feathers, twigs or other dry material are usually pulled into the nest by males as well as females, the latter doing so during egg laying.

A shallow bowl is dug, using the feet and turning the body to kick the dirt up and out to the bowl edge. Males usually dig the next bowl while females will inspect and fit their bodies into it on occasion. Nests were located in wash bottoms, in raised areas of broken terrain such as the edges of arroyos, or in nearby flat areas wherever suitable plant cover existed. There does not seem to be any relationship of nest placement to edge of habitat, with nests being found widely scattered or sometimes two in close proximity to each other. Soil textures were usually sandy or desert pavement while some nests were placed in harder-packed alkaline areas.

Renesting can be expected to occur whenever the first nest is lost and it is also possible, in view of the extended nesting season, that early nesting males might have a second nesting even though one nest would seem normal for crested tinamous. In table 5, concerning the gonadal development of crested tinamous in relation to their nesting seasons, it appears that sexual development for both males and females is optimum for breeding by late September, while active egg laying and incubation occurs after mid-October for the earliest nesters. The gonads continue in an active breeding condition until about mid-January. There is some sporadic nesting before late September and after January but in general the main nesting period occurs between these two months. Nests later than January can often be attributed to a second nesting attempt where the first nest was destroyed or first young have been lost.

While it was not uncommon for crested tinamou males to have two or three separate nestings under penned conditions this involved removing the young after four weeks of age so that the male did not have to brood them longer. In the wild, males with young hatched after late October each year appeared inclined to take care of these birds for a considerable period of time extending into at least late January. The tenure of this care would then normally prevent a second complete nesting during the nesting periods. Future specific wild nesting studies may modify our present knowledge concerning crested tinamous having two broods or less each year.

Figure 37. A crested tinamou nest under a retamo bush in arid San Juan Province.

Attempts at renesting occur when nest young die or when nests are destroyed by various means. These could include plowing by tractors, eating of eggs by wood-workers or villagers, taking of eggs for hatching, taking of eggs for selling, cloudbursts of rain and hail that destroy nests which are unprotected by brush or grass, or when young die from extreme drought conditions or other causes early in the brooding period.

In summary, the bulk of young crested tinamous are hatched in late November, December and January in Argentina. At higher elevations, from 2000 feet to 5000 feet, there appeared to be a delay of nesting from two to three weeks as compared to nesting areas nearer sea level as found in La Pampa, Buenos Aires, Rio Negro and Chubut Provinces, especially where they border on the Atlantic Ocean.

The nine genera of tinamous (Hellmayr and Conover, 1942) lay eggs with porcelain-like surfaces as if heavily glazed or polished, with colors ranging from light brown and reddish brown-pink to purple, dark bluish green, light yellowish green, gray or almost black. Each species has its

own distinctive color. Crested tinamou eggs are an apple green color, lustrous, thin shelled and without spots. They are considered to be among the most beautifully colored of bird eggs.

Table 6 presents the size, weight, shape and color of eggs of two subspecies of Eudromia elegans , comparing eggs found in wild nests to those handled by FGIP personnel from pens in Mendoza. In size, crested tinamou eggs are significantly larger than those of the Chinese ring-necked pheasant, although the latter is a larger bird.

Sizes of wild and game farm eggs averaged 53.4 x 38.0 mm. and weights of unincubated eggs ranged from 32 to 52 grams. Eggs are oval and slightly pointed at both ends. Under game farm conditions a female crested tinamou may lay 30 to 40 eggs during the season. Nevada Fish and Game propagation records for 1967 indicated the 21 crested tinajou sent them by the FGIP laid an average of 34.6 eggs per hen.

Figure 38. In a fallow agricultural field this male incubates twelve eggs, Campo Los Andes, 4500 feet elevation.

Table 6. Size, shape, weight and color of eggs from two subspecies of the crested tinamou (Eudromia) group.

Items	Subspecies			
	Eudromia elegans albida		Eudromia elegans elegans	
	Wild nests (a)	Pen nests (b)	Wild nests (c)	Pen nests (d)
Size				
Average	53.4 x 39.0 mm.	51.1 x 38.3 mm.	52.3 x 40.0 mm.	51.1 x 38.0 mm.
Largest	63.0 x 42.0 mm.	56.0 x 39.0 mm.	56.0 x 43.0 mm.	59.0 x 39.0 mm.
Smallest	46.0 x 35.0 mm.	35.0 x 41.0 mm.	50.0 x 39.0 mm.	45.0 x 36.0 mm.
Weight	32.0 to 58.0 grams	32.8 to 50.3 grams	---	32.0 to 52.0 grams
Shape	Oval, slightly pointed both ends		Same as albida	Same as albida
Color	Lustrous apple-green		Same as albida except slightly darker tone.	

(a) Size of eggs based on 47 eggs from 10 wild nests; weight, on 36 eggs from 7 wild nests.
(b) 220 eggs.
(c) 12 eggs from 2 wild nests.
(d) 206 eggs.

No difficulties were encountered shipping Argentine crested tinamous at the end of their laying season south of the equator to the United States where they began a second nesting season within a month. One female from Mendoza pens laid a total of 40 eggs before shipment to Nevada and on their game farm during the breeding period laid another 44 eggs for a total of 84 eggs in less than one year's time.

Incubation by males takes from 20 to 21 days in the wild while artificial incubator conditions at higher temperatures may induce the eggs to hatch in 19 days.

With adequate brushy nesting cover, crested tinamou males can consistently raise two or three broods annually under game farm conditions. Males sit very tight on the nest; they can often be lifted off pen nests and will return quickly to continue incubation.

That two females lay in one nest is evident at times in the field, the eggs of one hen contrasting with the other by size or coloration. Pereyra (1928) says usually 9 to 11 eggs comprise the completed clutch; FGIP research in the field disclosed the average-sized clutch ranged from five to seven eggs per nest (table 4). Eleven E. e. albida nests collected in arid parts of San Juan Province averaged 5.1 eggs; while nine Mendoza Province wild nests located in semiarid habitats averaged 6.3 eggs. Another Mendoza Province nest contained 12 eggs. For 13 nests tallied by Bump and Rumboll in La Pampa Province, the average was 6.0 per clutch. Those nests with more than 6 eggs per clutch may be the laying of two or more females, while those with 6 eggs or less have been seen to be the laying of one or two females. Figure 39 illustrates a typical-sized clutch in the wild, this one with five eggs. Figure 40 illustrates color differences between the eggs laid by two subspecies of crested tinamous and a comparison in size with smaller California quail eggs which were collected in Chile.

Eggs in wild nests are laid usually in the early morning hours by one or two hens. Under our experimental propagation unit conditions a lesser but sizeable portion of eggs were laid in the late afternoon from 4:30 to 6:00 p.m. Nevada Fish and Game Department personnel reported that crested tinamous laid many eggs in the mornings and these had to be picked up early in the day or they were ruined by exposure to the desert sun.

Figure 39. Five to seven eggs comprise an average-sized clutch for crested tinamous.

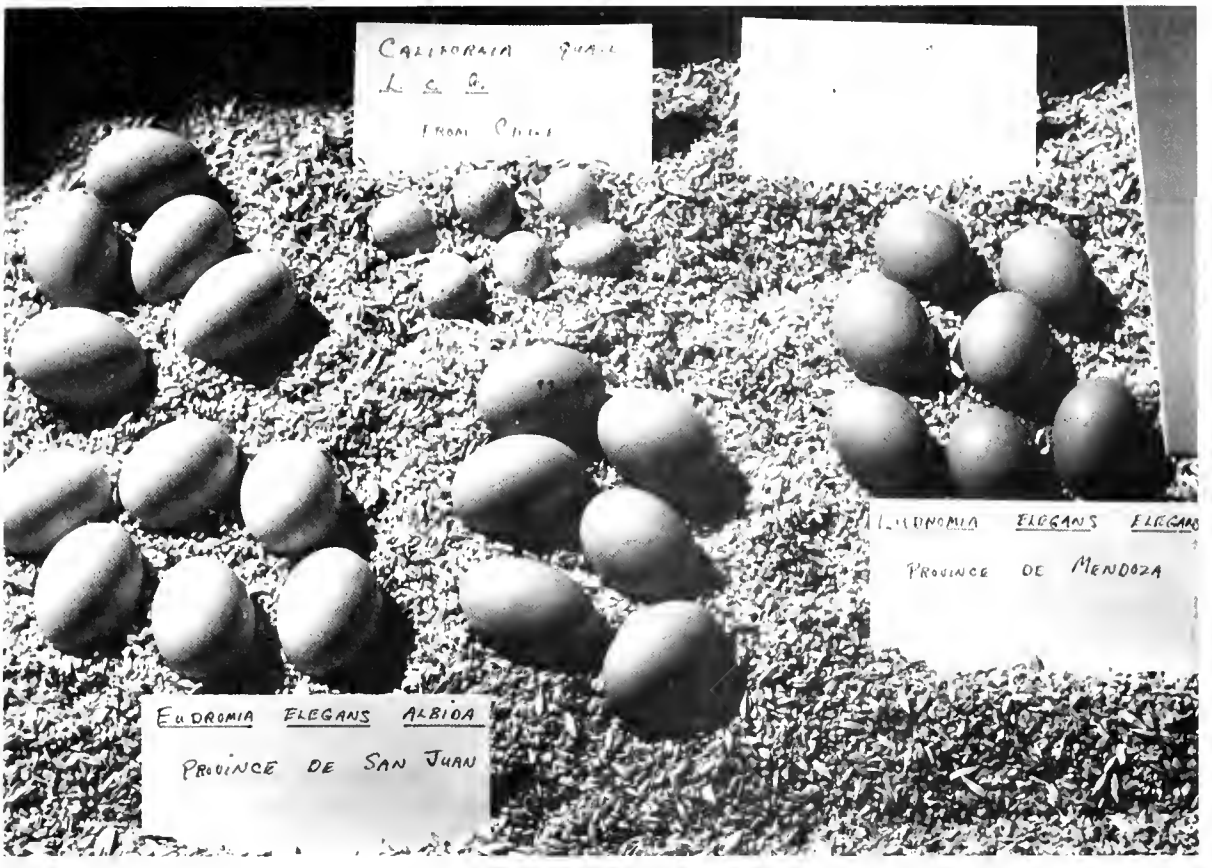


Figure 40. Crested tinamou eggs from arid San Juan Province typically are lighter colored than those from semiarid Mendoza Province.

Upon leaving the nest with its freshly laid egg, the female will issue low calls (not whistles) from a half-stooped position, at the same time placing or throwing twigs, feathers, or leaves back over her shoulders into or towards the nest to partially cover the eggs. This female action appears to be a stimulant for the male to begin incubation. Prior to actual incubation the male duplicates her behavior by also adding dry material to the nest and eggs.

Both sexes roll the eggs with their bills, sometimes moving them several inches out of the nest, in apparent efforts to stimulate one another during the early part of the nesting cycle. Few eggs are seen far from the nest in the wild but eggs laid under domestic conditions often are moved more than several feet, some of which are not rolled back to the nest. Egg rolling occurs more at the beginning of the nesting season than in the middle or later periods.

Based upon pen observations, crested tinamou males usually begin incubation after five or six eggs are laid. With two females laying in one nest, a clutch of six eggs can be completed in about five days' time. Should a male attempt to begin incubation before the clutch is completed the females may threaten and haze him away from the nest. Only the male incubates the eggs,

turning the eggs with his bill and settling his body close onto the eggs with rapid gentle movements of his legs. A brood patch appears during incubation and the male continually carries or pulls feathers, twigs, or leaves to the nest edge, covering the eggs lightly when he is off for feeding.

Rearing

The male broods the young, which are able to leave the nest as soon as they are dry. During sunny periods the young remain close at the male's side or periodically burrow under his wings to seek body warmth. In cold or rainy periods the young remain under the male and at night are found in the roost bowl, again under the protective cover of the male's body and feathers. Of several broods seen in the wild, only one adult bird was ever flushed with the young, this bird trying to decoy the observeraway much the same as penned males tried to lead personnel away from their young. In general the penned females paid little attention to the young, while the male was continually alert in caring for his brood.

Males are active in attempting to protect their young and they warn them of approaching danger by various calls or by fluttering off the ground with beating wings in low flight simulating a "cripple", attempting to lead intruders away. During this fluttering the young, if unable to fly, scamper for the nearest cover and are very difficult to locate with their protective ground coloration. Wetmore (1926) noted that the young lay motionless with heads outstretched but, unlike young gallinaceous birds, slipped away to one side, when opportunity offered, to a new hiding place.

After 8 to 10 days the young are able to fly short distances. They are fully feathered and capable of independence by three to four months of age. Young remain with the male until the fall flocking occurs.

Water availability is poor over much of the crested tinamou ranges and it was earlier noted by Wetmore (1926) that perhaps some of their moisture needs were met by the young eating the droppings of the adult. None of the three young taken by the FGIP had droppings in their crops but all were taken from a fairly high rainfall area in La Pampa or San Luis Provinces. It is interesting to observe that over the ranges where the most detailed field work was conducted only two droppings were ever found, none from the desert areas. Where other tinamou genera occur in Argentina it is not difficult to find their droppings, particularly those located in the roost bowls. Young crested tinamous, like adults, do not leave any droppings in their roost or dust bowls.

Gregariousness

Flocking is common during the winter months, with Wetmore (1926) reporting scattered individuals as common but that it was not rare to see flocks of 30, 40 or even 100 banded together. Prior to 1935, Liebermann (1936) reported seeing in Buenos Aires Province groups of more than 1000 crested tinamous. Nothing like this occurs today, with the increased hunting pressure and perhaps changes in land use practices of this Province. Observations by FGIP personnel of winter flocking during 1964 to 1967 in areas similar to those covered by Wetmore did not disclose flocks anywhere approaching the numbers he reported over forty years ago. Today it is more

common to see small groups of 15 to 20 from Patagonia to San Luis Province, while further north and west in more arid habitats 4 to 18 often are observed.

The breeding season is preceeded by the breaking up of winter flocks. After the eggs are deposited the females leave the males to assume the role of rearing the young. Young and adult males join other groups and females during the winter period in a continuing cycle.

Temperament

Observations in the wild and under penned study conditions indicate that crested tinamous are alert, curious and sometimes shy. When hunted these birds tend to become very wild and often walk, run or fly to a distance at the slightest disturbance in their habitat. Except for the two main feeding periods each day crested tinamous are more likely to be heard than seen since they move about only slightly in their brushy localities and move into the brush if closely sought out. They readily adapt to confinement so that Argentines in general prefer to rear them than the more shy and retiring tinamous of other genera, except perhaps for the red-winged tinamou.

Given proper isolation and cover under penned conditions, the crested tinamous retain their natural wildness. Except for the red-winged tinamous the cresteds are the only tinamous to consistently rear two or three broods yearly under penned conditions and have both adults and young remain wild.

The birds will quickly retire behind brush or grass at the rear of the pens if given suitable escape cover. Crested tinamous can be caught easily with nets and handling them poses no problem when the legs are grasped firmly and a hand laid over their wings. When released, birds remain alert and run behind the nearest cover. While hand-reared birds are not overly nervous and appear highly adaptable to penned confinement, wild-trapped adults under penned conditions are extremely nervous and flush wildly in the pen if care is not taken to enter slowly.

Depending upon the season, females are likely to be more agitated about nearby calling crested tinamous than the males. Throughout confinement females are more nervous and more aggressive than males. Young are guided by the male's protective behavior, with females paying little attention to their needs under penned conditions.

Calls

Crested tinamous are more often heard than seen. They use calls extensively in communicating with one another, since their wooded or grassy habitats provide limited vision. Certainly they are the loudest and most vociferous of all tinamous in Argentina and Chile, whether in flocks during pre-breeding months or isolated in their territories in the breeding period. Only during late fall and winter months is calling reduced substantially to limited periods of daylight. Calling occurs in all types of weather including snowstorms, rainfall, sunshine and wind. Little calling occurs under penned conditions unless birds are separated into pairs or singles. Birds

flock mated in pens in groups of 10 to 20 birds call infrequently compared to small isolated numbers of birds. Generally, females issue sharp whistle calls early in the breeding season, distinct from male calls, after which males setting up their territories call much more than females.

Breeding calls begin considerably in advance of the main nesting season. Some calling can be heard by mid-July, which is the middle of winter in Argentina, followed by increased calling in August. To a great extent, birds are still in flocks from July to September. The most active calling is in September, October and November, with September probably having the largest amount of calling of all months. Territories are being set up in earnest by October. Calls diminish from December through February, the reasons for this being that males do not use the breeding call after incubation begins and when they are with young. Last calling is heard about March or April of each year.

Orientation calls do continue between the end of breeding calls and July, but for the most part the birds are silent in the main daylight hours of these months. Crested tinamous have developed a habit of early morning and late evening calling that apparently orients themselves with other groups roosting nearby. Unless one is in the field listening during the early light period or the last light when the sky has lost 95 percent of its illumination the crested tinamou whistle calls are seldom heard. Calling is for a duration of less than 15 minutes at night; some calling is heard almost to the last minute of light, after which silence prevails until the birds start to leave their roosts in the early morning. A typical example of this orientation calling was recorded on July 7, when straight whistle calls were heard near the evening. These calls occurred at 5:50 p.m., 6:00 p.m., 6:23 p.m., and 6:24 p.m., after which there was silence.

Under penned conditions, calls offered the best means of differentiating between sexes of the crested tinamous, after cloacal sexing had been accomplished. Once the repertoire of calls was categorized, through direct observation of color-banded males and females and tape-recording of calls with verbal description of each, it was possible to proceed into the field where the sexes could be distinguished on the basis of certain distinctive calls. Although our studies indicated otherwise, some early researchers noted that whistle calls were not characteristic of crested tinamous and that their calls are easily confused with other perdices (de Costa, 1953). Another (Pereyra, 1928) stated that the call is a very loud whistle "fuiii". The latter description probably is of the male bird which we chose to label the whistle-warble call. Calls vary between different birds within the subspecies and it has been tentatively determined that calls also differ between some of the various subspecies scattered widely over Argentina.

Of their wide variety of calls, major ones include guttural, pumping, sharp whistles, nasal or foghorn-like, whistle-warbles, twittering, cat meowing or whining types. They also have sharp warning calls, often given with head bobbing. All of these calls are difficult to hear at a distance beyond 10 feet to 30 yards, except the sharp whistles and whistle-warble calls.

Females use the guttural, pumping, nasal and whistle calls, during the breeding period in particular, although the first two types are also given throughout the year as they exhibit their dominance or irritation toward

other calling females or males. Separate loud, sharp whistles, each lasting about one second or less and continuing rather steadily over a minute or more of time, are characteristic of females in the breeding season. One female called 25 times in a minute and a half, another 16 times in one minute 10 seconds, each call spaced about five seconds apart. This same distinctive female whistle often turns into a duet when the male answers, almost simultaneously, with a lower-toned short call. These female whistles sound much like a person whistling to a friend or a dog to obtain his attention. Nasal calls last 2 to 3 seconds and may be given in any number, depending upon the amount of irritation. They have been heard at least 14 times in a row. Usually they are followed by pumping calls in further demonstration of irritation to nearby birds.

Guttural calls earlier noted are given by females with crests flared widely, the bird standing very tall and erect, and usually directed toward males to intimidate them. These calls may be given to drive a male away from feed, to prevent a male from approaching closely for copulation or to haze a male from freshly-laid eggs and thus prevent him from incubating until the clutch is completed. Foghorn or nasal calls are used by females in pre-breeding situations when they are dusting and facing males who are also dusting, immediately after laying an egg, or when leaving the nest following the laying of an egg. After laying an egg the female leaves the nest in a half crouch, giving this call and at the same time picking up and throwing or placing twigs, feathers, leaves or other dry material over her shoulders into or towards the bowl. One other situation when the female gave this call was while the male silently dug the nest bowl.

Males have a distinctive breeding season call which can be described as a whistle at the start, followed almost immediately by a warble as they break away from the whistles. Females have never been heard to break into the warble portion of this call so these distinctly male calls are easily distinguished in the field. These whistle-warble calls are the most persistent of all male calls and are to be heard in the field during the breeding season over the entire ranges of these birds. They are used to attract females to male territories and are given throughout the day as well as into the night when the moon is out. They are also given from the roost bowl in the early morning hours by particularly ardent males. One male called 11 times from his roost in December on a moonless night between 3:40 a.m. and 4:30 a.m.

Male whistle-warble calls are most frequent in the early morning, the first hour after sunrise, somewhat tapering off through the heat of the day. Some idea of the sequence or rhythm of calling by males in the breeding season may be shown by an observation during early November, temperature 78° F., in San Juan Province when calling from 12:28 p.m. to 1 p.m. resulted in 17 calls in 32 minutes. Similar calling of penned birds in Mendoza Province but from early morning until early afternoon disclosed the following individual male call rhythm: 5 a.m. to 6 a.m. - 11 calls in one hour; 9:20 a.m. to 9:30 a.m. - 9 calls in 10 minutes; 11:45 a.m. to 11:56 a.m. - 9 calls in 11 minutes and 12:51 p.m. to 2:55 a.m. - 18 calls in 64 minutes. This last sequence was made by a male on November 5, 1964 and on November 23 he began incubation of five eggs and did not call again nor did the female confined in the same pen.

Daily maximum and minimum temperatures collected in the Mendoza pen studies from February 1966 to February 1967 were compared to calling rhythms tallied throughout this same period. These records indicated that males do not begin serious whistle-warble calling until the daily minimum temperatures average above 40° F. and daily maximums above 74° F. These temperatures occurred in Mendoza after September 7 in this test year.

The following sequences of daily breeding calls of crested tinamous in two areas of high population:

Campo Los Andes, Mendoza Province, elevation 3300 feet, November 14, 1965

4:30 a.m. dawn-no calling
4:48 a.m. one male calling
4:55 a.m. one male calling
4:59 a.m. two males calling
5:00 a.m. one male calling plus first large brushland tinamou; temperature top of low ridge, 43° F.; bottom of ridge 38° F.
5:01 a.m. one male calling plus one large brushland tinamou
5:10 a.m. one pale spotted and several large brushland tinamous calling
5:25 a.m. sunrise-no more male crested tinamous calling since 5:01 a.m.; 4 to 6 large brushland and 2 to 3 pale spotted tinamous calling
5:31 a.m. one male crested tinamou calling; temperature 46° F. top of ridge, and 41° F. bottom of ridge
5:50 a.m. nine female crested tinamou whistles; 4 to 6 large brushland tinamous calling until 6:45 a.m.
6:28 p.m. sundown-no crested tinamous calling with temperature 70° F.; large brushland tinamous calling from sundown until 7:14 p.m.
6:45 p.m. five crested tinamou males calling (stop observations)

La Tranca, San Luis Province, elevation 2000 feet, November 20-21, 1965

7:45 p.m. several female whistles, sky slightly red
8:00 p.m. sundown
8:10 p.m. 2 to 3 crested tinamous still whistling
8:40 p.m. full moon tonight-some calling throughout the night by male crested tinamous
4:50 a.m. male and female crested tinamous calling
4:50 a.m.-5:22 a.m. strong calling from unknown number of crested tinamous
5:22 a.m. sunrise
5:30 a.m. duet calling heard twice from male and female crested tinamous
5:50 a.m.-5:55 a.m. so many crested tinamous calling from one group (10 plus birds) I was unable to separate calls into individual sexes

Peculiar to males is a twittering call given when in pursuit of the female just prior to copulation. This is a soft rapid twittering utterance given from an extremely erect body position as he makes tighter and tighter circles around the female. Following copulation the male, with bill closed, gives a throaty foghorn call, often for several minutes, each call lasting two to three seconds each. During this call the male's throat expands and constricts, all the while the bill is kept closed.

When he is with young the male gives a very thin whining call, similar to a cat's meow, which cannot be heard much further than 30 feet away. This call is used for several weeks to warn the young of danger. Another call by the male was heard when he had been flushed from his nest and gave a very low plaintive whistling while in direct flight. When flushed from young or the nest, males attempt to decoy the intruder away with a "cripple display" at the same time giving a call similar to that heard in direct flight.

Young crested tinamous have thin peeping calls when just hatched; by 20 weeks of age their calls are similar to adults, but less strong and rich. Therefore, young and adults consistently may be distinguished by their calls.

Call count routes patterned after ringneck pheasant counts were utilized in the crested tinamou study in attempts to ascertain relative abundance and location of prime habitat as well as for calculating the breeding call frequency in relation to nesting season. Thirteen counts were run in 1964 and 1965 over four separate routes in Mendoza and San Juan Provinces, allowing comparisons of Eudromia elegans elegans and the albida subspecies. These counts of one-minute duration were run over a route comprising ten stations while other early season counts were of ten-minutes duration conducted just after sunrise. September proved to be the month with the greatest number of calls, with prime habitat at Pareditas, Mendoza Province, totalling 159 separate breeding calls of males for ten stations. Highest count for certain individual stations on this route amounted to 17, 18, 18, 20, 19 and 18 breeding male calls. Temperatures at the beginning and end of this route were 47° F. and 55° F. None of the ten stations had less than 11 separate calls recorded, starting at 7:10 a.m. and ending at 7:40 a.m. It is of interest that for the 159 breeding calls heard along the ten station routes there was not one sighting of a bird along the dirt road. Good populations were considered present in November when four to nine calls of males could be tallied during station counts of one-minute duration. When wind velocities were less than five miles per hour calls of male or females could be heard up to several hundred yards on either side of the observer. In fact the calls carry so well in the desert air that call count stations might be spaced 1.5 miles apart rather than one mile, to avoid overlapping of calls heard.

A comparison of breeding call count routes in desert areas of San Juan Province to those of Mendoza Province showed there were almost no calls in September but by October calling had begun in earnest and continued strong into November and December before tapering off. In desert areas such as this, calling to start the breeding season appears to begin about one month later than in semiarid habitats of Mendoza Province. Densities of crested tinamous in San Juan Province desert areas of 4 inches annual rainfall were much less than in semiarid areas of Mendoza Province, as evidenced by call count analyses. Temperatures in San Juan Province during morning mid-September call counts beginning at 7:05 a.m. were colder than those noted in Mendoza Province and ranged for the former Province from 40° F. at the start to 49° F. at the end of the route.

From the routes of greater density in San Juan Province, Guanacache, Las Berros and Matagusanos, the highest number of separate male breeding calls for any one route totalled 52, with no stations having higher than 10 separate calls. Others ranged from 2 to 9. These summations of call counts

in Argentina should provide State game department biologists with comparative trend information on densities and breeding call rhythm in relation to the nesting season after crested tinamous are liberated in the United States.

Interbreeding

Taxonomic studies are continuing, not only to ascertain the validity of the reported eight races of crested tinamou in Argentina but also to determine if other undescribed races might be present. It appears that some ranges must overlap, probably by marginal populations only, but it seems clear that where this situation does occur, interbreeding would be possible. Mendoza penned studies disclosed that even though calls were different for the two subspecies, when a crested tinamou albida was allowed to experimentally breed an elegans elegans the eggs were hatched without problems. No further breeding of these two races was undertaken to ascertain if the young as breeders would be fertile.

Due to lack of pen space in the beginning of confinement on the Yerrington game bird laboratory of the Nevada Fish and Game Department, some of both races, elegans elegans and elegans albida, were confined together during their first breeding season. These produced at least 95 young the first breeding season and all were to have been released in a specially selected area in southern Nevada the spring of 1968 so as not to cloud future findings when pure strains of elegans or albida would be released in separate areas.

Summary of Reproductive Capacity

Crested tinamous in the wild are extremely shy during the breeding season, making it difficult to ascertain the answers to some questions such as the sex ratio in a polyandrous species. In mating of polyandrous species, Thomson (1964) notes that males are believed to outnumber the females but he does not say by what ratio. These ratios were not definitely determined for crested tinamous. We do know that females travelled in small groups visiting individual males during the breeding season months. Trapping efforts were unsuccessful in catching enough birds to calculate approximate sex ratios. Random shooting of various races of this tinamou resulted in a sex ratio of 36 males and 38 females. However, on two occasions the collection was not strictly random in that the object was to take all birds in small groups to check their sex ratios. Results in these two cases, both in the breeding

season, were the collection of 3 females together and 2 females and one male, the latter calling strongly from his territory. Thus the collection was heavier on females which is probably true of any groups after October, the real beginning of the breeding season. Information from our field and pen studies, plus literature concerning reproductive capacity, reveal the following:

Breeding age -- Crested tinamous normally breed in the wild as well as in the pens the first year following hatching.

Number of eggs - Wild clutches average 5 to 7 eggs with as many as 12 or more laid in some nests, usually by two or more females. Game farm egg production averaging 30 to 40 eggs annually per hen is possible. One female laid 40 eggs during the summer in Mendoza pens and after being shipped to the United States she laid 44 more eggs in our summer months, or 84 eggs in less than one year's time.

Brood survival -- Good, except when extremely dry conditions prevail in the deserts or semiarid areas before and during the breeding season.

Life span -- At least 7 to 9 years in captivity. Adults are considered to live a rather long life in the field, but this is unsubstantiated.

Sex ratio -- As a variation of a polyandrous species the sex ratios may be nearly balanced or slightly in favor of the females.

Renesting -- Tend to renest as soon as the first or other nests are disturbed or destroyed.

Second broods -- A long staggered breeding season, peaking in late November, December and early January does leave some time for second broods. If the male loses his brood or they are separated from him by as early as January there is reason to believe that he will set up another territory for a second nesting, resulting in young in February or March. However, because of considerable nest destruction each year, renesting seems to be a better reason for an elongated nesting season.

Predation

Seldom does one learn of predation on adult crested tinamous. Throughout the ranges of this species potential predators include foxes, skunks, opossums, armadillos, hawks, falcons and owls. Two poisonous snakes, Crotalus and Bothrops, are present in their ranges, the former an Argentine rattlesnake.

Nests probably offer the best prospects for destruction, especially before the male begins incubation or when he is off feeding. By far the greatest nest depredations appeared to be woods workers, hunters and school children taking eggs for food, hatching and rearing in private aviaries and for selling to truck drivers and others passing through to be used for food. Selling of eggs is an annual affair in several localities. Wood cutters probably make the largest inroads over the breeding months. Some trappers in addition to taking the eggs will make a brush trap over the nest and catch the male when he returns to his incubation duties.

More varieties of hawks are found in Argentine crested tinamou habitats than in comparable arid regions of our Southwest. In La Pampa at the General Pico airport on February 18, Rumboll saw a chimango, Milvago chimango, eating an egg of the crested tinamou." This date would place the nest of eggs at the extreme end of the breeding season. Graves (personal communication) notes also from La Pampa that a carancho, Polyborus plancus, an attractive hawk, attacked a crested tinamou in a ploughed field knocking feathers loose. This hawk stopped his attack when Graves approached the area.

Observations during the period 1964-1967 indicated that predation appeared inconsequential to crested tinamous since nest destruction brings on an immediate renest attempt by the breeders.

Diseases and Parasites

In the wild, crested tinamous appear to be relatively unaffected by diseases or parasites. Where their open, desolate habitat overlaps a sheepherder's or cattleman's field, house or camp, they often are liable to pass through feeding areas in which domestic chickens are running. It is this situation which can lead to disease or parasite problems.

In our experimental propagation operations in Argentina, poultry flock management was emphasized. Quality sanitation methods and preventive treatment with antibiotics and specific drugs for the most common diseases during the two months of quarantine proved to be the best practice for preventing outbreaks as well as for eliminating diseases and parasites. Local Argentine veterinarians were consulted periodically on disease problems but few had been trained beyond identifying and prescribing for but the most common diseases and few had any experience with game birds. Parasites were taken from crested tinamous, preserved and forwarded to Janet Bump, Buenos Aires, for preliminary examination and then to Georgia to Dr. Katherine Prestwood of the Southeastern Cooperative Wildlife Diseases Study for final laboratory identification. Both Drs. Byrd and Prestwood of the University of Georgia laboratory were able to visit FGIP stations in Buenos Aires and Mendoza in 1966, at which time they were able to examine firsthand parasites from tinamous collected from the wild.

When we arrived in South America in 1964, certain areas of eastern Argentina were closed to hunting of tinamous because they were suspected of being carriers of a serious disease, Argentine hemorrhagic fever. The suspicion was held that this disease was spread by lice commonly found on both wild tinamous and rodents or by mites. At the suggestion of Drs. Byrd and Prestwood five spotted tinamou, Nothura maculosa, were sent to Dr. Karl Johnson, Director, Middle American Research Unit, Panama, and a recognized authority on this disease. Dr. Johnson had earlier determined that this disease was spread through the feces of rodents rather than by lice or mites. Following extensive tests on the spotted tinamous, utilizing live virus introduced orally and by injection, he uncovered no reason to suspect that these birds might be carriers or even artificially infected with Argentine hemorrhagic fever.

Diseases

Two problems of crested tinamous under penned conditions in Argentina were their susceptibility to respiratory ailments when young and a die-off from a few days of age to 4 or 6 weeks of age when the chicks seemed to be thriving and a sudden death could be traced to no specific disease. Respiratory ailments may have been triggered by a vitamin or mineral deficiency in young birds, but further tests also suggested that the ailments could have had their origin in improper balance of incubator humidity and temperatures. Although eggs of other tinamou subspecies in the same incubator at the same time as crested tinamous hatched well, and the young thrived, the eggs of the cresteds have proven to require more critical control of humidity and temperatures. Common problems at the Mendoza station were unabsorbed egg yolk sacs remaining in the body cavity, urates formed on the kidneys and improper healing of umbilical cords. Many autopsies of young birds, with the assistance of Dr. Berkoff, University of Chile, Santiago, indicated that dehydration in the incubation cycle could have led to respiratory ailments as secondary infections caused by microbes entering the unhealed umbilical cords. Crested tinamous at the Mendoza station showed a higher susceptibility to respiratory ailments than any other of the tinamou races.

Fungus -- Aspergillosis, Aspergillus spp., a disease caused by fungi is highly contagious to crested tinamou young and adults. In the wild, however, this does not seem to be any problem as compared to penned conditions where mold on feed, waterers, or escaping destruction in fumigated incubators is picked up by young as well as adults. We learned quickly that it is mandatory with crested tinamous to exert special sanitation measures to exclude conditions favoring Aspergillus growth.

Bacterial or virus -- A continual lookout was maintained for Newcastle disease, a disease involving respiratory and nervous symptoms which is highly destructive to domestic fowl. Some outbreaks of Newcastle disease have occurred in Argentine poultry populations but none was detected either in our Argentine quarantine pens or in crested tinamous shipped.

Non-specific enteritis -- This enteritis appeared commonly in the intestinal area under penned conditions but did not cause much loss of birds.

Protozoan -- Coccidiosis eggs were detected in some droppings of crested tinamou. Systematic treatment with sulfa drugs on all incoming birds was maintained to break and eliminate this common poultry disease. Losses from this disease in Argentina and the United States quarantine stations were insignificant.

Internal and External parasites

Table 7. lists the types of parasites, both internal and external, found in the crested tinamous from San Juan, Mendoza and La Pampa Provinces. These birds were all collected from the wild, their parasites removed and preserved for identification. Roundworms and some tapeworms were common in crested tinamous collected from the arid desert of San Juan Province around Matagusanos, a Spanish word meaning "kills worms". Here temperatures are extremely high during summer months, the rainfall averages about four inches annually and in some years it rains not at all. Although it proved difficult to completely eradicate worms from captive populations of crested tinamous in FGIP pens, the small number of worms present did not seem to have much adverse effect.

Table 7.. Parasites of crested tinamou in Argentina collected by the Foreign Game Investigation Program.

Host	Parasite[a]	Class	Location in host
Eudromia elegans albida	Family Heteroxynematidae	Nematoda	ceca
	Raillietina sp.	Cestoda	small intestine
	Menacanthus sp.	Insecta	crest and
	Heptapsogaster sp.	Insecta	body feathers
Eudromia elegans elegans	Family Anoplocephalidae	Cestoda	small intestine
	Family Heteroxynematidae	Nematoda	ceca
	Habronema sp.	Nematoda	gizzard
	Raillietina sp.	Cestoda	small intestine
	Subulura sp.	Nematoda	ceca
	Tetracheilonema quadrilabiatum	Nematoda	body cavity
	Tetrameres sp.	Nematoda	proventriculus
	Menacanthus sp.	Insecta	crest feathers

(a) Parasites - preliminary identification by Janet Bump, consultant for the FGIP; final identification by Dr. Katherine Prestwood, University of Georgia. Ectoparasites - identified by K. C. Emerson, University of Georgia.

Except under penned conditions crested tinamous did not harbor many external parasites such as lice. Dusting of newly-received birds and those about to be shipped were standard practice in eliminating these external insects.

Analysis of Competing Interests

Relation to Agriculture

Major ranges of crested tinamous contain little agricultural acreage and nowhere did we find this brushland or grassland tinamou dependent upon agricultural products. Instead, the destruction of good brushland habitats for agricultural uses can bring a reduction in population numbers, particularly when large fields are cleared which leave little, if any, brush and grass cover. Agricultural lands are utilized by these tinamou when fields have been fallow with a resultant invasion of secondary succession species of herbs and annuals. This type of agriculturally associated plant cover is used for feeding as well as nesting cover, especially where extensive brush or grasslands adjoin the fallow fields. Most western United States areas now being considered for trial liberations of crested tinamous contain very few agricultural areas.

Major grains with which some populations of crested tinamous are associated in Argentina include corn, oats, wheat, barley and some rye, especially in the Provinces of Buenos Aires, San Luis and La Pampa. More and more fields are cleared yearly for planting grains in these three Provinces. Ten other Provinces, due in part to arid conditions and poor soil, have little if any

agricultural lands intermixed with the scrub brush or grasslands favored by crested tinamous. These latter Provinces are grazed by sheep, goats, horses and, to a lesser degree, cattle.

Crop analyses of over 100 birds collected in Argentina indicated that agricultural products, except as a result of feeding from fallow fields, make up probably less than five percent of the total annual diet of crested tinamous over their entire ranges. Trapping attempts using a variety of grains for bait resulted in acceptance so low that trapping never became profitable during the two years' try at collecting tinamous. The one seed of agricultural origin acceptable in Mendoza and San Juan Provinces that required only a longer time of pre-baiting was that of the grape. Hunters as well as trappers often dumped a load of this seed in brushy habitats to attract crested tinamous. After the grape seeds were found it was only a matter of time until larger and larger populations built up, making it possible to hunt or trap cresteds with this special bait.

In general about 90 percent of crested tinamou habitats are in livestock grazing areas. Desert scrub conditions occur in most of the Provinces occupied by this tinamou and due to low precipitation, and often poor soil, little grass is found that would provide grazing for cattle. Where sufficient vegetation and water do occur, the main livestock types grazed are sheep, goats and horses. Where controlled grazing practices are employed or more favorable vegetation growth conditions exist, such as in western Mendoza Province between Tunuyun and San Rafael, cattle are grazed at least seasonally and some of the highest crested tinamou populations of Argentina occur.

Conversely, even in the most arid and desolate desert scrub lands of San Juan, La Rioja, Catamarca and Tucuman Provinces, there are crested tinamous and rheas where even sheep, goats or horses can find only limited seasonal sustenance. Lack of direct water in these harsh situations does not appear to adversely affect crested tinamous.

Usefulness

As a game bird -- Where other tinamou races occur in numbers within crested tinamou habitat the former are likely to be pursued by hunters much more than the latter. This stems not only from the fact that hunters hold other tinamou races in higher esteem from a culinary standpoint, but also from an actual hunting standpoint the birds hold much better to a dog than do crested tinamous. However, over the bulk of their range crested tinamous are considered a challenge to all hunters living in these areas.

Habits and behavior of crested tinamous during the hunting seasons in Argentina are somewhat comparable to those of Gambel and scaled quail. All these birds basically are runners and need cover of brush or grass in which to hide when pursued. Breaking up a flock of birds before serious running begins is smart planning, after which some birds can be expected to hold fairly well in good cover. Although crested tinamous are somewhat hard to hold with hunting dogs, old time hunters report that those dogs which were especially trained to head the runners or were more patient in their approach, particularly pointers, could often do a creditable job in stopping or pointing the birds. Figure 41 shows Argentine hunters and trappers who ardently pursue crested tinamous as well as rheas, rabbits, and guanacos.

Figure 41. Sportsmen of Argentina have keen interest in hunting and trapping crested tinamous.

An example of crested tinamou hunting in the past was one hunt in a favorite area of Mendoza Province when 6 hunters walking with dogs for 4 straight days collected 406 birds. These hunters reported walking hours at a time, sometimes a day or more, before finally sighting and flushing the birds, which always tried to keep cover between themselves and the moving line of men. One of the same party reported shooting by himself, in a good population year, 110 birds in one day after considerable walking. Crested tinamous do not like to cross fairly deep arroyos; hunters take advantage of this knowledge in forming lines of men to push the birds eventually towards these locations. As the birds approach arroyos they are forced to fly to the sides or forward to escape the oncoming line of men. Tracks of running crested tinamous are followed by hunters, usually for some time after the initial sighting before they can force the birds to flush into sight. In the winter the flocks that may be flushed may be as small as 15 birds or up to 100 or more. The birds are fairly easy to bag with number 6 shot but for longer ranges number 5 shot or even 4 would ensure collection. They are certainly much easier to down than our ringneck pheasants, excluding the first day shoots when pheasants are taken often at closer ranges with 7½ shot.

Once flushed, crested tinamous can be flushed again through persistent followup but dogs are very helpful at this stage as they are better able to find and flush birds which hold tightly. In areas not heavily hunted, birds sighted and pursued by hunters often flush at 30 to 60 yards distance, while others may crouch closely to the ground and be passed over by the men. The coloration of crested tinamous blends so well into desert pavement backgrounds that even a bird lying tightly pressed to the open surface without vegetative cover is difficult to sight. It pays to scan carefully areas from which birds have just flushed to see if any others have held close to the ground or moved into nearby brush cover. Even dogs covering these areas have been seen to overlook birds lying immobile in plain sight on the desert pavement. As with the sandgrouse, these well-camouflaged crested tinamous may aptly be called the "gray ghosts of the deserts."

Crested tinamous have been greatly persecuted since early in this century when excellent populations were located throughout Argentina. Since then the populations have been reduced through hunting or poor range conditions, not to an extremely dangerous level, but to a point where more stringent hunting regulations plus enforcement in the field is needed. There are commendable bag limit and season hunting dates on paper but almost no enforcement personnel in the field. Here shooting occurs throughout the year, including the breeding season when birds as well as eggs are taken. It will be necessary to institute more stringent enforcement in order to quickly bring the hunting under better control. Observations in Neuquen Province in November 1966 and February 1967 disclosed 4 to 6 hunters each in the rear of two pickups shooting at birds and animals moving along or across the roads, with occupants of one car bagging more than ten crested tinamous in very warm weather. November is deep into the breeding season and February is the end of the season, much too early to begin hunting of any of the game species.

While trapping and selling of tinamous in the markets is generally not permitted, certain individual cities in particular Provinces allow this. In Mendoza City, crested tinamous, spotted tinamous and some large brushland tinamous were sold annually, as well as being advertised on restaurant menus. Selling usually occurs in the winter months, with many birds coming from Santa Fe, Entre Rios, Cordoba and San Luis Provinces where trappers and birds are decidedly more numerous than in Mendoza Province. On June 2, 1965 both spotted tinamous from eastern Argentina and California quail from Chile were being sold in Mendoza city poultry markets at about 50 cents and $1.00 apiece, respectively. The tinamous were dead; the quail were imported alive and held in small cages.

As a source of food -- The flesh of crested tinamous is white and tends to be dry, requiring some culinary knowledge to increase the moisture content and produce a palatable dish. It should be the policy of the hunter to clean out as quickly as possible the intestinal area of the bird, especially the large caecum which if ruptured will impart an unnecessarily pungent odor to the flesh in its immediate vicinity. Two ways are predominantly used for preparing the bird for the table. Roasting quartered sections over low flames, with repeated basting of butter or barbecue sauces, without salt in the beginning, will result usually in some tasty portions. A more common method throughout Argentina is of Italian origin and is used also for the

spotted tinamous and other races of tinamous but has special merit for crested tinamous because of the dryness of their meat. A recipe, one of several, called "escabeche de perdices" is as follows:

Perdices in Escabeche

Clean ten perdices or crested tinamous well, wash and season them, and place them in a saucepan. Add: 8 carrots cut into fine strips
1 teaspoon pepper
3 laurel leaves
8 cloves of garlic
1 cup vinegar
1 glass wine
3 cups oil
salt

Put a lid on the saucepan and boil slowly until well cooked. Ten minutes before removing from the fire, add four slices lemon. Remove and let cool. Serve either cold or hot.

The more simple the seasoning, the more delicate they remain. If they are to be used within a few days, a tomato cut in half can be added when making the escabeche.

Wine is also used extensively in cooking crested tinamous, adding moisture to the meat of the birds.

Spotted tinamous, large brushland tinamous and red-winged tinamous are universally considered by hunters in Argentina as the best eating of all tinamous. Since in many western Argentina brushlands these three exist only in limited populations crested tinamous are as readily accepted as these three by Argentine hunters who look forward each year to cooking up large batches of their "escabeche de copetona", replete with excellent wines.

As a pet and aviary bird -- Single birds allowed to run loose around a home are inclined to lose their wildness. This concerns young collected as chicks; adults collected from the wild seldom if ever lose their wildness. Two or more confined in a pen with ample brush cover maintain an aloofness, never completely losing their inherent shyness with humans. The tinamou most commonly kept in pens or around houses in western Argentina is the crested tinamou because of its interesting disposition and because it is less likely to seek cover as do spotted, canyon and large brushland tinamous. Of outstanding importance to those keeping crested tinamous in captivity is the unusual fact that pairs will incubate and rear their own young. By removing young at about two weeks of age, a second clutch and sometimes three complete clutches can be brought off by a particular male.

From personal experience, de Costa (1953) relates that a crested tinamou collected as a chick was an interesting bird that became accustomed to entering the house, following people around and recognizing those who gave it food. Further she says the bird was a good guard, giving warning with loud cries at the presence of strangers. She noted that the single bird becomes domesticated to an incredible degree. De Costa concluded her observations by stating that it did not like to be alone and would search until it found

a person, took baths under dripping clothes, played with moving objects, picked at shoes, untied laces, preferred eating from the hand, exhibited understanding of preparations for a trip by fussing, followed on the street, and was a faithful companion.

Although most species of tinamous are shy in the wild, given proper isolation, privacy and cover under penned conditions the crested tinamous lend themselves well as subjects for controlled behavior studies. From a nesting behavior standpoint, crested tinamous could be relied upon consistently to bring off their own young under penned conditions and to retain most of their wildness during confinement. Five male crested tinamou incubated, hatched and reared seven different clutches of young in Mendoza pens while one male averaged two complete nestings each year for three years of our studies.

Relation to Other Game Birds

Distribution of the two species of crested tinamous in Argentina is almost as widespread as any other of the tinamou species, including the spotted tinamou groups. Four tinamous, the pale spotted and spotted tinamou groups; Ingoufi's tinamou of Patagonia, Tinamotis ingoufi; and the large brushland tinamou are found in close association with crested tinamous in parts of their ranges. Additionally, rheas are found throughout many of the crested tinamou ranges in arid western Argentina.

Red-winged tinamous are associated to a limited degree with crested tinamous in eastern Argentina. Liebermann (1936), quoting Wetmore, stated that where crested tinamous appear the redwing tinamou disappears, being unable to compete. A closer look at the habitat requirements of the red-winged tinamous indicates that for optimum living conditions they need either tall grass or a comparable situation involving forbs and grass. When these conditions are changed or destroyed, leaving only a minimum amount of grass, brush or weed cover, this tinamou is reduced tremendously in numbers. Habitat unsuitable for the redwings is often suitable to crested tinamous, which do not normally inhabit or need as dense a cover as the redwings. Redwings are sought more by hunters for their excellent flesh than crested tinamous. Redwing populations have been drastically reduced in the past 30 years (Godoy, 1963). Thus we can visualize that it is a change in prime habitat conditions of one tinamou species to those suited for another, and not competition as held in the earlier 1925-1930 hypothesis (Liebermann, 1936), which results in one species becoming predominant in an area formerly a haven for the other.

Nowhere in the ranges of crested tinamous have we personally observed, or heard from local workers, any adverse behavior involving other tinamou species. In general the crested tinamous and other species of tinamous are so non-aggressive towards each other that when their paths do cross they appear indifferent to any except their own particular species. Grasslands being the prime habitat of thriving populations of the pale spotted tinamous, they seemingly have excellent feeding conditions that still allow some crested tinamous to find ample food for their own needs. From the brushlands of western Argentina south into Patagonia crested tinamous are rarely associated with any other species of tinamous and food appears ample to have maintained

existing populations year after year. Large brushland tinamous thrive in fairly open to dense brushlands consisting of trees or tall brush and have slight, if any, association with cresteds in the wild. The very shy Ingoufi's tinamous live in Patagonian plateau or mesa areas and seldom cross the paths of crested tinamous except when they move through valleys to other ranges for water purposes. Preliminary food habit comparisons between these two genera showed little similarity in their preferred food choices. No conflicts have been noted or reported between rheas and crested tinamous throughout ranges where they overlap.

As studied at the FGIP experimental rearing units in Argentina, behavior of crested tinamous towards other species of tinamous appears the same as in the field, shyness coupled with indifference to others penned with them, including the pale spotted and large brushland tinamous. In figure 51 young canyon tinamous are seen with crested tinamous with no pugnaciousness noted between them. However, both male and female cresteds often expressed their irritation toward calls from other subspecies of crested tinamous isolated by pens from them by giving sharp calls or even attacks on their mates, being unable to vent their antagonism upon the nearby penned birds. Usually each subspecies was confined in separate pens but in one instance a male California quail penned with a 24-week-old crested tinamou from Patagonia harrassed the tinamou to such an extent that the tinamou had to be removed before it became further scalped from its wild jumps to evade the attacks of the quail.

Looking to the United States and potential liberation areas the crested tinamous might be most closely associated with Gambel's and scaled quail in our southwestern deserts. The tendency of crested tinamous to range over sizeable distances of flat lands could provide a supplemental game bird to the quail populations, furnishing a fairly large-sized bird that might thrive where no direct water is available.

Crested tinamous in Argentina utilize seeds and some flowers of the creosote bush and can be expected to use some of this food in our southwestern deserts where no North American game bird has been reported as taking any portion of this particular plant. In general, crested tinamous are very versatile in their food choices, taking a wide variety of foods, and can be expected to eat more leafy, flower and fruit items directly from brush than seeds from the ground as is more common with the predominantly seed-eating Gambel's quail. In better brush areas, the preferred habitat of crested tinamous, it is believed that greater food utilization would be made by this tinamou in the United States than by scaled quail for which this type of habitat is marginal as compared to its more optimum desert grasslands with scattered brush.

Further north in the United States figure 30 outlined certain possible liberation areas, with the reservations that some or all might not have enough suitable varieties of food present, might be too cold, or might have snow remaining on the ground for too long a period. In these areas, including Nebraska, Wyoming, Idaho, northern portions of Utah and Nevada, and eastern Oregon and Washington, crested tinamou associations with our game birds could involve marginal or medium populations of sagegrouse, sharptail grouse,

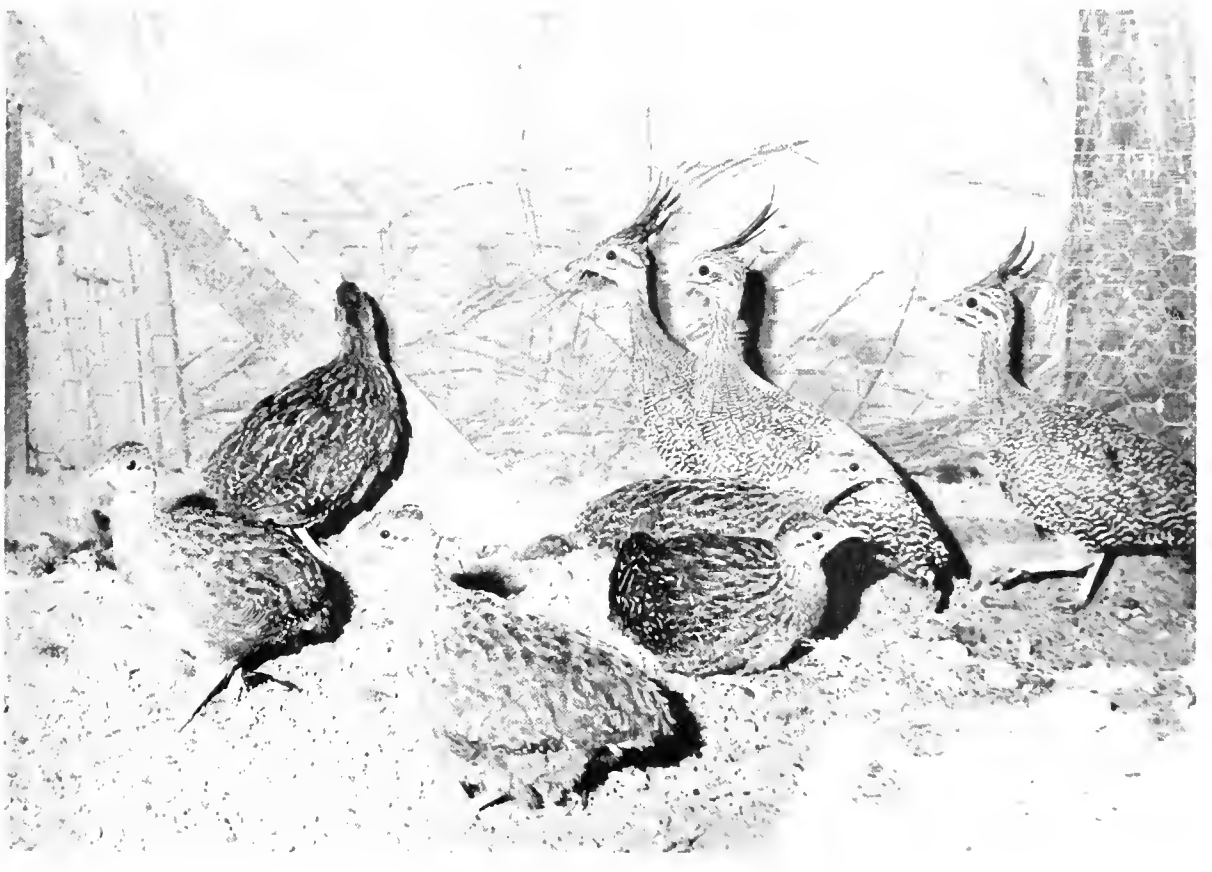


Figure 42. Under penned conditions crested tinamous are indifferent and non-aggressive toward other genera of tinamous.

prairie chicken, and the California quail. Habitats are primarily brush or grasslands with few agricultural lands. The shy indifferent behavior of the crested tinamou to other game birds in Argentina indicates that if there were aggressiveness displayed by any bird, it would probably be by our native game birds. Prairie chickens and sharp-tailed grouse would appear to have comparable behavior to that of crested tinamous in being shy and retiring throughout most of the yearly cycle. In some of the States mentioned above, present game bird habitats are marginal for grouse, and there is a desire now by some States for a more tolerant game bird or a supplemental species. The main emphasis on experimental liberations of crested tinamous in the United States will be first in southwestern arid deserts from California east to Texas, with nonparticipating States watching closely the results in regard to success or failure.

Breeding and Raising

Crested tinamous are easy to breed in captivity and can be held under the most primitive of penned conditions such as small pen sizes with only

a minimum of brush or grass cover for nesting. Figures 43 and 44 illustrate certain aspects of breeding and rearing crested tinamous as they were experimentally produced at our Mendoza station in Argentina. Good results with breeder ratios of 1:1, 1:2, or even flock mating were obtained, however the first two ratios produced the greatest number of fertile eggs. Often when two females were present with one male, one of the females proved more dominant than the other, which resulted in only one being bred even though both laid eggs. Considerable adjustment was necessary when two or more females were present with the male. In cases of trouble in introducing a new breeder into a pen it proved better to add the females to pens with the male already present, rather than a male to a female's pen.

Two supplemental data reports on breeding and rearing tinamous were forwarded to State Game Departments through March 15, 1967 by FGIP biologists and the following are some of the comments noted especially for crested tinamous. Hand-reared young birds made the best breeders, producing the first year following their hatching while wild-trapped birds did not begin serious egg laying until the second year at our experimental units. Gravel, sand and dirt floors were used in pens measuring from 9 by 10 by 6 feet to as large as 8 by 30 by 6 feet. Both sizes were designed so they could be modified by dividing for breeder use or left their entire size for holding brooder stock of from 6 to as many as 16 birds. Cover was placed in every pen in the form of brush, forbs or grass clumps so that males could build nests or certain severely harrassed females could find refuge.

Figure 43. Breeding and raising young is simple but special attention to diet and disease is mandatory.

Figure 44. Young crested tinamous can be extremely hardy after the critical first six weeks, requiring only normal quality feed and pen sanitation.

Following cloacal sexing of males and females for forming the desired breeder pen ratios, the sexes were marked by attaching colored leg bands. Some 40 to 60 eggs a breeding season can be expected if breeders have been satisfactorily matched, with a fertility rate of over 85 percent not uncommon. With many eggs laid in the early morning hours it is important during hot weather to pick these up each morning and place them either in cold storage of 50° F. to 55° F. for a few days or to start incubation. Crested tinamou eggs should be set in the incubators as soon after laying as possible. To hold them longer than seven days even at cool temperatures leads usually to low hatching success.

The incubation period varied from 18 to 21 days in still-draft incubators. The greatest proportion hatched at 18 to 19 days. Incubation temperatures ranged from 101° to 102° F. with wet bulb readings of 60-65 percent for the first 16 days. Afterwards this was raised to 70-75 percent for the hatching period. No forced draft incubators were available for testing. There were many unexplained deaths of young at 7 to 10 days of age. A combination of improper incubation control, diet problems and respiratory ailments usually climaxed the troubles at this young age.

Once young have passed the first two weeks of life in protected surroundings they need night warmth in outside pens until their body feathers are well developed. A high protein mash supplemented with cooked liver and chopped egg yolk was a standard part of caring for the young. Because crested tinamous consume much green leafy material in the wild, alfalfa was grown especially for them at Mendoza and chopped fresh alfalfa was a part of their daily diet. It was readily accepted. Few losses of young occurred after they had reached 10 weeks of age and adult breeders proved exceptionally hardy under penned conditions.

Trapping

Attempts to trap crested tinamous with grain as bait were almost completely unsuccessful. It appears that agricultural products, other than grape seeds which were not readily available to us, are low on their preferred list of foods and therefore traps utilizing scratch grains and other cereal types were unacceptable, even during the winter months when these birds were in flocks. Figure 45 illustrates one type of Argentine trap that will catch occasionally one or two birds, using grain as bait, but in general this is not feasible for catching large numbers. Some of the more original country folk bait a large rat trap with a corn kernel, place it in the usual paths of crested tinamous and catch some birds.

Figure 45 . A common country trap for tinamous, inexpensively prepared by Argentines. Birds trip the pole support when they go after bait.

Figure 46. Night trappers use a strong light, pole and net for catching birds in their roost bowls.

In figure 46 is shown one of the most successful trapping methods used for crested tinamous, involving a powerful light, long pole and net. This method is similar to that used for trapping live ringneck pheasants at night in the United States but the terrain is so rough in Argentine crested tinamou habitats that walking is necessary rather than the use of a vehicle. When roosting birds are found the trapper moves in concentric circles about a bird until he can place the net over the tinamou, after which it is quickly placed in a burlap sack. Although many persons offered to trap crested tinamous by this method for the FGIP, less than 10 birds were ever caught, seemingly because this type of trapping is not as easy as it appears, especially in rough country where bird densities may run only two birds per ten acres.

When good populations are present and daily travel paths of crested tinamous are known, funnel traps might be used as for sage grouse and prairie chickens. In these the trapper drives the birds slowly forward into the funnel areas for collecting. In eastern Argentina where wire fences are much more common than in arid western habitats these fences are utilized by placing a trap at a corner. The bottom strands of fence wire are barricaded by hanging brush on them so the birds experience difficulty in passing through.

Rather than fly over the obstacle crested tinamous will walk down the barricade to the corner which has a wire funnel to allow them to pass into a larger trap out of sight of free birds. Chicken wire of 3/4-inch mesh is often used to form both the barricade and the collecting trap which is held down with stakes.

The study of daily movements of crested tinamou by hunters and trappers has led to the development of other minor traps, including placing horsehair snares on travel lanes between brush or rigging spring-type traps that lift the bird into the air when it steps into a noose. None of these methods appeared to be profitable for catching sizeable numbers of birds for game farm production; birds caught were usually taken solely for food.

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