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NATURAL HISTORY OF THE MONTEZUMA QUAIL IN MEXICO

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The Montezuma Quail (*Cyrtonyx montezumae*) is best known in ornithological literature from the extreme northern fringe of its range in southern Arizona, New Mexico, and Texas. There the local race, *C. m. mearnsi,* generally called the Mearns Quail, is extremely rare. Throughout the Mexican highlands, however, the species is widespread and in many localities it is abundant. The natural history and ecological relations of the bird can best be studied in México.

One of us, Leopold, has had the opportunity to observe and collect Montezuma Quail in virtually all parts of the highlands in the course of a survey of Mexican wildlife that has been pursued intermittently since 1944. In the summer of 1948 we both worked rather intensively on the species in northwestern Chihuahua under the auspices of our respective institutions, with some additional support from the Wisconsin Alumni Research Foundation and from the Associates in Tropical Biogeography at the University of California.

Prior to preparing our material for publication, we submitted a questionnaire to most of the museums in the United States soliciting information on existing specimens of *Cyrtonyx*. We are deeply grateful to the many curators who generously responded to our inquiries: R. H. Baker, J. R. Curttenden, W. B. Davis, J. L. Diedrich, W. C. Dilger, W. C. Hanna, T. R. Howell, L. M. Huey, J. B. Hurley, G. H. Lowery, Jr., J. D. Macdonald (British Museum), J. R. Millar, C. E. O'Brien, R. T. Orr, A. R. Phillips, W. L. Schmidt, W. J. Sheffler, K. E. Stager, L. K. Sowls, R. W. Storer, G. M. Sutton, and Lida Whittier. Records also were sent from the Academy of Natural Sciences in Philadelphia and the Denver Museum of Natural History.

The writers further wish to acknowledge the cooperation and courtesy of Elmer Heft of Green Lake, Wisconsin, who made available quail from his aviary for studies on incubation, growth, and molt.

DISTRIBUTION OF RACES

The species *Cyrtonyx montezumae* is represented by three, well-marked geographic races whose approximate distribution is shown in figure 1. Description of the races may be found in Ridgway and Friedmann (1946). Differentiation is based entirely on plumage characters, not on size. Figure 2 depicts characteristic male specimens of the three races of *montezumae* and the closely allied Ocellated Quail, *C. ocellatus*.

Cyrtonyx montezumae mearnsi occurs in southern Arizona, New Mexico, and Texas as well as in northern México from Sonora and northwestern Coahuila (Sierra del Carmen) south to Durango and probably to central Zacatecas and Aguascalientes. The zone of intergradation with the race *montezumae* to the south seems to occur along the crest of the Sierra Madre Occidental in Durango, Jalisco, and Zacatecas. Five specimens from Las Flores, Durango (7500 ft., 55 km. S Durango City and on the east slope of the Sierra), are clearly *mearnsi*. Presumably this pale race occupies the whole arid interior slope of the Sierra as far south as Aguascalientes. Five additional specimens

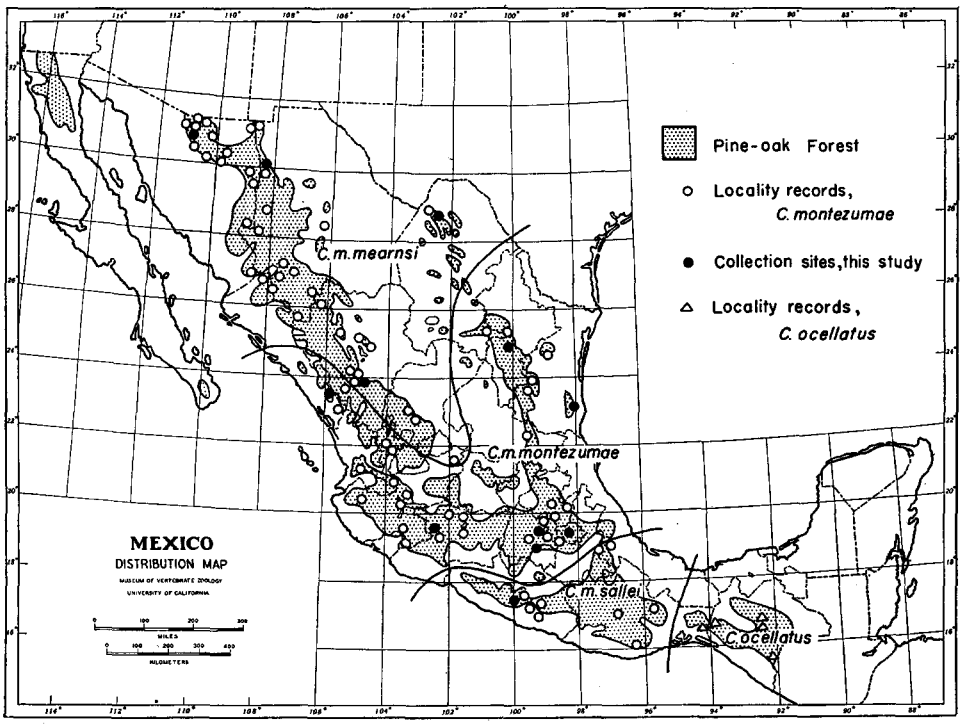

Fig. 1. Mexican distribution of quails of the genus *Crytonyx* in relation to pine-oak forest. Ranges of the three races of *C. montezumae* and of the closely allied *C. ocellatus* are indicated.

taken immediately across the Sierra from Las Flores, on the humid Pacific slope at Batel, Sinaloa (5100 ft., 70 km. NE Mazatlán) are of much darker plumage, being indistinguishable from typical *montezumae* of the southern uplands; comparison was made with specimens from Tequila, Jalisco, Los Reyes, Michoacán, Tres Marías, Morelos, and Río Frío, Estado de México. The zone of intergradation therefore is presumed to follow the Sierran crest as shown on the map.

C. m. montezumae occupies the pine-oak uplands from Sinaloa south to Michoacán, east to Tlaxcala and northern Puebla, and north along the Caribbean escarpment to the Sierra Madre Oriental of Tamaulipas and Nuevo León. To the north and west this eastern segment of *montezumae* is separated from *mearnsi* by deserts. To the south the arid Río Balsas valley intervenes between *montezumae* and the race *sallei* save along the eastern escarpment in Puebla and west-central Veracruz where the two races intergrade. Hellmayr and Conover (1942:285) describe an intergrade from Chalchicomula, Puebla. Even farther east close to the Valley of México some specimens of *montezumae* show a slight tendency toward *sallei* as mentioned by Pitelka (1948).

From Mount Orizaba in the middle of the narrow area of intergradation, Nelson (1897) described a form which has generally been recognized as a fourth race, *C. m. merriami*. The type specimen of *merriami*, a male, and apparently the only one existing, is figured by Nelson (1902) and appears to be an intergrade between *montezumae* and *sallei*. It is peculiar in having the black throat patch directly joined to the chestnut breast, thereby interrupting the normal white collar. However, this character, to which Nelson attaches much importance in differentiating *merriami*, is highly unstable through-

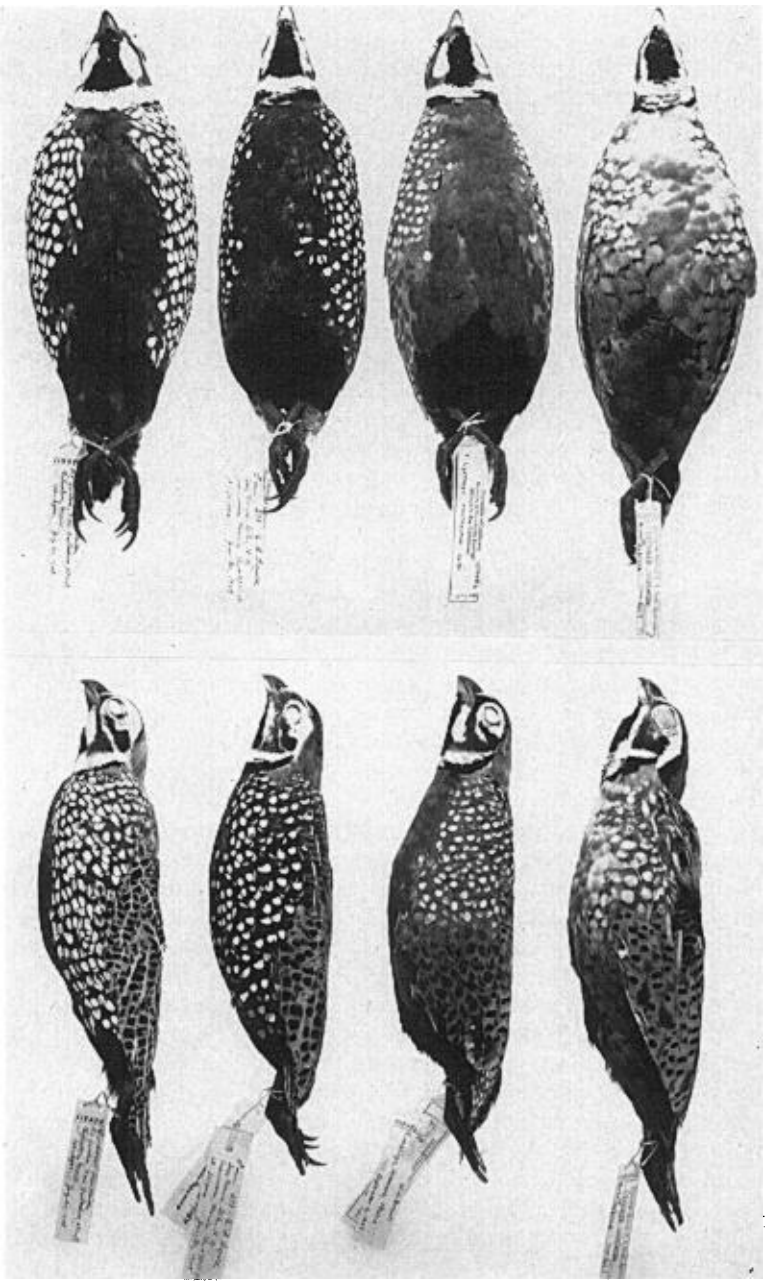

Fig. 2. Left to right, ventral and side views of male specimens of: *Cyrtonyx montezumae mearnsi,* Pacheco, Chihuahua; *C. m. montezumae,* Tres Marías, Morelos; *C. m. sallei,* Cuapongo, Guerrero; and *Cyrtonyx ocellatus,* Teopisca, Chiapas.

out the species and is probably of little taxonomic significance. Among 40 adult male specimens of *Cyrtonyx montezumae* represented in the collections of the Museum of Vertebrate Zoology, white collars vary in width from 4 to 13 mm., some being partly interrupted by scattered black feathers. One specimen of *mearnsi* (no. 98157, Las Flores, Durango) has an interrupted collar precisely as described for *merriami*. Additional specimens from Mount Orizaba would probably have white collars among them as was the case of the specimen already mentioned from Chalchicomula, Puebla, which is only 20 kilometers west of the peak. Hence Nelson's race *merriami* almost certainly represents merely a localized, intergrading population between two well-marked and widely distributed forms, and it is our feeling that the name should become a synonym of *sallei* as suggested earlier by Ogilvie-Grant (1902).

C. m. sallei was long recognized as a distinct species because its markings are so strikingly different from *montezumae*. Ridgway and Friedmann (1946) correctly designated the two forms as races of the same species in view of their intergradation along the eastern escarpment. The richly colored *sallei* occurs in the uplands of Guerrero, Oaxaca, and eastern Puebla as the accompanying map indicates.

To the east *C. m. sallei* is separated from the closely related *C. ocellatus* by a narrow neck of tropical vegetation which crosses the Isthmus of Tehuantepec. These two species occupy precisely the same ecologic niche but are quite distinct in plumage coloration.

RANGE IN MEXICO

Relation to pine-oak zone.—The Montezuma Quail is strictly a bird of the pine-oak vegetation zone. Highest densities are attained in open pine and oak woodland with an understory of low shrubs and tufted perennial grasses. Such conditions occur widely through the Sierra Madre Occidental and locally in the southern uplands both north and south of the Río Balsas valley. Likewise some good habitat, with accompanying high quail populations, may be found along the eastern escarpment and in the Sierra Madre Oriental. Figure 3 shows typical habitat for *Cyrtonyx* along the Río Gavilán in northwestern Chihuahua.

Lesser numbers of Montezuma Quail occur in other types of pine-oak associations such as dense pine forest, open pine grassland on the fringes of the boreal zone, and arid oak scrub bordering the desert. We use "pine-oak forest" in a broad sense to include all these types. We have collected Montezuma Quail at timberline on the great volcanoes of central México and at the last outpost of scrubby oaks scattered among the creosote bushes on the edge of the desert. The species shows up on isolated islands of pine-oak far removed from the main upland, as for example in the Sierra de Tamaulipas and the San Carlos Mountains in Tamaulipas, and numerous small mountains in the central desert from Chihuahua and Coahuila south to the border of Guanajuato. But we have not one record of the Montezuma Quail from any other vegetation type.

The pine-oak complex, including all of its varied associations, has been defined and mapped in a previous paper (Leopold, 1950) and is depicted in figure 1. Eighty-seven locality records for Montezuma Quail have been plotted on the map and of these 85 fall within the pine-oak zone as mapped. The apparent exceptions (Cañada, Chihuahua; Cuarenta, Jalisco) are areas that we have visited, and oak scrub occurs in both of them in north-facing canyons. Therefore they are not exceptions but reflect merely inadequacies of our small-scale map. It seems safe to assume, therefore, that the range of *C. montezumae* is fairly well represented by the pine-oak area as shown. Additional isolated colonies of the quail doubtless occupy scattered units of pine-oak not mapped. The quail, in effect, is an indicator species of the vegetation type in all parts of México north of the Isthmus of Tehuantepec except in Baja California where it does not occur.

Likewise the range of the closely related Ocellated Quail in Chiapas and eastern Oaxaca presumably is coincident with the pine-oak highland of the region (fig. 1). Our one contact with *ocellatus* was in typical mixed pine and oak woodland near San Cristóbal, Chiapas.

Habitat requirements.—It is not the pine or the oak trees themselves that make the uplands proper habitat for *Cyrtonyx* but rather the elements of the understory. As will be shown directly, this quail depends for its food and water upon underground bulbs and tubers of the sort that occur specifically in the climatic belt of the pine-oak forest. Removal of the forest by logging does not necessarily spoil the habitat for quail, for we have seen heavy populations in second-growth scrub. Neither does the frequent passage

Fig. 3. Ideal habitat for Montezuma Quail along the Río Gavilán near Pacheco, Chihuahua. The dominant trees are *Pinus montezumae* and various scrubby oaks.

Fig. 4. Former range near Galeana, Nuevo León, in which the birds have been exterminated by overgrazing.

of fire impair the carrying capacity of the range. Much of the pine-oak belt in México is burned annually. Even clearing and cultivating the land will not drive the bird out completely so long as fence rows, gullies, and roadsides remain undisturbed. In parts of Hidalgo, Tlaxcala, and Puebla the Montezuma Quail persists in fair numbers around the edges of fenced corn fields and maguey plantations in former pine-oak country.

Heavy grazing on the other hand will spoil the environment completely by selectively eliminating the bulb-bearing forbs and sedges. These perennials are replaced by annual weeds or by grazing-resistent perennials, such as brush and coarse bunch grasses, that supply adequate cover for the quail but no underground food reserves for the dry season. The quail then disappear.

As any Mexican traveler knows, most of the pine-oak zone in México is grazed, but the intensity of grazing varies greatly. The woods near villages, along watercourses, and on flats or gentle hills are as a rule severely chewed up by livestock. Areas of rough terrain, far from water, or far from population centers are grazed lightly or not at all. It is in these latter situations that the Montezuma Quail is found in good numbers. The condition of the forest canopy does not seem to matter.

Some examples may serve to clarify this situation. In northern Michoacán there are thousands of volcanic cones many of which are steep, rough, and completely dry. These cannot be grazed by livestock because the animals will forage only a mile or so up the

slope from water, which is at the base. The ground flora high on the cones remains rich and varied, and quail are numerous. The lower slopes are grown to poor weeds and there are no quail, although in gross appearance the forest looks the same.

The outskirts of Mexico City are overgrazed and eroded down to the hardpan, but within the suburbs are some ungrazed canyons surrounded by expensive homes. Montezuma Quail occur in the canyons, even though these have gone through a stage of grazing and erosion in the past. Now protected, the ground flora has partly recovered. Often the forest has disappeared or in some places it has been replaced by eucalyptus.

The environmental factor most frequently limiting Montezuma Quail therefore is the lack of underground food reserves which have been destroyed by grazing. If the requisite bulbs are present, the species can tolerate a wide range of cover conditions, from forest to fencerows. Water is no issue, since it is obtained from the bulbs.

We do not claim originality in asserting that grazing is a primary depressant of populations of *Cyrtonyx*. Ligon (1927:140) in New Mexico noted the adverse effects of grazing on various game birds, and of the Montezuma Quail, specifically, he says that "the birds . . . have been . . . reduced in numbers in recent years on account of the destruction of ground cover." In the unpublished field notes of Aldo Leopold appears the entry: "A pair [of Montezuma Quail] was seen in a box canyon above Pueblo Park, New Mexico, July 2, 1933, altitude 6400 feet, ponderosa pine type. This was within a few hundred feet of the only ungrazed spot seen in an eight-mile walk." A. H. Miller in a talk before the Northern Division of the Cooper Ornithological Club (Condor, 1936: 254) discussed the effects of overgrazing on Arizona range of the Montezuma Quail. L. Miller (1943:109) wrote that "overgrazing by domestic animals probably is the greatest danger to the species." In Texas, the Game, Fish, and Oyster Commission (Anon., 1945:67) reports that the range of this quail has shrunk "largely as a result of excessive range use by livestock." A dissenting opinion is expressed by Wallmo (1951: 42–R–2, Job 2, p. 6) who found that "on Fort Huachuca there is better grass cover in the Mearns' [Montezuma] Quail range than elsewhere in the Huachucas but the quail were found in fair abundance throughout the mountains with no apparent relation to range conditions." However, he worked in Arizona in a year of exceptional quail abundance which may have obscured range relationships.

In our experience within the pine-oak zone of México, the abundance of Montezuma Quail is inversely proportional to the local abundance of livestock.

PHYSICAL CHARACTERS AND BEHAVIORISMS

Adult weights.—We have weights of only 67 adult Montezuma Quail, of the 420 adult specimens of which we have record. The average weight of 45 males was 194.9±2.4 grams and of 22 females 175.7±3.4 grams. The heaviest cock and hen weighed 224.5 and 200.0 grams, respectively.

The differential weight of the sexes in this species is unusual for North American quail. In most species males are only slightly heavier than females, or at some seasons (breeding) may even average lighter.

Flight.—The flight of a Montezuma Quail is not unlike that of a Ruffed Grouse (*Bonasa umbellus*); it is usually short in distance but extremely rapid. The breast muscles of both species are light in color, indicating a lack of myoglobin, a muscle hemin-containing protein which combines reversibly with oxygen and is deep red in color. Myoglobin has the ability to hold oxygen in reserve for birds which rely on sustained flight and which characteristically have red muscles, such as ducks and prairie chickens. Miller (1943) discusses the colorless or translucent breast muscles of *Cyrtonyx* and relates this condition to the explosive short flight of the bird. The sustained fliers are

usually slower on the take off than "white-breasted" species. We would be at a loss to say which is faster, the Ruffed Grouse or the Montezuma Quail, but concur with Fowler (1903:68) who thinks that Montezuma Quail "cannot be equalled by any other species of the quail family." They lie very close in coveys and are even less prone to fly when in pairs. The covey separates on the flush like Bobwhites (*Colinus virginianus*). After alighting the birds run a short distance and then hide in the ground cover. Without the aid of a dog they are very difficult to reflush after one flight.

Stevens (1878) states that the female lies closer than the male, but we found no difference in this respect. To indicate the degree to which these quail lie close and restrict their flight, we kept a record of a series of flushes and flight distances (table 1). In four of the five instances when the birds refused to flush, they were with young.

Table 1

Montezuma Quail Flushing Behavior and Flight Distance during the Breeding Season

Jump distances			Flight distances	
Feet	Number		Feet	Number
1–10	7		1–50	0
11–20	4	13	51–100	2
21–30	2		101–150	10
31–40	0		151–200	3
41–50	0	5	201–250	3
51–60	5		251–300	0
61–70	0		over 300	1
71–80	2	2	ran	4
81–90	0			
91–100	1	4		
over 100	3			

The data substantiate in part what the "white" breast muscles presuppose, namely, that the birds do not fly far. An average flight was scarcely 50 yards. Another peculiarity of flight is the manner in which Montezuma Quail alight after a flight. They seem to tumble to the earth as if shot. Fuertes (1903) aptly describes it as dropping "woodcock-like" into the grass. This awkward landing may be caused by the short, soft tail which is not as efficient a landing mechanism as the tails of other American galliforms.

Voice.—The Montezuma Quail has two principal call notes. The common assembly call used by both sexes and even by chicks is a low quavering whistle in which the notes slowly descend the scale. Fuertes (1903) calls it owl-like. Its ventriloquial character is well known, and trying to locate birds through their vocalization is difficult. On two occasions we confined live juveniles in paper sacks and when all was quiet in camp they would emit the plaintive whistle. Once an adult male responded and came into camp where we collected him. Imitations of the note have been used successfully by us to call both males and females.

An entirely different note is given by males during the breeding season. It is a very high-pitched *buzz* that ascends rapidly to an inaudible level. The call is so high, thin, and reed-like that it sounds more like an insect than a bird. This we presume to be the mating call. It is given largely and perhaps entirely by lone males, who answer and come rapidly to an imitation of the descending tremolo described above, apparently seeking female company. In central Nuevo León in mid-July of 1945, many males were heard giving the *buzz* call and several of them were called up and collected. In Chihuahua in the summer of 1948, on the other hand, we heard very few *buzzing* males.

Jouy (1893:790) tells of a caged bird (probably a male since he calls it a beautiful specimen) in Guadalajara that was "answering its master's call and keeping up a continual piping as long as any attention was paid to it."

On various occasions a squealing call was heard when the birds were flushed. Several writers (O'Connor, 1936; Baird, Brewer, and Ridgway, 1875) speak of a conversational note used by the birds when feeding or in covey. In the Sierra del Carmen, Coahuila, W. C. Russell heard this low chatter among three birds (2 ♂♂, 1 ♀) observed at 20 feet. He states that the notes were scarcely audible even at that distance.

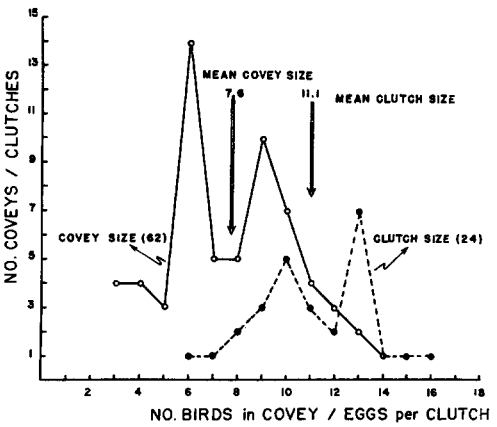

Fig. 5. Data on clutch and covey size, combining our records with those previously published.

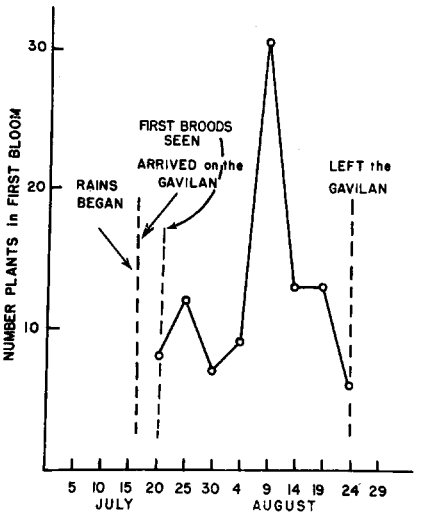

Fig. 6. First broods were observed in the Gavilán area after rains began and flowering plants started to bloom.

Coveys.—Montezuma Quail generally do not form large aggregations. This fact was noted in the earliest reports on the species (Bendire, 1892). Judd (1905) observed that they do not pack, and Bailey (1928) stated of Montezuma Quail in New Mexico that it "does not gather in large flocks." In 1949 Wallmo (1951) observed 15 coveys in the Huachuca Mountains of Arizona that averaged 10 birds and, in 1950, 49 coveys that averaged 8 birds. Henshaw (in Wheeler, 1875) corroborated the tendency toward small coveys when he reported coveys from 4 to 8 birds, seldom exceeding 10. Of our own records of 33 coveys jumped in various places in México in winter (November to March), the average covey was 6.4 and the largest was 10.

The covey is undoubtedly a family unit, but there are sufficient records of large coveys to indicate that some combining occurs: 30 (Brandt, 1951); about 25 (Fowler, 1903); 20 at least (O'Connor, 1936); about 20 (Swarth, 1929). Also Wallmo (1954) observed a group of young birds that included "two age classes."

All covey-size data from published reports were combined with our own, plus information given us by Charles Wallmo of the Arizona Game and Fish Commission. Averages were used when size ranges were given. These data when plotted (fig. 5), show a bimodal curve, with peaks at 6 and 9 per covey. The second peak, at 9 birds per covey, could mean the addition of unmated adults or unsuccessful breeding birds to the covey nucleus. This bimodal curve is strikingly similar to that of the clutch size distribution, to be discussed. When these two curves are compared, the two peaks of each curve are

exactly four units apart. In the case of the clutch-size data, we might regard the peculiar distribution as an artifact resulting from small numbers, but the unique correlation between covey-size and clutch-size is difficult to explain, particularly since the two sets of data are not associated in either time or place. No explanation is obvious to us.

Table 2

Comparison of Covey Sizes in Several Species of North American Quails

Species	Authority	Covey size	Season
Bobwhite	Wilson and Vaughn (1944)	9.11	winter (av. 8 years)
	Jackson (1951)	11.7	fall (av. 3 years)
	Ridley (1952)	11.2	fall and winter
	Rosene (1950)	11–12	fall
	Stoddard (1931)	13.8	winter
California Quail	Sumner (1935)	34.8	winter
Montezuma Quail	This study	7.6	fall and winter

If 7.6 is the average covey size which results from a pair with an average clutch of 11.1 eggs (hatchability unknown), then about a 40 per cent mortality of the eggs, young, and adults takes place between the start of incubation and the time when the group is identified as a covey. The time interval here is about four to six months. Emlen (1940) reports a 91.5 per cent mortality in California Quail (*Lophortyx californica*) from egg to 12 months of age. Unfortunately, we have no hunting-bag data or marked birds in order to compare the Montezuma Quail with other species.

The average covey size is smaller than that of the Bobwhite or the California Quail. The latter two species apparently have a greater tendency toward brood and covey combining. Table 2 presents covey sizes for the three species. In all cases where the observation was labeled a brood, or where the birds were obviously juveniles, the data were not used to determine average covey size.

Movements.—A covey of Montezuma Quail, established on its winter range, is very sedentary. Often we have found fresh scratchings day after day in the same place, indicating that a covey comes there regularly to feed. Miller (1943:106) states that "covies of the birds have repeatedly been located within the same fifteen yards of a canyon's course upon consecutive days or even at longer intervals." On the average we would estimate a covey range to be less than 200 yards in radius.

However, there is a period in the autumn when some coveys seem to move considerable distances before becoming established. Ligon (1946) stated that the bird is "wandering" in habit. Judd (1905) claimed that the Montezuma Quail "is more or less migratory." Several writers (Elliot, 1897; Swinburne in Bendire, 1892; Bailey, 1928) have mentioned an altitudinal movement, which we also have observed on some of the higher mountains of México. But it is our impression that these seasonal shifts, altitudinal or otherwise, are short—never over a few miles. There is nothing comparable to the long semi-annual treks of the Mountain Quail (*Oreortyx picta*), for example.

NESTING

Time of the nesting season.—The Montezuma Quail is a late-nesting bird, although pairs apparently form soon after winter coveys break up. Fowler (1903:68) stated: "I was out in these hills [Carmelita Mountains, Arizona] for a few days in the latter part of March 1892, and found that the Messenas had already paired and were evidently

busy hunting up good nesting places." Wallmo (1954), working on the Fort Huachuca Wildlife Area in southern Arizona, first observed a pair of Montezuma Quail on April 15 in 1949, and on April 11 in 1950. Ligon (in Bailey, 1928) reported them paired by May 15, but he thinks they do not begin to lay until late June. Nest, eggs, and young have been recorded in June, but in northern México we found most of the young appearing about mid-July. Willard (1913) said that they nest "regularly in August." Falvey (1936) stated that they start nesting in late June and that one of his captive pairs began nest building on September 15. Records are common of birds collected in November and December still in partial juvenal plumages.

The lateness of the Montezuma Quail breeding cycle is apparently timed to coincide with the summer rains. In the range of this species the rainy season occurs in July and August, the time we also find eggs hatching and the young in a period of rapid growth.

The chances of survival of young hatched during the pre-rain drought would indeed be slim. We found young quail and adults eating quantities of insects in July and August. Some of these insects, we reason, are made available when rain breaks the dormant period. The sprouting and flowering of plants is for the same reason coincident with the appearance of associated insects. Insects which are both succulent and rich in protein are doubtless the key item in the diet of quail chicks as they are for other gallinaceous birds. Perhaps, also, young Montezuma Quail require water, although adults do not. There is plenty of rainwater for drinking in summer. In any event the correlation between summer rain, plant growth, and nesting of the Montezuma Quail is definite, and this is shown graphically for our study area on the Río Gavilán in figure 6.

One writer (Swarth, 1909:43) speculated that summer rains may be the direct cause for late nesting. He states that "it is possible that the heavy summer rains that occur in the regions inhabited by this species destroy many of the earlier sets of eggs, thus forcing the birds to bring out their young later, but the same reasoning would apply to other species not so conspicuously dilatory."

The fact that there is a lack of cover prior to the greenery fostered by the rainy period was thought by Campbell (1934:202) to be at least one of the reasons why midsummer nesting is of some survival value. Speaking of an area in southern Santa Cruz County, Arizona, he stated that "the ranchers in the region who are rather sharp observers, maintain that the birds nest in the rainy season, in other words, in July and August. This I was unable to verify, though I believe it to be true. This is the only time they would have adequate cover." We doubt that cover is a critical issue in the timing of breeding.

Aviary-bred quail at Green Lake, Wisconsin (about 44° N) gave us a chance to make comparisons with conditions in the southwest at Tucson, Arizona (about 32° N). The north-south distance between these two points is roughly 650 miles. Kirkpatrick and Leopold (1952) and Glass and Potter (1944) call attention to the effect of photoperiodism on the sexual physiology of the Bobwhite Quail. From these works it seemed logical to assume that captive Montezuma Quail breeding in Wisconsin would respond to light intensities comparable to those occurring during the breeding season in their native range (Tucson, Arizona).

In terms of day length, both places have about the same number of hours of light on March 21 (and again on September 21), but Green Lake builds up more rapidly so that at the peak of day length on June 21, there is about 70 minutes difference between Green Lake and Tucson. The longest day at Tucson is 14 hours and 10 minutes. This day length occurs at Green Lake on May 1.

In the wild, Montezuma Quail begin to lay at the earliest about June 1, or 20 days before the peak period of day length. At Green Lake, Wisconsin, the same period of day

length would come about April 10. The onset of laying in the Heft aviary at Green Lake, for at least three years, has been in mid-June (June 10, 1952; June 11, 1953; and June 19, 1954), the same time as for the Montezuma Quail in Arizona. What this means is not clear. It appears, however, that the breeding cycle of pen-reared birds in Wisconsin does not respond to the same photoperiod as wild raised birds in the Southwest.

In summary, the timing of the nesting season is such that broods appear shortly after rains have made dormant plants sprout green leaves and flowers. At this time, also, there appear to be plenty of free water, succulent plant parts above the ground, and an abundance of succulent insects. This period in the range of the Montezuma Quail occurs in July and August.

Nest, eggs, and incubation.—The Montezuma Quail, like all New World quails (Odontophorinae) builds its nest on the ground. Unlike the nests of other members of this group, those of the Montezuma Quail are domed or roofed over. Some writers (Bailey, 1902; Headstrom, 1951) have indicated that the cavity is partly arched over, while Poling (in Bendire, 1892) claimed that it is so completely roofed as to require a tunnel entrance. Falvey (1936) adds that the nest is so thoroughly roofed over as to be "practically waterproof." The best nest description is given by Wallmo (1954:126) who noted that "the nest [no. 1] was placed against the base of a small Arizona oak and consisted of a chamber sparsely roofed with bedstraw (*Galium* sp.) and bullgrass (*Muhlenbergia emersleyi*). The floor was lined with dry leaves of Arizona oak. Interiorly it was about 5 inches wide and 4 inches high."

A scrape is made prior to nest construction, and according to numerous authors varies considerably in depth. G. W. Todd (in Bent, 1932) recorded one so deep as to make the top of the nest level with the surrounding ground.

No one has recorded observing the Montezuma Quail building a nest in the wild. Falvey (1936), however, claimed that a captive male and female jointly constructed a nest. This cooperative effort seems to be in keeping with the general attentiveness shown by the male during the breeding season. Falvey also stated that the hen covers the nest entrance after laying. We assume this refers to the period when the eggs are being deposited in the nest. Once laying is completed and incubation is underway, it seems unlikely that the entrance would be closed. Pearson (1917) and St. John (in Wallmo, *loc. cit.*) also pointed out that the nest entrance is sometimes sealed. This act appears comparable to egg covering during the laying period by other ground-nesting galliforms. It is little wonder that nests are difficult to find if they are roofed over and sealed.

The eggs of a Montezuma Quail are chalky white. They are similar in appearance to those of the Bobwhite, except that the apex is noticeably less pointed. Twenty eggs measured by us averaged 32.2 mm. (31–34) by 24.9 mm. (24–25.5), which dimensions do not differ significantly from measurements given by Bent (1932) and others.

We found no information on egg weights in the literature. However, we were able to obtain the weights of 15 fresh eggs from two females kept at the Elmer Heft Aviary, Green Lake, Wisconsin. The mean weight was 10.59±.25 grams and the heaviest and lightest eggs weighed 11.2 and 10.2 grams, respectively.

Clutch size varied from 6 to 16 eggs. All available records of clutch size were taken from the literature and to these data were added records of egg collections from a number of museums and private egg collections. When the data were plotted, a peculiar curve resulted (fig. 5), with peaks at 10 and 13 eggs. This variation was very likely the result of our small sample. Numerous accounts list the clutch size as an indefinite number, "about 10" or "8–12." It was difficult to tell when one author was quoting another; in no case were such data used in the graph. No generalized clutch size ranged over 12. The average for the exact records was 11.1 eggs per clutch.

The seasonally late start in nesting virtually precludes the possibility of a second nesting. Only Falvey (1936:241) claimed that a second clutch is laid. We collected a female on August 20 with a completely formed egg low in the oviduct. It might be assumed that this bird was attempting a second nest, but on examination we found only nine ruptured follicles in the ovary. This case indicates instead that a first nesting can occur as late as August 20. Four other ovaries were examined for ruptured follicles, and the counts were 12, 13, 13, and 16, respectively. Some of the enlarged follicles remaining after the last egg was laid could have become atretic and appeared as ruptured follicles. Under penned conditions where eggs are removed to perpetuate laying and discourage broodiness, a female may lay as many as 35 to 40 eggs. Two birds laid 62 eggs in the Heft aviary in 1953, one contributing about 40 eggs.

The incubation period previously has been unknown. Falvey (1936:227) had a reasonably good record of a clutch gathered in the wild and set under a bantam. He states of this clutch that "on the twenty-first day they started to pip their eggs, and all were out by the twenty-fourth day." The circumstances, too long to discuss here, were such that the assumed incubation period could have been in error by 24 to 28 hours.

At the Elmer Heft aviary in 1953 two clutches of fresh eggs that had been gathered daily from two laying hens were incubated. One clutch was placed in a standard electrically controlled incubator and the other set placed under a bantam. The eggs placed in the electric incubator hatched in 25 days and those under the bantam in 26 days. Another incubator setting in 1954 came off in 26 days. The incubation period as we have used it is the interval from the onset of incubation to the emergence from the egg of the last chick in a given clutch.

The speed of emergence may vary according to attentiveness of the hen, climatic conditions, and clutch size, but in any event it should have no appreciable effect on the incubation period. The following is an excerpt from McCabe's field notebook, concerning the 15-egg clutch hatched in the electric incubator: "These eggs began pipping Thursday, August 6, 1953, some time during the morning. The first bird was out of its shell and partly dry between 11:00 a.m. and 12:00 noon on Friday. All were hatched by 5:00 p.m. except three that were infertile." It appears that it takes between 24 and 36 hours from the onset of pipping to the hatching of the last egg. This interval is shorter than observed by Falvey (*loc. cit.*) for a clutch hatched by a bantam.

The incubation period according to our findings is therefore 25 to 26 days, which is a day or two longer than that in other North American quails.

Care of young.—Montezuma Quail broods are reared by both parents. The male is attentive and assumes an equal share in bringing up the brood. Bent (1932:86) quotes Frank C. Willard to the effect that both sexes incubate and that "in about half of the nests examined the male was on the eggs." How common this is has not been verified, since there were no other records of follow-up examination once a nest was found. Floyd Johnson of Colonia Pacheco, Chihuahua, told us that he once flushed a female from her nest and a male apparently sitting beside the hen also flushed. He has seen a number of nests but has never observed the male incubating. It is likely, however, that the male shares in incubation in the light of his ardent attentiveness toward the brood.

In our experience, the male never deserted the young when the brood was discovered. The female is no less active in protecting and caring for the brood. On one occasion in the Gavilán River area of northwestern Chihuahua, a pair and brood were encountered. The male immediately feigned injury and floundered about in the grass. The female concentrated her efforts on one of our horses. Twice in rapid succession she hovered in the horse's face, weaving back and forth in the air like a hummingbird. In the confusion that ensued, the young made good their escape into the tall grass.

In the same area one evening we came upon a family that had gone to roost on the side of a mesa in the shelter of zacate (*Muhlenbergia* sp.) and a prickly ceanothus patch (*Ceanothus huichagorare*). The male, with crest spread, looked twice normal size. Protruding from under the extended breast feathers was the entire brood of about eight chicks which were two to three days old. The female was only a few feet away. Both birds remained motionless for a moment and then began to vocalize with a husky churring sound and dashed madly about. We caught several of the chicks whose frantic peeping called the adults into view several times. In this encounter also, a good view was had of the lateral spreading of the crest on the male. The young were released and the brood re-assembled higher up the slope. This brood was never again seen in the same area, although several attempts were made to relocate it at roosting time.

On another occasion, the male was much more tenacious in staying with a brood after it was discovered than was the female who retreated to safe distance. The male fluttered very close to the intruder and only after the brood was well hidden did he attempt to escape.

Broods.—The degree of mixing of broods is undoubtedly a function of population density. The brood with two age classes observed by Wallmo (1954) occurred when the birds were more numerous than they had been for many years. Since the Montezuma Quail rarely attains the high densities reached by most other quails, there is little likelihood of numerous broods of mixed age groups. That such broods exist, however, is attested by Kennerly (in Baird, Brewer, and Ridgway, 1875), who claimed that October and November coveys contained birds of various ages from the "very small and partly fledged to the full grown bird."

The amazing speed with which the chicks can scatter and hide is common knowledge to those who have observed a brood in peril. It is often impossible to get even an approximation of the brood size, so that exact brood counts are rare. Brood data recorded in the literature that were reasonably precise, plus our own of like quality, are shown in table 3. Only those records in which the group was obviously a brood and not a covey were used. The average size of ten broods was 8.4—about three birds less than the average clutch size of 11.1. Wallmo's data, which include only those groups in which the young could be distinguished from the adults, show an average of 6.6 birds per brood. The calculated hatching dates range from July 1 to August 28.

Growth of young.—The newly hatched Montezuma Quail weighs about 7.7 grams (14 specimens). On an average, the shell, egg membrane, allantois, and extra body fluids weigh only 2.9 grams. An egg and day-old chick are shown in figure 7.

The young from two sets of eggs hatched in captivity 11 days apart were weighed at 6 to 10-day intervals for 12 weeks after which several additional weighings were made in order to ascertain the adult weights. Adult weight, as we use it here, is that attained at the time when the bird is full-winged and in complete first winter plumage. The growth data are shown in figure 8. The growth rate follows the typical sigmoid curve, reaching an asymptotic level at about 190 grams. The average weight of wild adults (both sexes together) was 188.6 grams, indicating a very close correlation with the weights attained by the hand-reared birds. A cock and a hen, weighed only once at 25 weeks, weighed 202.7 and 174.1 grams, respectively, indicating that handling birds weekly had no effect on their adult weights. The adult weight was reached in 10 to 11 weeks by the aviary birds. How long it would take in the wild is a matter of conjecture, but in general the growth curve in figure 8 appears to be normal for what we know of wild gallinaceous birds.

The contour feathers of the first winter plumage are complete by 15 weeks, but the eighth primary (nos. 9 and 10 are not shed in the postjuvenal molt) which sheds in the

Table 3

Montezuma Quail Broods

Date observed	Size	Approximate age	Calculated hatching date	Authority
July 11	? (1)	10 days	July 1	This study
July 12	? (1)	1 day	July 11	This study
July 16	2	.....	.....	Wallmo (1954)*
July 20	? (3)	2–3 days	July 17	This study
July 25	7–8	3 days	July 22	This study
July 27	12	1 week	July 20	Bendire (1892)
July 29	9–10	3 days	July 26	This study
Aug. 3	10	.....	.....	Wallmo (1954)
Aug. 4	5	.....	.....	Wallmo (1954)
Aug. 5	5	.....	.....	Wallmo (1954)
Aug. 9	8	5 days	Aug. 4	This study
Aug. 9	8	2 days	Aug. 7	This study
Aug. 9	6	⅔ grown	.....	This study
Aug. 10	8–10	1 week	Aug. 3	Wheeler (1875)
Aug. 12	9	.....	.....	Wallmo (1954)
Aug. 12	6	½ grown	.....	This study
Aug. 15	6–8	5 days	Aug. 10	This study
Aug. 31	12	3 days	Aug. 28	Bendire (1892)
Sept. 7	7	.....	.....	Wallmo (1954)
Sept. 28	11	.....	.....	Wallmo (1954) 2 age classes in this brood
Oct. 6	7	.....	.....	Wallmo (1954)
Oct. 6	7	.....	.....	Wallmo (1954)
Oct. 9	4	.....	.....	Wallmo (1954)
Oct. 30	11	.....	.....	Wallmo (1954)
Oct. 31	1	.....	.....	Wallmo (1954)

*Wallmo states (p. 125), "These brood counts may not in all instances represent the entire brood."

Table 4

Age in Days at which the Primary Feathers are Dropped in the Postjuvenal Molt of Various Gallinaceous Birds

Primary	Ring-necked Pheasant	Hungarian Partridge	Bobwhite Quail	Montezuma Quail	Wild Turkey
1	28	28	28	?	39
2	35	35	35	?	46
3	40	42	42	42	53
4	46	49	49	49	60
5	56	56	56	56	67
6	63	63	63	77	81
7	70	77	74	98	98
8	77	91	102	119	133
9	84	....	....	....	....
10	91	....	....	....	....

Bobwhite: Petrides and Nestler (1943).
Hungarian Partridge: McCabe and Hawkins (1946).
Pheasant: Buss (1946).
Wild Turkey: Leopold (1943).

17th week, is not replaced and fully grown until the 19th week (133 to 135 days). Feather replacement and growth may be accelerated in the wild. The rate of primary replacement compared with several other upland game birds is shown in table 4. Unfortunately we did not determine at what age primaries one and two were shed by Montezuma Quail, but from the close correlation with the molt pattern in the Bobwhite and Hungarian Partridge (*Perdix perdix*), the beginning of the sequence in Montezuma Quail should be about the same. The lag in shedding of primaries 6, 7, and 8 is more like that found in the Wild Turkey (*Meleagris gallopavo*). The Ring-necked Pheasant (*Phasianus torquatus*) as shown does not hold juvenal primaries 9 and 10 into the first winter.

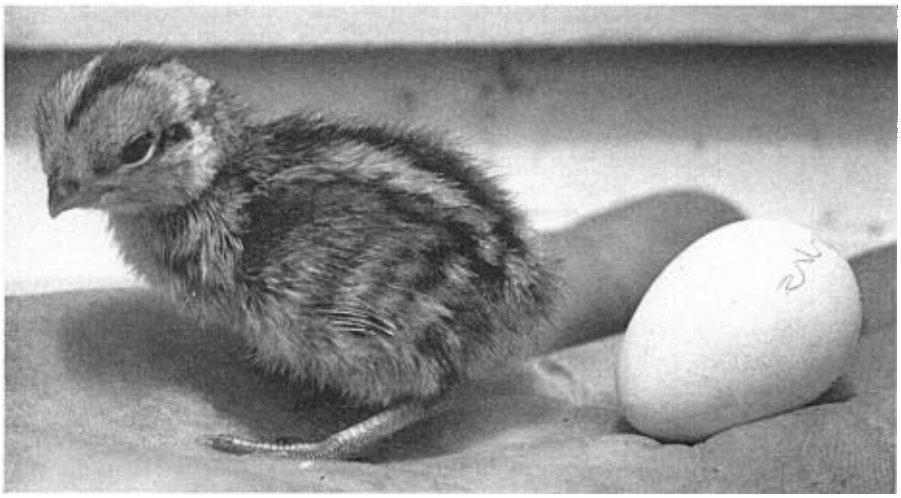

Fig. 7. Egg and day-old chick of Montezuma Quail (Heft aviary).

The data in table 4 may have suffered slightly in reducing fractions of weeks, given in the original sources, into days used in the tabulation. The variation within each species is doubtless greater than the error in reducing all time data to days. The molt sequence could be used as a crude indicator of age.

FOOD HABITS

To our knowledge there is no single paper in the ornithological literature dealing at any length with the food habits of *Cyrtonyx*. Martin, Zim, and Nelson (1951), in their valuable summary of plant foods of American wildlife, list a total of only 39 specimens of Montezuma Quail available to them for study, none of which came from the spring or fall season.

The Montezuma Quail is a bird of México and the arid southwest and must therefore adapt itself to long rainless periods. Plants of such a region must likewise adjust to prolonged drought. One of the ways this is done, particularly by perennial herbaceous plants, is to form bulbs or tubers which can survive seasonal droughts. These dormant plants, high in stored nutrients, are dug up and eaten by the quail. Morphologically *Cyrtonyx* is well equipped for digging with its stout legs and long toes and claws, as has been shown by Miller (1943).

With the coming of the summer rains and lush vegetation the annual crop of insects

becomes available and the quail shift their diet from plant to animal foods. Unfortunately the seasonal picture of the ratio of animal to vegetable food is incomplete. Martin, Zim, and Nelson (*loc. cit.*) show that 71 per cent of the winter diet is made up of vegetable matter, while in the summer only 3 per cent is vegetable. Our quantitative data were gathered in summer but at a time when the rains were just beginning. In all, we collected and analyzed the crops of only 15 Montezuma Quail, although many more were examined in the field at other seasons and in other places. If 0.05 cc. is arbitrarily

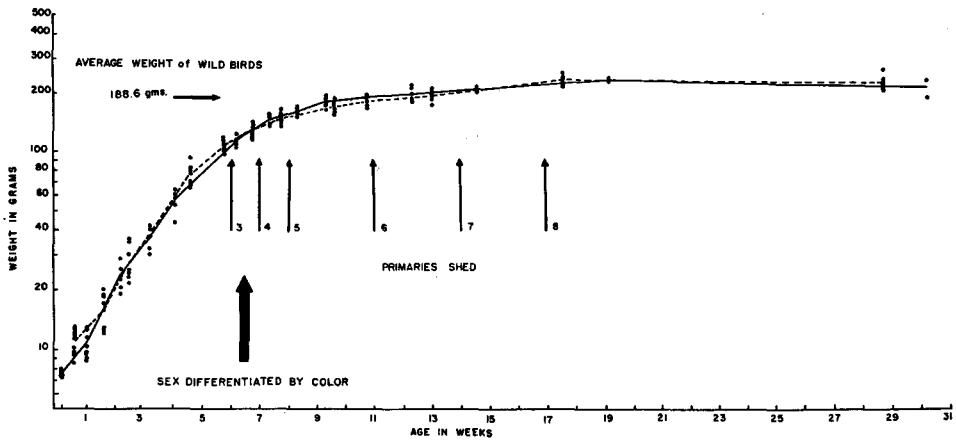

Fig. 8. Weight curve and records of primary feather replacement obtained from two broods of pen-reared Montezuma Quail (Heft aviary).

allowed for each item listed as a *trace,* on a volumetric basis we found that 38 per cent of the food eaten in summer was vegetable. Neither the data presented here nor those of Martin, Zim, and Nelson are sufficient to be more than suggestive on a seasonal basis.

Plant food.—No single investigation lists many different food items but when a number of such investigations are taken in aggregate the list becomes rather long. Thus in grouping ten earlier studies with our own, 24 plants from 18 different families are known to be eaten by Montezuma Quail (table 5).

The most frequently recorded item in the diet of this quail is the general category "bulbs." Identification of plant bulbs is difficult and frequently no specific plant names accompany field records. For this reason complete scientific names for bulbs are not used in the table. Our experience in identifying bulbs and tubers was disappointing. Only after much trial-and-error digging at likely feeding sites were we able to locate bulbs similar to those we had found in quail crops. In many instances it was impossible to find bulbs even by digging in areas where quail had fed. A number of bulbs taken from quail crops and planted in a greenhouse failed to grow. It was only when a recognizable portion of a bulb adhered to the roots of a sprouted plant that the kind of plant could be determined. A few species were identified in this way. Throughout the Mexican range of *Cyrtonyx* these bulbs are paramount in the winter diet. The bulb of nut grass, *Cyperus esculentus,* we feel is most common although positive identification is difficult. Some bulbs tasted nutty, others were onion-like, some tasted starchy like a potato, and others were tasteless.

Montezuma Quail diggings are very typical (fig. 9). The bird digs a hole about two inches long, one inch across, and from two to three inches deep. Soil is usually pulled to one side of the cone-shaped excavation, the open end of which is oval. The apex is pre-

Table 5

Food Items Eaten by Montezuma Quail

Plant

Family	Genus-species	Common name	Part eaten	Reference
Fagaceae	*Quercus virginiana*	live oak	acorns	x, 2, 4, 5, 8, 9, 10
Liliaceae	Sp.	lily	bulbs	x, 2, 6
	Echeandia terniflora	lily	tubers	x
	Brodiaea sp.		bulbs	10
Cyperaceae	*Cyperus esculentus*	sedge	bulb	x, 5, 7, 10
Leguminosae	Sp.	legume	seed	x, 2
	Acacia	acacia	seeds	2
Gramineae	*Triticum aestivum*	wheat	seeds	x
	Zea mays	corn	seeds	10
Solanaceae	*Physalis* sp.	ground cherry	fruit	x
Ranunculaceae	*Ranunculus geoides*	buttercup	tubers	x
Cactaceae	*Opuntia* sp.	prickly pear	fruits, seeds	1, 6, 10
Euphorbiaceae	?	spurge	seeds	2, 10
Ericaceae	*Kalmia latifolia*	mountain laurel	fruits	2, 4, 5
	Arbutus sp.	madrone	fruits	2, 4
Pinaceae	*Juniperus* sp.	juniper	fruits	2, 4, 5
	Pinus cembroides	piñon pine	seeds	2, 7
Zygophyllaceae	*Kallstroemia maxima*	caltrop	fruit	10
Oxalidaceae	*Oxalis* sp.	wood sorrel	bulbs	10
Anacardiaceae	*Rhus* sp.	sumac	fruits	7
Polygonaceae	*Eriogonum* sp.	eriogonum	foliage (seeds?)	10
Convolvulaceae	*Ipomea* sp.	morning glory	seeds	10
Compositae	*Helianthus* sp.	sunflower	seeds	10
Linaceae	*Linum* sp.	flax	green fruits	x

Animal

Scientific name	Common name	Reference
Hymenoptera	unidentified 4-winged insects	x
Formicidae	ants	x
Diptera	flys and maggots	x, 10
Lepidoptera	larva or caterpillars	x, 1, 2, 10
Coleoptera	beetles	x, 10
Rhynocophera	weevils	x, 1, 2, 10
Coccinellidae	lady beetles	x
Tenebrionidae	darkling beetles	10
Carabidae	ground beetles	10
Homoptera		
Cicadellidae		
Manzutus multilineata	leaf hoppers	x
Orthoptera		
Locustidae	grasshoppers	x, 1, 2, 3
Gryllidae	crickets	3
Isoptera	termites	x
[larva unidentified]		1, 2
Araneida	spiders	1, 10
Chilopoda (class)	centipedes	10

References: 1, Bailey (1902); 2, Bailey (1928); 3, Cassin (1862); 4, Bendire (1892); 5, Grinnell (1910); 6, Judd (1905); 7, Ligon (1927); 8, Miller (1943); 9, Van Tyne and Sutton (1937); 10, Martin, Zim, and Nelson (1951); x, this study.

sumably the site of the bulb. Dried hulls which encased them could usually be found in or near the holes from which the bulbs were dug. Diggings occurred in many places within the quail habitat, but were most frequent along dry mesa slopes. Quail commonly scratched and dug around the edges of large buried stones or boulders and at the base of grass clumps.

Acorns are probably the most abundant, available, and nutritious of the foods to be found in the pine-oak forest biome. Miller (1943) comments on the importance of acorns

Fig. 9. Typical digging of Montezuma Quail. The hole is about two inches deep, and on the mound of dirt are hulls (arrow) of the bulbs that were dug up and eaten.

Fig. 10. Leafhoppers, grasshoppers, and miscellaneous seeds found in crop of a Montezuma Quail (Río Gavilán, Chihuahua, August 12, 1948).

as food for Montezuma Quail, and we likewise have noted them in many crops. The bird seems to be able to remove the hull and eat only the meat. The occurrence of domestic grains in some quail crops indicates that the birds occasionally use cultivated fields as a source of food, but this is not customary.

Animal food.—Insects in general are dependent on green plants. With the coming of the rains, dormancy is broken in bulbs and tubers, and green foliage appears. Moisture also promotes the maturation and breeding of many insect forms. Relative abundance of insects may be indicated by the amount of green vegetation and this in turn by the number of plants in first bloom following the onset of the rainy season. These data for northern Chihuahua have already been presented in figure 6. Quail diet shifts from vegetable to animal food in this period of lessened availability of bulbs (which have sprouted) and the greater availability of insects living on the growing plants.

Insect food appears to be a matter of feast and famine. Only the records from June, July, and August show an appreciable amount of animal food (68 per cent of the over-all diet). Birds collected in January, April, October, and November had eaten predomi-

nantly vegetable matter. When insect food was available it was eaten avidly. For example, the crop of one adult male which we collected contained 115 lepidopterous larvae, a grasshopper and a small amount of vegetable matter. Another had in its crop 111 leaf hoppers (*Manzutus multilineata*), 5 grasshoppers, and 14 small seeds (fig. 10).

We found no evidence that these quail feed anywhere except on the ground.

Water needs.—Vorhies (1928) kept two immature *Cyrtonyx* in an enclosure for two and one-half months without water with no apparent ill effects. Seeds, an occasional boiled egg, and bits of apple were the only food given these birds. They foraged for grasshoppers in the early part of their confinement. One bird died from unknown causes and the other lived an additional month and a half before it was turned over to an aviary.

We found Montezuma Quail in abundance in the absolutely waterless Cerro Hueco in the state of Michoacán. There is no livestock in this area because of the water shortage. In several other instances Montezuma Quail were found in areas far removed from a water source. McCall (1852) remarks on their occurrence in areas of west Texas where water was scarce.

The only report of drinking we were able to find is one record by Smith (1917:162) who stated, "I flushed a single bird September 26 while it was drinking at a tiny stream flowing in a deep canyon, at an altitude of 6500 feet." However, Montezuma Quail frequently forage along stream banks, so that merely flushing a bird would not constitute proof that it was drinking. We have never opened a crop that contained water.

Montezuma Quail very likely drink dew when it is available, but we believe their ability to withstand arid conditions is primarily a matter of obtaining water from their food.

POPULATIONS

Sex and age ratios.—Our only sources of sex and age data in populations of Montezuma Quail are the specimens that we ourselves collected plus additional museum specimens on which we have records. In the case of other quails, museum specimens have been found to give a fair cross section of normal sex and age distribution, "normal" being determined by such other sampling methods as hunting-bag checks and trapping records. Admittedly there may be some selective shooting of adult male Montezuma Quail, in fact we ourselves have on occasion chosen males when there was time and opportunity to be selective. So we cannot say that our sample accurately represents the normal distribution of sex and age groups in the wild. However, it is the best we have.

Of 57 Montezuma Quail in the collections of the Museum of Vertebrate Zoology at the University of California, the categories are represented as follows:

	Adults		Immature		Total
	Male	Female	Male	Female	
Number	13	9	20	15	57
Percentage	23	16	35	26	100

Sex was recorded from the labels. Age was determined from the appearance of the greater upper primary coverts as described by Leopold (1939). The differences between adult and juvenal coverts are subtle, but they can be recognized. Adult coverts are clearly barred or spotted with whitish buff; juvenal coverts are mottled with ochraceous buff.

From the preceding sample, therefore, the age ratio is 39 per cent adults and 61 per cent juveniles, or 156 young:100 adults. This is average for arid-land quails which generally run between 50 and 70 per cent young.

The sex ratio in this sample is 58 per cent males, 42 per cent females, or 138 ♂ ♂:

100♀ ♀. We have a much larger sample by including other museum specimens on which we have sex but not age data. In 502 such specimens we find a sex ratio of 63 per cent males and 37 per cent females, or 170♂ ♂:100♀ ♀. The weighting of males might be real or might be an artifact of selective collecting.

This can be checked by segregating sex data on juveniles, which presumably would not be selectively taken. There were 98 specimens designated as juveniles in the museum records sent to us (for example, "partly downy young," "bird one-third grown," or "bird in juvenal plumage"), of which 63 per cent were also male. The collecting bias, if it exists, would likely not hold for these comparatively drab young, yet the percentage of males is identical with the adult sample. Another sample of 84, including downy young less than three days old, 22 of which were collected in the wild but most of which were hatched in the Heft aviary, showed 50 males to 34 females, or 59 per cent males. Although the sample is not statistically significant, there is a strong suggestion that the discrepancy begins at hatching, which is contrary to the conclusion reached by Leopold (1945) regarding the excess of males in Bobwhite populations.

Fluctuations in population density.—We have only two estimates of actual populations of Montezuma Quail. Wallmo (1951) records the presence of at least 45 birds on about 1120 acres in the Huachuca Mountains of Arizona, or 26 birds per section. In the summer of 1948 we attempted a rough census of quail in the Gavilán basin of northern Chihuahua. All encounters with Montezuma Quail, as well as signs of fresh scratching, were recorded and mapped, from which data we estimated a minimum population of 28 to 30 adult quail per section. These may be considered conservative counts in fairly well populated range. In other parts of México, and in the Gavilán area itself ten years earlier (winter 1937–38), there existed much higher numbers of Montezuma Quail, but we failed to record estimated densities.

In any given area, the population of these quail may go up and down violently. Swarth (1904:4) illustrates the ephemeral nature of Montezuma Quail populations when he stated that "in the summer of 1896, with four of us scouring the mountains [Huachucas] daily, but two pairs of birds were seen, though two years later in 1898, Mr. O. W. Howard found them to be most abundant in the same region. In 1902, in spite of all our efforts, Mr. Howard and I were unable to find a single bird, and in the following year, 1903, though informed of their occurrence in various places by inhabitants of the mountains, I saw just three myself." Wallmo (1951) working in this same region of Arizona 50 years later found this quail to be relatively abundant.

One cause of sudden decline in Montezuma Quail is periodic winter mortality resulting from abnormally deep snow. Such a case was reported to us by Floyd Johnson of Colonia Pacheco, Chihuahua, where between January 6 and 22, 1946, a heavy snow fell in the table lands covering the ground up to 16 inches on the level. The temperature dropped to −20°F. This period of severe weather killed off nearly all the quail in that region. Ligon (1927) and O'Connor (1936) also called attention to the lethal effects of a deep blanket of snow that prevented the quail from digging in the ground for food. Severe weather very probably limits the range of the species to the north and on high peaks.

Another adverse weather factor is drought, which might well preclude successful nesting. Smith (1917) recorded a drop in population following several successive dry years, and in various parts of México we were told by native people that lack of rain was a cause of quail shortage. Certainly this is true of other arid-land quails. The effect of drought upon the quail is complex and may involve inadequate nutrition of the adults, lack of moisture to hatch the eggs, or lack of insects to rear the young.

Long-term downward trends in local populations of this quail are usually a result of

increased grazing, a factor already discussed. As land-use pressure increases in México there is a tendency to spread domestic livestock into all parts of the mountains where water exists or where it can be impounded or otherwise provided. This is by far the most critical factor in regulating quail numbers.

Mortality.—We have virtually no direct evidence of predation on the Montezuma Quail, although this bird is probably as vulnerable as any other quail. Ligon (1927) considered the Cooper Hawk (*Accipiter cooperii*) one of the main predators. This statement, which is doubtless correct, has been parroted by other writers, but we find no published records of Cooper Hawks killing Montezuma Quail. Miller (1943) described the attack of a Loggerhead Shrike (*Lanius ludovicianus*) on an adult quail, but no damage was done. It is also his opinion that the coati-mundi (*Nasua narica*) and peccary (*Pecari tajacu*) cause nest destruction. We, too, feel that these mammals are the most likely nest predators, along with the raccoon (*Procyon lotor*) and the several species of skunks (*Mephitis, Spilogale, Conepatus*).

We came upon the scattered remains of an adult male Montezuma Quail at Casita, Sonora, and from the sign attributed the kill to an owl (probably the Horned Owl, *Bubo virginianus*).

O'Connor (1936) presented to the sportsmen a long list of "suspected" predators of Montezuma Quail. Prominent in the list is the coyote (*Canis latrans*). Gorsuch (1934) working with the more abundant Gambel Quail (*Lophortyx gambelii*) in what might be considered excellent coyote habitat found coyotes did not deliberately prey on Gamble Quail and were not believed to be of importance in reducing quail numbers. Predation on Montezuma Quail is even more unlikely because of fewer quail and fewer coyotes in the latter's range.

In general, there is no evidence that these quail suffer excessive loss through predation. Similarly there is no record of diseased birds or losses that could be attributed to a pathogen.

Hunting is a negligible cause of mortality in most of the range of Montezuma Quail. The bird is protected in the southwestern United States and is not large enough or abundant enough to attract the attention of many native hunters in México. The species is hunted to a limited extent by sportsmen of Mexico City and some other urban centers. There are statements in the literature that hunting is a critical factor. López and López (1911) described the habit of the coveys of scattering after a short flight and holding well for single shooting (with dogs) and because of this behavior they asserted that "it is favored by hunters and . . . is growing steadily scarcer" (our translation). Vorhies (1928) attributed the scarcity of the bird in Arizona to past as well as current hunting. In our opinion hunting has no bearing whatsoever on populations. In point of fact, the Montezuma Quail is a fine game bird and its hunting, where it is reasonably numerous in México, should be encouraged.

SUMMARY

The Montezuma Quail is a common resident of the Mexican highlands, specifically of the pine-oak vegetation zone. The association between this quail and the pine-oak forest is so universal that the bird may be considered an avian indicator of the type.

Within the pine-oak zone, the highest quail populations are found in ungrazed areas where there occur many bulb-bearing forbs and sedges in the understory. In the dry season Montezuma Quail feed heavily on bulbs which they dig from the ground. Grazing eliminates these plants and hence eliminates the quail.

Winter coveys of Montezuma Quail are small (7.6 birds) and seem to be family units. Pairing occurs in April and May, nesting from May to July. The period of incubation is 25 to 26 days. Most young hatch in July and August when the summer rains

have induced plant growth and there is an abundance of insects on which chicks and adults feed. Both parents help rear the chicks. By October the young are essentially grown and coveys are established on winter ranges. At this time the birds have shifted back to bulbs as the staple diet.

Populations vary in density from place to place according to the quality of the habitat. They also vary locally from year to year with effects of weather. Either cold, snowy winters or dry summers will suppress populations.

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