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James R. Heffelfinger
Arizona Game and Fish Department

Ronald J. Olding
Arizona Game and Fish Department

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MONTEZUMA QUAIL MANAGEMENT IN ARIZONA

James R. Heffelfinger

Arizona Game and Fish Department, Tucson, AZ 85745

Ronald J. Olding

Arizona Game and Fish Department, Tucson, AZ 85745

ABSTRACT

The Montezuma quail (*Cyrtonyx montezumae mearnsi*) has substantially different habitat requirements than other quails found in the U.S. They inhabit evergreen oak woodlands of mountain ranges in the Southwest and feed primarily on underground bulbs and tubers. Populations respond to summer precipitation because the vegetation which provides food and cover for Montezuma quail flourishes after the summer rains. Moderate to heavy grazing increases availability of Montezuma quail food plants, but resultant lack of cover precludes use of such sites. Montezuma quail avoid areas with greater than 50% forage utilization by ungulates. As with other Arizona quail species, hunting has been shown to have limited or no impact on the population level during the following years. Birds may be depleted in localized areas temporarily, but available habitat is re-occupied when pre-nesting dispersal occurs. Annual pre- and post-hunt flush counts were conducted 1988–1996 by the Arizona Game & Fish Department, United States Forest Service, volunteers, and local quail hunters. Average covey size decreased during the hunting season, but the magnitude of the decrease was similar in unhunted populations. Montezuma quail populations fluctuate in response to habitat and weather conditions. A state-wide hunter questionnaire program estimated total harvest trends for Arizona. In addition, wing collection barrels had been placed in heavily hunted areas from 1981 to 1996 to obtain hunter-effort information and sex/age characteristics of the harvest. Data from these wings indicate average percentage of juveniles in the harvest was higher for Montezuma quail ($\bar{x}$ = 74.4%, range = 55.9–84.9%) than other Arizona quail species, such as Gambel's ($\bar{x}$ = 65.6%, range = 23–77%). Hunters harvested an average of 2.2 Montezuma quail per day. In 3,107 hunter-days during this period, only 13 (0.4%) resulted in a limit of birds. Three of these limits occurred in 1996 when the bag limit was reduced from 15 to 8 Montezuma quail.

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INTRODUCTION

Montezuma (also known as Mearns', Fool, Harlequin, Massena) quail (*Cyrtonyx montezumae mearnsi*) are present in most of the mountain ranges in Mexico, southeastern Arizona, southwestern New Mexico, and southwestern Texas (Leopold and McCabe 1957, Johnsgard 1973, D. Brown 1989; Figures 1 and 2). The range of Montezuma quail overlaps almost entirely with evergreen oak woodlands from 3,500 to 5,500 feet elevation (1,077–1,692 meters), which in the United States is almost entirely National Forest land (Figure 3). Montezuma quail habitat is best described as an open woodland consisting of evergreen oaks (*Quercus spp.*) and junipers (*Juniperus spp.*). A perennial grass understory (<45% utilization by cattle) and tree cover greater than 20% are essential, because Montezuma quail rarely venture farther than 45 yards (41.5 meters) from the edge of the trees (R. Brown 1978).

At night, Montezuma quail roost on the ground in tall grass. They huddle close to conserve heat. The roost site varies each evening, but is generally on a hillside near habitat structure which provides additional thermal cover (Stromberg 1990). As the morning air begins to warm, the covey will leave the roost site and begin feeding in a close group. Foraging generally begins low on the slope in the morning and progresses uphill. Crops are generally full by late afternoon, when

the quail work their way back down to the base of the slope to roost. Daily movements are typically very restricted with estimated covey use areas less than 15 acres (6 hectares; R. Brown 1976, Stromberg 1990).

Montezuma quail feed exclusively on the ground using long curved claws to scratch and dig for bulbs and tubers. Their annual diet is primarily (50–85%) bulbs from wood sorrel (*Oxalis amplifolia*) and flat sedge (*Cyperus rusbyi*); the remainder is made up of seeds and insects (Bishop and Hungerford 1965, R. Brown 1978). Small depressions and scratches resulting from this digging behavior are common in Montezuma quail habitat, and provide evidence of recent habitat use (Leopold and McCabe 1957). Acorns become important during the years when they are abundant but are not a reliable food source every year. Although Montezuma quail occasionally drink water, they appear able to procure enough moisture in the foods they eat, and are apparently not dependent on free water (Leopold and McCabe 1957, Bishop 1964, D. Brown 1989).

The maintenance of grass cover over 6 inches (15 centimeters) in height is extremely important to this quail species because of its defensive behavior of hiding from predators. Montezuma quail are known for their habit of holding extremely tight in cover when approached (Leopold and McCabe 1957). It is easy to nearly step on these cryptic birds before they flush.

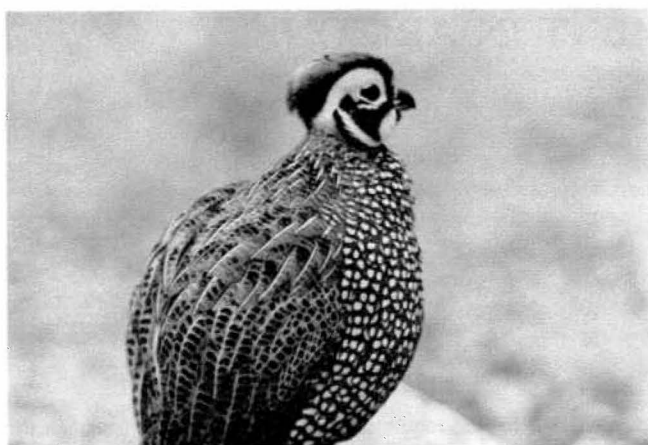


Fig. 1. Montezuma quail are as unique in habits as they are in plumage.

Removing too much cover eliminates this bird's primary defense mechanism and thus probably decreases survival.

Montezuma quail initiate pair bonds during late February. Breeding normally begins in mid-June (Bishop 1964). Nesting starts in late June and young birds are hatched during August (Wallmo 1954, Bishop 1964). This reproductive timing coincides with the summer phase of southern Arizona's bimodal precipitation pattern. Summer "monsoon" storms normally begin during early July, and provide more than 60% of the annual precipitation. Nearly all of the plants Montezuma quail rely on for food and protective cover throughout the year grow in response to summer rains.

The notes of early explorers indicate Montezuma quail were probably more abundant and widespread at the time of settlement than today. During the 1940's and 1950's, interest in this little-known game bird increased. Some people questioned whether it might be numerous enough to offer a unique hunting opportunity, while others thought hunting might jeopardize its existence. In the 1930's, Arizona did not allow the collection of these birds for scientific purposes (Spaulding 1949).

In 1960, the Arizona Game and Fish Commission authorized an experimental 2-day Montezuma quail season in the Santa Rita Mountains, which resulted in the harvest of 45 quail (D. Brown 1989). The following 2 years, until 1963, a 9-day season was authorized. At that time, the season was opened statewide for 25 days (Bishop 1964). By 1965, the season included all of December and January, and 875 Montezuma quail were reported harvested. Today, the season runs from late November to early February and thousands of Montezuma quail are harvested annually.

POPULATION INFLUENCES

Precipitation Relationships

In southeastern Arizona, rainfall occurs in a bimodal distribution, with a peak during winter (November–March) and a larger peak in summer (June–Sep-



Fig. 2. Montezuma quail occupy steep areas, which affords protection from intense grazing and excessive exploitation by hunting.

tember). Montezuma quail population fluctuations are highly correlated with the amount and timing of precipitation that occurs in the summer period (D. Brown 1979). The late-summer flush of food and cover must sustain them until the following summer, because perennial bunch grasses and other oak woodland vegetation do not respond substantially to precipitation during the winter months (Cable 1975). Furthermore, Leopold and McCabe (1957) observed that heavy winter snows suppressed populations because it created a barrier between the quail and their below ground foods.

R. Brown (1978) reported that average fall covey



Fig. 3. Montezuma quail in Arizona inhabit the evergreen oak woodlands which occur almost exclusively on U. S. National Forest land.

size was significantly correlated with preceding June–September rainfall. He observed that egg laying normally began before the summer rains started, and the annual differences in reproductive success were most likely a function of differential survival of young quail. The production of the 2 most important Montezuma quail foods (wood sorrel and flat sedge) shows a positive correlation with rainfall during June–August (R. Brown 1978).

Wing envelopes mailed annually to Montezuma quail hunters were used to calculate trends in reproductive success from 1965 to 1977 (D. Brown 1979). Montezuma quail reproductive success was found to be positively correlated with summer precipitation. These data also suggested that precipitation during the previous summer was also important in determining population levels and accounted for 28% of the annual variation in hunting success (D. Brown 1979). This indicates survival may play a more important role in annual abundance than reproductive success during the current year.

Effects of Grazing

Since the perennial bunch grasses essential to Montezuma quail for year-round cover are strictly summer-growing species, any removal of grasses after the summer growing season (i.e., October) reduces the amount of cover available until the summer rains occur during the subsequent year. Much of Montezuma quail habitat is managed by the U.S. Forest Service under a mandate for multiple use. One of the many user groups of National Forest lands are ranchers who hold long-term leases on allotments for the purpose of grazing privately owned livestock. Under normal precipitation and light or moderate grazing levels, Montezuma quail typically have adequate cover to escape predators and satisfy their thermoregulatory needs.

Leopold and McCabe (1957) hypothesized that livestock grazing in Mexico was by far the most critical factor in regulating the numbers of Montezuma quail. R. Brown (1978) found a direct relationship between the percentage of grass used by cattle and Montezuma quail food production. Since most of the Montezuma quail diet consists of foods that grow below the ground, overgrazing after the summer growth period does not generally remove their primary source of food. In fact, the highest Montezuma quail food production is often found on the most heavily grazed areas. Heavy grazing seemingly increases the amount of Montezuma quail food available by removing grass competition and allowing bulb-producing forbs to flourish.

This increase in abundance of Montezuma quail food produced is, however, almost entirely offset by the resultant lack of cover. The abundant food resources in heavily grazed areas are virtually unused by Montezuma quail because of the lack of protective grass cover. R. Brown (1978, 1982) documented that grazing available forage in excess of 55% by weight can nearly eliminate local Montezuma quail populations. Ninety-five percent of the mated pairs counted

during his study were found in areas having average utilization levels of 45% or less for their entire home range.

Thus, overgrazing limits the total amount of habitat available to breeding pairs and directly limits the size of the breeding population (R. Brown 1978). Dry summers with inadequate or delayed precipitation exacerbate the effects of grazing, because of the below-average production of herbaceous cover and the extension of the survival period with inadequate cover.

Effects of Hunting

Several studies have shown that hunter-caused mortality does not significantly affect the annual population fluctuations of Gambel's and scaled quail populations in Arizona (Gallizioli and Webb 1958, 1961; Gallizioli and Swank 1958; Gallizioli 1965). The steep topography and oak overstory occupied by Montezuma quail provide additional protection for the birds from hunters. Hunters often find it hard to get second (or even first) shots on a covey rise and have great difficulty observing where singles sift back into the grass. The Montezuma quail habit of holding tight further complicates efforts to relocate singles from a flushed covey.

Following extensive research on other Arizona quail species, the Arizona Game and Fish Department began 9 years of Montezuma quail research in 1967. As part of this research, 2 study areas 1,280–1,600 acres (518–648 hectares) were established in the most heavily hunted areas of the state. During the next 6 years, livestock grazing intensity, rainfall patterns, and Montezuma quail population levels were closely monitored on both areas. As predicted, (R. Brown 1969, Yeager 1966, Gallizioli 1967), it was apparent that climatic effects and subsequent changes in food production, rather than the relatively intensive harvest (annual harvest rates ranged from 31–75%), were largely responsible for population changes (R. Brown 1971, 1973, 1975, 1977, unpublished data). R. L. Brown (Arizona Game and Fish Department, unpublished data) reported that annual mortality rates between hunted and non-hunted areas were not different.

The bag limit was reduced from 15 to 10 birds per day for a portion of this study (1970–72), but this did not appreciably reduce the percentage of the population removed during the hunt (R. Brown 1977). An increase in season length during this period also did not result in excessive harvest.

SURVEY DATA

Montezuma quail have proved a difficult bird to survey because of the steep topography and diverse habitat they occupy. In addition, they do not call in a consistent manner, and they are reluctant to flush from cover.

Early attempts to locate coveys were made by playing audio tapes of a calling female (Bishop 1964, Levy et al. 1966). Males consistently answered calls, but only during the period when hens were sitting on

the nests (June 15–July 20). This provided a crude method for locating coveys and calculating an index of the number of breeding pairs on the study area.

R. Brown (1976) investigated an extensive array of possible survey techniques. Attempts to calculate a Mark-Recapture (Lincoln) Index were unsuccessful because he could not capture a sufficient number of birds. An intensive investigation of the use of recorded calls (call counts) was disappointing, with only 43 responses in 2,690 minutes of censusing (39.3 minutes per response, R. Brown 1976). It was estimated that between 0 and 50% of the resident males responded during the sampling period.

Diggings within belt transects were recorded and mapped in an attempt to delineate covey home ranges. This was found to be valuable as a supplement to other census methods, but problems of accurately identifying and interpreting quail diggings in areas of high rodent populations confound this census technique (R. Brown 1976).

R. Brown (1976) determined that the most accurate method for determining distribution and habitat use of Montezuma quail was repeated use of pointing dogs to locate and map covey home ranges. After sufficient time afield in a 2.5-mi² (6.5-km²) study area, he was able to reliably estimate the number of coveys present. By multiplying this figure by the average covey size, he calculated a population estimate. The method appeared to be accurate when the pre-hunt to post-hunt population change was compared to the known harvest of birds from the area. The obvious disadvantage of this method is that field effort required to obtain a reliable population estimate exceeds available personnel resources.

Holdermann (1992) located coveys with the aid of pointing dogs to document occurrence, distribution, habitat use, and relative abundance among different locations in New Mexico. The number of minutes spent searching per covey served as an index to relative abundance. This method provided relative abundance data, but was not subjected to statistical analysis to determine the confidence intervals surrounding these relative differences.

Currently, the Arizona Game and Fish Department coordinates volunteers to conduct pre-hunt and post-hunt flush counts to index changes in the population on the most heavily hunted area of the state (Santa Rita Mountains). Flush counts have been conducted during the weekend before the Montezuma quail season opens and during the weekend after it closes, 1988–1997. Volunteers consist mostly of experienced Montezuma quail hunters and their dogs, although there is variation in the number and quality of dogs. Survey teams consisting of 1–3 dogs and 1–4 people follow a standard route plotted on topographic maps and work the area as if they are hunting. The routes are approximately 1 mile (1.6 km) up the wide, flat-bottomed canyons in typical Montezuma quail habitat. Survey crews work the area where the base of the canyon slope meets the bottom along the canyon and return to the starting point by following the other side of the canyon bottom.

Table 1. Results of pre- and post-hunt flush counts in Hog and Gardner canyons, Santa Rita Mountains, Arizona, 1988–1996.

Year	Pre-hunt counts			Post-hunt counts		
	No. of coveys	No. of birds	Mean covey size	No. of coveys	No. of birds	Mean covey size
1988–89	26	220	8.5	12	50	4.2
1989–90	13	82	6.3	2	7	3.5
1990–91	9	46	5.1	12	37	3.1
1991–92	30	257	8.6	11	40	3.6
1992–93	11	86	7.8	12	47	3.9
1993–94	7	43	6.1	11	38	3.5
1994–95	8	45	5.6	3 ^a	11 ^a	3.7
1995–96	9	57	6.3	3	9	3
1996–97	3	7	2.3	4	20	5
1988–96 Mean	12.9	93.7	7.3	7.8	28.8	3.7

^a One of 5 routes could not be run because canyon was washed out.

When a dog goes on point, observers get in position to see and classify the birds as the covey flushes. Male Montezuma quail are easily distinguished by the black rump observable as the covey flushes. An effort is made to maintain consistency in the number of people and dogs on each route from year to year, as well as how intensively the canyon is covered. Due to variation in the number and quality of participants, a high degree of consistency is not always possible.

The sex ratio and number of birds in the covey are recorded on a data sheet and the location is plotted on a topographic map. These data allow the monitoring of trends in average covey size, number of birds seen, and number of coveys flushed (Table 1). Variations in scent conditions, quality of dogs, area covered by dogs, number of dogs per observers, ambient temperature, and humidity, can potentially confound the number of birds and coveys flushed per route. Average covey size, however, is independent of these conditions as long as the entire covey is flushed and counted accurately.

These data are not used directly to set seasons or bag limits, but are useful to predict the relative hunt success in the upcoming season, and monitor large scale changes and trends in the population. Such data are useful for making land use and management decisions. The process of getting Arizona Game and Fish Department biologists, U.S. Forest Service biologists, quail hunters, and local residents together in Montezuma quail habitat twice a year to look at and talk about quail management, and land use practices, is probably the most valuable aspect of this program.

Average covey sizes determined by flush counts conducted in 1988–1996 ranged from 2.3 to 8.6 for pre-hunt ($\bar{x}$ = 7.3) and 3.0–5.0 ($\bar{x}$ = 3.7) for post-hunt surveys (Table 1, Figure 4). These estimates are similar to average covey sizes reported in the literature (Leopold and McCabe 1957, Yeager 1967, R. Brown 1978, Stromberg 1990, Holderman 1992). The reduction in average covey size from the pre- to the post-hunt surveys parallels natural attrition reported in un-hunted populations (Stromberg 1990, Holderman 1992).

Multiple regression analysis of average pre-hunt

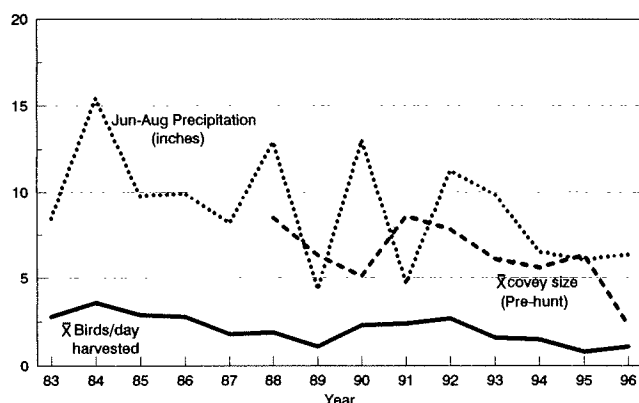


Fig. 4. Mean number of Montezuma quail harvested per day, mean covey size, and summer precipitation from flush counts and wing barrels, southeastern Arizona, 1983–1996.

covey size and precipitation totals for the preceding summer and the previous summer were not significant ($R^2 < 0.32$, $P > 0.16$). A simple linear regression of average pre-hunt covey size and the total precipitation in last 2 summers combined was also not significant ($r^2 < 0.30$, $P > 0.12$). This is counter-intuitive since coveys are primarily family units (R. Brown 1978) and abundant rainfall during the summer months should result in higher reproduction and lower mortality. This may suggest that the factors influencing population fluctuations are more complex than a simple model using summer rainfall. Alternatively, the lack of a statistically significant relationship could be a function of low sample sizes.

HARVEST DATA

A statewide hunter questionnaire is mailed to a random sample of small game hunters in Arizona after each hunting season. This questionnaire provides an estimate of the number of hunters pursuing quail, the number of birds harvested, and average daily bag (birds/hunt-day). Because only a small proportion of the questionnaire respondents actually hunt Montezuma quail, extrapolation of these harvest data must be viewed with caution. However, questionnaire data show annual fluctuations in number of hunters and Montezuma quail harvested. These fluctuations generally follow the habitat-induced variations in abundance (Table 2).

Wing collection barrels are erected beside roads which provide access to the most heavily hunted Montezuma quail habitat. Four barrels have been placed in consistent locations for 9 years (1988–1996). Each barrel is fitted with a weather-proof box containing wing envelopes. Each envelope has a short hunter questionnaire printed on it. A sign encourages hunters to complete the questions and place one wing from each bird harvested in the envelope and to deposit the envelope in the wing barrel. At the end of the season, data are tabulated from the questions on the envelopes and the sex/age of wings contained therein recorded for that hunting party. These data are used to identify

Table 2. Montezuma quail harvest data gathered from post-season statewide hunter questionnaire mailed to sample of small game hunters, 1969–1995.

Year	Total Arizona quail hunters ^a	Total Montezuma quail harvested
1969–70	63644	6000
1970–71	59497	9836
1971–72	46092	9460
1972–73	41730	28835
1973–74	63009	42308
1974–75	65163	29469
1975–76	74511	41568
1976–77	73735	45418
1977–78	66702	32849
1978–79	78142	51719
1979–80	95814	80702
1980–81	92949	no data
1981–82	84322	no data
1982–83	78428	no data
1983–84	71772	no data
1984–85	71208	no data
1985–86	75806	no data
1986–87	77754	no data
1987–88	65111	17447
1988–89	55828	14670
1989–90	45143	17007
1990–91	43924	21772
1991–92	54868	33068
1992–93	64021	43101
1993–94	74716	27482
1994–95	73108	24320
1995–96	63060	20055
1969–95 Mean	67410	29854

^a This includes all quail hunters, only a portion of which hunt Montezuma quail.

trends in variables such as the reproductive success (percent juveniles), birds harvested per day and hour, success with and without dogs, wounding loss, and bag limits attained (Table 3).

The average number of birds harvested per day estimated by the wing barrel data for the period 1983–1996 ranged from 0.8 to 3.6 ($\bar{x} = 2.2$). Hunters averaged 0.50 birds harvested per hour of hunting effort during that same period (Table 3). Out of 3,107 hunter-days recorded at wing barrels from 1983–1996, only 13 (0.4%) resulted in a limit of birds. Reproductive success averaged 74.4% juveniles during the period 1984–1996.

Multiple regression analysis did not detect a significant relationship between the reproductive success (percent juveniles) and precipitation totals for the preceding summer ($R^2 < 0.37$, $P > 0.13$). The average number of birds harvested per day was related to the total amount of precipitation in the preceding summer ($R^2 = 0.51$, $P < 0.01$), but not the previous summer ($P > 0.10$). The regression of average birds/day against the combined total precipitation in the preceding and previous summers, showed a weaker, but still significant, relationship ($P < 0.02$). The combined precipitation of the previous two summers explained less of the variation in average birds/day ($R^2 = 0.38$) than the preceding summer alone.

Reproductive success as measured by percent ju-

Table 3. Harvest data gathered by voluntary wing barrels in Montezuma quail habitat, Santa Rita and Patagonia Mountains, Arizona, 1983–1996.

Year	Hunter-days reported	Mean birds/day	Mean birds/hour	Limits reported	% juvenile
1983–84	144	2.8	0.45	0	83.7
1984–85	277	3.6	0.8	0	80.9
1985–86	367	2.9	0.71	2	68.5
1986–87	181	2.8	0.51	0	69.4
1987–88	188	1.8	0.43	0	71.5
1988–89	331	1.9	0.42	1	82.1
1989–90	213	1.1	0.27	0	56.9
1990–91	232	2.3	0.56	3	79.8
1991–92	319	2.4	0.52	2	75.6
1992–93	257	2.7	0.59	1	78.3
1993–94	172	1.6	0.34	0	72.9
1994–95	133	1.5	0.34	1	45.6
1995–96	150	0.8	0.19	0	75.3
1996–97	143	1.1	0.22	3 ^a	75.2
1985–96 Mean	224	2.2 ^b	0.50 ^b	1.1	74.4 ^c
1985–96 Total	3,107			13	

^a Bag limit reduced from 15 to 8 in 1996.

^b Based on 6,550 birds, 13,221 hunter-hours, and 2963 hunter-days, 1984–1996.

^c Based on 4,268 juvenile and 1,468 adult birds aged during the period 1984–1996.

veniles in the harvest was not correlated with pre-hunt covey size ($P = 0.62$) or average birds harvested per day ($P = 0.15$). These results seem counter-intuitive, but may be an artifact of small sample sizes and lack of robust data. Average pre-hunt covey size was not correlated with average birds harvested per day during the hunt ($P = 0.146$), which may indicate the number of coveys is more important in influencing hunter success than the number of individuals per covey.

DISCUSSION

Precipitation patterns in the Southwest are extremely erratic. This results in large annual fluctuations in the amount of Montezuma quail food available and also the cover necessary for the birds to exploit those resources. These unstable food and cover resources influence reproduction and survival of adult birds.

In addition to the total amount of rainfall during this summer period, the timing of the precipitation is also important. Short duration, heavy rainfall events are less beneficial than long duration, light rainfall events. Also, if rainfall is delayed until late in the summer period, vegetation has less time to respond before cool weather and shorter day length slows growth.

Periods of low or poorly timed rainfall are exacerbated by the detrimental effects of inappropriate grazing. When minimal vegetation growth occurs during the summer period, grazing only 30% of the biomass may not leave sufficient residual vegetation to meet the cover requirements of Montezuma quail through the following summer. Even grazing at levels less than 40% during one year may cumulatively result in inadequate cover the following year, if summer precipitation is lacking during the second year (D. Brown 1978).

In exceedingly dry summers when grass production is negligible, any grazing in Montezuma quail habitat is likely to be detrimental to the population.

Ranchers have long-term grazing agreements for their allotment. Should the U.S. Department of Agriculture, Forest Service require the rancher to remove all cattle from his grazing allotment and find other means of income until adequate summer rains return? This issue is probably the major challenge facing Montezuma quail managers and land management agencies in the Southwest. Unfortunately, there are no easy answers. Most importantly, Montezuma quail management requires proper range management and flexibility in grazing plans to eliminate range overuse during dry years.

The U.S. Forest Service established interim Montezuma quail grazing management guidelines in 1986. These guidelines were to: (1) identify and map Montezuma quail habitat, (2) allow grazing utilization levels of 35–40% in Montezuma quail habitat, and (3) retain an average residual stubble height of 6 inches (15.2 cm). Efforts to determine an effective method for measuring stubble height in the steep, sparse bunch grass community have been largely unsuccessful. Montezuma quail habitat has been mapped, but funding to support the U.S. Department of Agriculture, Forest Service range staff necessary for adequate monitoring has been lacking in recent years. This problem is only getting worse; the U.S. Forest Service's range management budget has been cut drastically in the last 2 years. As a result, interim guidelines cannot be enforced and monitoring is lacking on many allotments.

"Managing" quail during periods of adequate rainfall is easy. However, when a series of dry summers happens, some individuals become interested in restricting hunter harvest to ameliorate the Montezuma quail population declines. Suggestions to reduce seasons and bag limits frequently ensue.

Much of this concern stems from the fact that intensive, localized shooting can eliminate quail from easily-accessible canyon bottoms until pre-breeding dispersal repopulates vacant habitat (R. Brown, Ari-

zona Game and Fish Department, personal communication). Drastically reduced season lengths have the potential to reduce total quail harvest moderately, but data show reductions in bag limits will have little effect (Engel-Wilson 1995).

Using data from the 1968–69 hunt in Gardner Canyon in the Santa Rita Mountains, R. Brown (unpublished data) estimated that a reduction of the bag limit from 15 to 10 would only result in a 5% decrease in total harvest. In spite of this, during 1970, the statewide bag limit was reduced to 10 because of concerns of overharvest. In 1973, the bag limit was restored to 15 birds. Data from the hunted portion of the study area showed that the highest harvest during the study actually occurred when the bag limit was 10 and the season length was 62 days. The lowest harvest was recorded during the 77-day hunting season with a bag limit of 15 (R. Brown, Arizona Game and Fish Department, unpublished data).

Furthermore, wing data indicate the average daily bag is 2.2 birds. Less than half of 1% of the hunter-days recorded in wing barrels from 1983–1996 resulted in a limit (15 birds). Data summarized from the hunter questionnaire program indicate that a reduction in bag limit from 15 to 8 would have reduced the total Montezuma quail harvest by only 6% and 0% in 1992 and 1994, respectively (Engel-Wilson 1995). Over 90% of the Montezuma quail hunters took less than 7 and 4 birds per day in 1992 and 1994, respectively.

During 1996, the statewide bag limit was reduced to 8 birds per day. Arizona historically has had an aggregate bag limit for all 3 species of quail, allowing hunters to harvest up to 15 total quail of any species. Lowering the bag limit of only 1 of 3 quail species forced the Arizona Game and Fish Department to require that hunters retain evidence of legality by leaving one fully feathered wing, head, or foot attached to all quail until they reach their home.

A majority of the opinions expressed by the hunters at public meetings, at regional open house, and at the commission meeting were opposition to the 1996 reduction in the bag limit for several reasons. During years of abundant summer rainfall and high quail densities, recreational opportunity is limited unnecessarily by reduced bag limits. In dry years with low quail densities and small covey sizes, birds are exceedingly difficult to locate because of the nature of the habitat and their behavior. Also, the law of diminishing returns causes many hunters to pursue other small game that are more abundant and provide more recreation per unit of time expended, or devote more time to other recreational pursuits (Figure 5). The total number of hunter-days recorded with wing barrels was positively correlated with the average pre-hunt covey size ($P < 0.02$).

Future management needs include improving methods of indexing Montezuma quail populations and sampling Montezuma quail hunters. Future research should include Montezuma quail movements in relation to varying cattle grazing intensities. Management may be improved with an increased awareness of the optimal size, shape, timing, and juxtaposition of

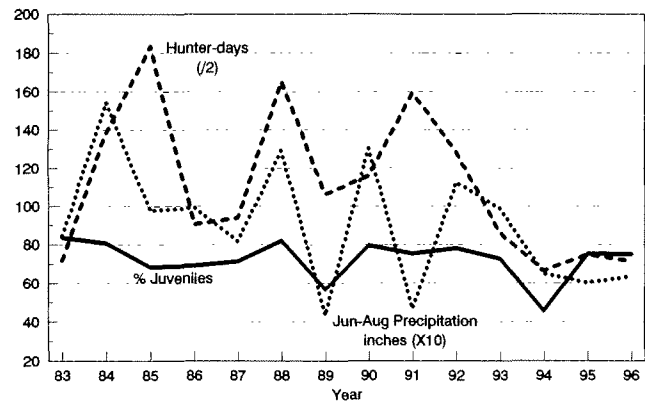


Fig. 5. Summer precipitation, hunter effort, and reproductive success of Montezuma quail based on information collected with wing barrels, southeastern Arizona, 1983–1996.

grazed areas within various topographic and vegetative components of Montezuma quail habitat. Current research is focussing on: (1) indexing Montezuma quail populations; (2) determining effects of hunting; (3) determining effects of grazing; and (4) documenting hunter demographics.

Good Montezuma quail management is essentially good livestock management. Although we can not predict or manage summer rainfall, managing the range properly to protect the health and integrity of the grass species will maintain the required elements for abundant Montezuma quail.

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