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Impact Climate Change On Biodiversity- A Case Study On Quails

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A. INTRODUCTION:

The average surface temperature is predicted to rise 0.5 to 6˚C by the year 2100. When Japanese quail (*Coturnix coturnix japonica*), a source of protein for many, are subjected to heat stress, their blood acid-base equilibrium and ability to regulate electrolytes may change. Climate change adversely affects food security because of its undesirable consequences on agricultural crops as well as on livestock (Shukla et al., 2019). Further, temperature is adjudged to be the most important environmental determinant amongst all bioclimatic variables usually evoking stress. Quails and quail hunting represent an important component of the culture and economy of rural communities throughout the western United States (U.S.). Each year, thousands of quail hunters venture onto western rangelands for the opportunity to hunt wild quails. The popularity of quail hunting in western states extends not only from the beautiful landscapes that western rangelands provide for upland gamebird hunting but also from the rich diversity of quails. Six quail species occur in the U.S., and all 6 species are found on western rangelands. The 6 species of quail occur in 4 genera (*Colinus*, *Callipepla*, *Cyrtonyx*, and *Oreortyx*) and are classified within the order Galliformes, family Odontophoridae, and sub-family Odontophorinae. These quails are found across a variety of vegetation types in the U.S. ranging from grasslands to mountain shrublands to coniferous woodlands and consist of the northern bobwhite (*Colinus virginianus*), scaled quail (*Callipepla squamata*), Gambel's quail (*Callipepla gambelii*), California quail (*Callipepla californica*), Montezuma quail (*Cyrtonyx montezumae*), and mountain quail (*Oreortyx pictus*). Western quails are *r*-selected species whose populations are strongly influenced by weather, particularly rainfall. Given the diversity of quails that occur on western rangelands, it is impractical to discuss each species' life history, ecology, and management. Consequently, we synthesize the literature on quails and provide generalizations of life history, ecology, and management for this taxon, acknowledging that individual species may show deviations from generalizations. In cases where such deviations are notable, we reference the species. In addition, of the 6 quail species, northern bobwhite is the only species that also occurs in the eastern U.S. In this chapter, we focus on the ecology and management of northern bobwhite as it pertains to the western portion of its geographic distribution.

B. Review of literature:

The present paper described the review of literature and impact of climate change on Quails. The review describes the impact on different behavioral aspect of quails nesting, brood rearing, brood success and chick survival, non-breeding, survival and sources of mortality, seasonal movements and dispersal and population Dynamics. Nowadays, heat and changing weather stress is one of the major climatic problems which negatively influences the production, reproduction and growth performance of different Quails species

1. Nesting:

Nesting season for quails generally begins shortly after covey break-up in the spring when males leave winter coveys and begin seeking female mates from other coveys (Gullion 1962; Gee et al. 2020; Pair formation takes place generally 2–3 weeks prior to nesting but can occur much earlier (Gullion 1962; Wallmo 1954). Nests are usually built on the ground beneath herbaceous, succulent, or shrubby vegetation providing both security and thermal cover (Pope 2002; Stromberg et al. 2020). Although herbaceous cover is an important component of nest concealment, Gambel's quail have adapted to desert environments lacking such cover (Gee et al. 2020) and instead rely on cryptic coloration of the eggshells to reduce the probability of detection (Brennan 2007).

Quails also select nesting structure depending on annual availability. For example, mountain quail in west-central Idaho relied more on woody cover for nesting and brood-rearing during a drier-than-average year but used more herbaceous cover in a wetter-than-normal year (Reese et al. 2005). Nest success varies greatly among species and within populations through time and space

2. Brood-Rearing:

Female quail generally lay one egg per day to every other day until the clutch is complete (≈ 12–14 eggs), with nest incubation initiating soon thereafter and lasting 21–26 days. Both parents tend to incubate the clutch and care for the chicks, but the degree of care varies by species (Brennan 2007; Gutiérrez 1980). Quails traditionally have been considered monogamous and, of the 6 species, mountain quail likely are the most monogamous (Beck et al. 2005). However, ambisexual polyandry (i.e., one female mating with more than one male) is common and has been documented in several species. Both males and females are known to incubate and raise broods with more than one mate during the breeding season (Curtis et al. 1993; Brennan 2007; Davis et al. 2017). In addition, a small portion of the breeding population often produces multiple broods (i.e., individuals raising more than 1 brood per nesting season), at least in California quail (Francis 1965), Gambel's quail (Gullion 1956), and northern bobwhite (Guthery and Kuvlesky 1998). However, the influence of multiple broods on annual populations is likely insignificant because second and third broods contribute little to age ratios under a typical probability of nest success (Guthery and Kuvlesky 1998). In contrast to an ambisexual polyandry approach, female mountain quail lay two simultaneous clutches, incubated separately by the male and female in each monogamous pair and thereby optimize breeding success in mountainous areas typified by short growing seasons (Beck et al. 2005).

3. Brood Success and Chick Survival:

Brood success and chick survival vary among quails and likely is related to habitat and weather conditions (Brennan 2007). Chicks of all quail species are precocial and susceptible to a variety of mortality sources such as predation and exposure to inclement weather. In mesic environments, exposure to rain during the first weeks of life has been associated with chick mortality (Terhune et al. 2019). In xeric environments, Heffelfinger et al. (1999) documented that hot, dry summer weather reduced the percent of juveniles in Gambel's quail populations in Arizona compared to cool, wet weather and speculated that reduced food availability reduced juvenile survival. Chick survival can have a significant impact on quail population dynamics, although less so than adult survival (Guthery and Kuvlesky 1998; Sandercock et al. 2008). Reliable estimates of chick survival generally are lacking due to the difficulties in capturing and monitoring juvenile quail of all species; however, research on chick survival has increased during recent years given advances in technology (e.g., Orange et al. 2016; Terhune et al. 2019).

4. Non-breeding:

Quails are gregarious species, and the covey is the primary social unit during much of the year. Covey sizes generally are largest after brooding season (autumn). Depending on the species, autumn coveys are composed of one or more adult pairs and their broods, and covey sizes may range from 8 to 30 individuals. Covey sizes of Montezuma and mountain quail occur at the lower end of this range, whereas Gambel's and scaled quail occur at the upper end (Brennan 2007; Gutiérrez and Delehanty 2020). Whether in coveys or not, quails roost together at night. Quails most often roost on the ground in grass or shrubby ground cover, although Gambel's and California quail prefer to roost above ground in dense shrubs or trees (Gee et al. 2020; Calkins et al. 2020). Quails generally leave the roost shortly after sunrise to begin feeding (Gutiérrez and Delehanty 2020; Stromberg et al. 2020). Communal roosting and feeding presumably provides both thermal protection and enhanced predator detection (Anderson 1974).

5. Survival and Sources of Mortality:

Annual survival of quails generally is low (< 20%) but varies among and within species (≈ 10–70%) and is considered a primary driver of populations (Guthery and Kuvlesky 1998; Sandercock et al. 2008. Sources of adult quail mortality may include predation, exposure to weather and extreme temperature, disease, parasites, and starvation. Habitat quality and availability can exacerbate or ameliorate the effects of each of these (Brennan 2007). Mammalian predators are the primary predators of nests, whereas raptors pose the greatest threat to adults (Brennan 2007; Turner et al. 2014).

Similar to other Galliformes, quails tend to walk or run more often than fly and usually respond to potential predators with some variation of a "run and hide" escape strategy. For example, scaled quail will often run from potential predators and then, when pressured, fly long distances to hide (Dabbert et al. 2020). In contrast, Montezuma quail tend to crouch and hide in response to danger, relying on their cryptic coloration to prevent detection. Montezuma quail flush only when approached closely and fly short distances to again hide in the relatively dense oak (*Quercus*)-juniper (*Juniperus*) savanna they inhabit (Stromberg 1990). The other quails exhibit some variation between these two extremes, and the escape strategies they exhibit appear adapted to the habitat in which they evolved. For example, Montezuma quail will crouch and hide rather than fly even when found in areas lacking cover (Brown 1982; Stromberg 1990).

6. Seasonal Movements and Dispersal:

Quails tend to be less mobile than other gallinaceous birds. Maximum annual movements of coveys < 4 km have been reported for several species (Stromberg 1990; Gee et al. 2020). Although quails are not known to migrate in a strict sense, mountain quail move seasonally between winter and breeding habitat presumably to avoid snow accumulation at higher elevations (Gutiérrez and Delehanty 2020). Similarly, scaled quail in the northern portions of their distribution are reported to make short (< 4 km) movements between summer and winter ranges (Dabbert et al. 2020). Information on movements from nesting to brood-rearing cover is limited. Large movements (e.g., > 20 km) by quails have been reported and may be associated with dispersing males (Campbell and Harris 1965 but see Townsend et al. 2003).

7. Population Dynamics:

Quails are *r*-selected species (Guthery and Brennan 2007), and their population fluctuations are largely determined by weather (Brennan 2007). Variations in demographic parameters such as percent hens nesting, nesting rate, and nest success, combined with low annual survival, create conditions for fluctuating quail populations that are subject to the vagaries of habitat and weather conditions. Given their low survival, quail population fluctuations largely are the result of varying reproductive success. For example, Swank and Gallizioli (1954) reported that 90% of the variation in Gambel's quail population indices were attributed to nesting success. Hernández et al. (2005) documented a lower percentage of northern bobwhite hens nesting, lower nesting rates, and shorter nesting seasons during drought compared to wet years. Consequently, in years of poor environmental conditions, quail numbers drop significantly only to rebound when conditions improve, resulting in "boom and bust" population dynamics (Hernández and Peterson 2007).

The reproductive success of quails that inhabit semiarid environments has been positively correlated with rainfall (Bridges et al. 2001; Hernández et al. 2005; Brennan 2007). The ideal timing for rainfall varies by species but generally occurs 1–3 months prior to the nesting season. For example, northern bobwhite occurs over a wide range of vegetation types, and the months of critical rainfall as well as the relative influence of rainfall varies by region (Bridges et al. 2001; Hernández and Peterson 2007). Other researchers have explored the relationship between quail reproductive success and heat indices (Francis 1970; Heffelfinger et al. 1999) and have documented that cooler summer temperatures can have an ameliorating effect on drought with respect to quail reproduction (Heffelfinger et al. 1999).

The mechanism by which weather exerts its influence on quail reproduction presently is unknown (Hernández et al. 2002) but often attributed to the materialized effects of rainfall (e.g., increased food, nesting cover, etc.; Brennan 2007). For Gambel's quail, forb growth that proliferates after favorable winter rains is presumed to provide higher levels of Vitamin A, which is thought to stimulate reproductive organ development and positively influence reproductive success (Hungerford 1960, 1964). However, this relationship has not been empirically established in quails (Lehmann 1953; Guthery 2002). Investigations into other factors that may enhance (e.g., phosphorus) or possibly inhibit (e.g., phytoestrogens) quail reproduction have failed to provide conclusive evidence to explain the boom-and-bust population phenomenon (Cain et al. 1982, 1987). Research that has focused on food and water supplementation also has failed to provide explanatory evidence (Koerth and Guthery 1991; Harveson 1995; Lusk et al. 2002). More recently, thermal stress has been explored as a possible cause of decreased reproductive performance during dry conditions (Guthery et al. 2005) and, of all the proposed mechanisms, this heat-stress hypothesis presently appears the most plausible (Hernández et al. 2002).

C. Current Species and Population Status:

There is considerable conservation concern among ecologists and the public regarding the population status of quails (Brennan 1991; Church et al. 1993; Hernández et al. 2013). Of the 6 western quails, 3 species are declining (northern bobwhite, scaled quail, and mountain quail), 2 species have inconclusive data (Gambel's quail and Montezuma quail), and 1 species is increasing (California quail; Table 11.2). Currently, none of the western quails are federally listed as endangered or threatened at the species level (Table 11.2). Some species, however, receive special protections at the state level given that most states have their own system for listing species beyond the federal Endangered Species Act. For example, California quail and mountain quail have received focused attention from state agencies due to their popularity (California quail is the official state bird of California) or limited scientific knowledge of their management (mountain quail).

D. Climate Change:

Climate models project that the Southwest and Central Plains of the U.S. will become drier during the twenty-first century, a transition that already appears underway (Archer and Predick 2008; Cook et al. 2015). These regions are projected to experience warmer temperatures and higher frequency of extreme weather events (e.g., droughts, heat waves, and floods; Archer and Predick 2008). For both the Southwest and Central Plains, the risk of multidecadal drought is expected to increase from < 12% (1950–2000) to ≥ 80% (2050–2099), a level of aridity that exceeds even the persistent megadroughts of the Medieval era (1100–1300 CE) (Cook et al. 2015). This projected change in climate may negatively impact western quails, particularly those species inhabiting semiarid and arid environments. The primary impacts likely will involve how quails respond to increasing temperatures and aridity, as well as accompanying distributional and compositional changes in vegetation communities resulting from climate change and projected increases in wildfire frequency (Heidari et al. 2021).

Quails inhabiting arid and semiarid environments live near their physiological limits. For example, the thermal neutral zone for northern bobwhite is estimated at 30–35 °C (Lustick et al. 1972; Forrester et al. 1998), with gular flutter occurring at 35.0–38.5 °C (Case and Robel 1974) and death at 40 °C if individuals are exposed to this temperature for a prolonged period of time (Case and Robel 1974). The thermal environment therefore strongly influences quail life history and ecology, and minor changes in climate can substantially influence their performance (Guthery et al. 2000; Burger et al. 2017). High temperatures are known to cause embryonic mortality (Reyna and Burggren 2012), reduce food intake (Case and Robel 1974), reduce egg laying (Case and Robel 1974), decrease productivity (Heffelfinger et al. 1999), and shorten the nesting season (Guthery et al. 1988). Quails can partly minimize the risk of thermal stress via modifications in space use. For example, northern bobwhite and scaled quail in Oklahoma and New Mexico nest in sites with temperatures that are 6–8 °C cooler than the available landscape (Carroll et al. 2018; Kauffman et al. 2021). However, such behavioral adjustments depend on the availability of thermally suitable sites, which can be limited even in the present climate (Kline et al. 2019; Palmer et al. 2021). The proportion of thermally suitable areas on a landscape may be as little as 40–60% during the hottest time of the day (Forrester et al. 1998) and may become even more limited in the future.

In addition to demographic responses of quails to climate change, quails also can respond by adjusting their geographic distribution because of compositional or distributional changes in vegetation communities. The National Audubon Society used their large-scale, bird-observation database and climate models to project how climate change may affect the geographic distributions of birds (www.audubon .org/climate/ survivalbydegrees). Assuming a 3 °C increase in temperature as projected by climate models, 1 quail species is considered to possess high vulnerability (Montezuma quail), 1 moderate vulnerability (scaled quail), 2 low vulnerability (California quail and mountain quail), and 2 stable (northern bobwhite and Gambel's quail) relative to changes in their respective geographic distribution. These projections agree in general with those of Tanner et al. (2017) who modeled changes in geographic distribution of western quails using an ensemble approach of four general circulation models. They documented that 4 of the 6 species (scaled quail, California quail, Montezuma quail, and mountain quail) are projected to have a net loss in area of geographic distribution. The geographic distributions of Montezuma quail and mountain quail are projected to shift higher in elevation as potential distribution contractions occur in lower latitudes and gains occur in higher latitudes. The net change in the geographic distribution of northern bobwhite is projected to be minimal; however, the species is projected to lose population strongholds. Gambel's quail is the only species projected to experience an increase in area of geographic distribution. Collectively, the geographic distributions of western quails are projected to be displaced northward and eastward, with losses in their southernmost extents (Tanner et al. 2017).

E. Conservation and Management Actions:

The rangelands that western quails inhabit represent a mix of ownerships including federal government, state governments, local municipalities, tribes, corporations, and private individuals (USGS GAP 2018). The differing management authorities among these entities can create a disconnect in conservation objectives for quails. Additionally, wildlife species do not recognize jurisdictional boundaries, further complicating management of western quails. Collaborative efforts among these managing entities have had, and will continue to have, the greatest potential for quail conservation and management in western rangelands.

F. Conclusion and recommendations:

Climate variation and heat stress is an important environmental factor in the purview of climate change and global warming which adversely affects the performance of quails worldwide. Exposure of birds to it produces significant untoward effects on production, reproduction and growth performance due to generation of physiological, behavioral and immunological responses. It incurs huge economic losses to the quail's production and its economic viability for livelihoods. In quails and layers, adverse effects of heat stress encompass reduction in egg production, survival and quality

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