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EFFECT OF PRECIPITATION ON RIO GRANDE WILD TURKEY POULT PRODUCTION IN TEXAS

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Abstract: ecipitation can strongly influence the population dynamics of gallinaceous birds in semiarid regions. Little is known, however, about the interaction of precipitation and Rio Grande wild turkey (*Meleagris gallopavo intermedia*; RGWT) production in Texas, particularly across broad spatial and temporal scales. We compared RGWT production data with precipitation and drought data across 5 ecological regions of Texas for 1976–2000. Poult production was positively correlated with both the June Modified Palmer Drought Severity Index (PMDI) and September–June raw precipitation in all ecological regions. We found weaker correlations with June raw precipitation in all ecological regions except the Post Oak Savannah, and with cumulative September–June PMDI in the Edwards Plateau, Cross Timbers and Prairies, and South Texas Plains. Our results indicate that poult production is more influenced by cumulative weather effects over several months than by individual rainfall events, suggesting that direct precipitation-induced mortality does not substantially affect RGWT production in Texas. Further, precipitation data provides managers with an inexpensive, effective indicator of RGWT production in Texas.

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Precipitation is one of the most important factors influencing the distribution and abundance of terrestrial organisms (Krebs 1994). It is known to affect avian populations directly by killing individuals (Welty and Baptist 1988), destroying nests, and regulating the timing of breeding (Marshall 1959), and indirectly through its effects on vegetation and other environmental factors (Welty and Baptista 1988). Precipitation affects the abundance or production of several species of gallinaceous birds, including black grouse (*Tetrao tetrix*; Baines 1991), capercaillie (*Tetrao urogallus*; Moss 1986), gray partridge (*Perdix perdix*; Panek 1992), northern bobwhites (*Colinus virginianus*; Bridges et al. 2001, Lusk et al. 2002), and scaled quail (*Callipepla squamata*; Campbell et al. 1973, Bridges et al. 2001).

The influence of precipitation also extends to wild turkeys. Precipitation can directly affect turkey production by flooding nests or drowning poults (DeArment 1969, Kennamer et al. 1975, Zwank et al. 1988, Healy 1992), and causing hypothermia-induced mortality among poults (Markley 1967, Healy and Nenno 1985, Roberts and Porter 1998*a*). It also might indirectly influence turkey production by facilitating

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predation (Palmer et al. 1993, Roberts et al. 1995, Roberts and Porter 1998*b*) or altering intermediate environmental variables believed to be correlated with turkey production. These include the structure of vegetative cover (Beasom 1973, Cable 1975), as well as the abundance of forbs (Beasom 1973) and arthropods (Johnson and Worobec 1988, Belovsky and Slade 1995, Frampton et al. 2000), which are important food items for turkey poults (Hurst 1992).

Most research regarding the influence of precipitation on wild turkey populations has been conducted in the eastern and northern United States, where the climate is relatively wet and/or cool. In New York, Roberts and Porter (1998*a,b*) found that nest survival of eastern wild turkeys (*M. g. sylvestris*) was negatively correlated with precipitation during incubation, and poult survival was negatively correlated with precipitation during the second week following hatching. Precipitation also was negatively correlated with eastern wild turkey production in West Virginia (Healy and Nenno 1985), and wild turkey recruitment declined in Mississippi following droughts (Palmer et al. 1993).

Studies addressing how precipitation affects RGWT are uncommon. DeArment (1969:31) maintained that RGWT hen:poult ratios on 3 study areas in the Texas panhandle ‘‘closely paralleled’’ rainfall during 1954–1958. On 2 study areas in south Texas, Beasom and Pattee (1980) found a strong correlation between previous year's rainfall and poult production. However, both studies investigated localized effects of precipitation over relatively short ($\leq$10 years) periods. To our knowledge, no one has examined the relationship between weather and RGWT production at broad spatial scales over long time-periods ($>$20 years).

We tested 2 precipitation-related hypotheses: (1) precipitation strongly influences RGWT production in Texas, and (2) RGWT production in Texas responds indirectly to cumulative effects of precipitation (e.g., effects on vegetation structure or food availability), rather than directly to episodic events such as flooding, exposure, or enhanced predation. If our first hypothesis is supported by data, then RGWT production and precipitation should be strongly correlated. If this correlation is strongest with cumulative precipitation over several months, rather than individual monthly precipitation, it would lend support to our second hypothesis. Also, positive correlations would suggest that precipitation influences turkey production by affecting factors that respond positively to soil moisture, such as vegetation structure or food availability; negative correlations would suggest precipitation directly increases mortality by increasing risk to drowning, nest inundation, and hypothermia. Finally, we performed exploratory analyses to determine whether a moisture index that incorporated a number of weather variables would be a better predictor of turkey production than raw precipitation alone, in order to suggest to managers a suitable weather-based index to RGWT production in Texas.

METHODS

Study Area

We evaluated the effects of precipitation on RGWT production in the Edwards Plateau, Rolling Plains, Cross Timbers and Prairies, Post Oak Savannah, and South Texas Plains ecological regions of Texas (Gould 1975; Figure 1A). These regions encompassed the majority of RGWT range in Texas (Figure 1A). Mean annual precipitation was 584–864 mm, and generally decreased from east to west. Rio Grande wild turkey also were present in the High Plains, Trans-Pecos, and Gulf Prairies and Marshes ecological regions (Gould 1975). However, populations tended to be confined to small portions of these regions, thus limiting their region-wide abundance. TPWD historical data for these regions were relatively limited, thus precluding analysis.

Production Data

Texas Parks and Wildlife Department (TPWD) biologists conducted annual RGWT brood counts during 1976–2000 across the subspecies' range in Texas. Biologists recorded all RGWT observed in the course of routine daily activities during 1 June–15 August. Although these counts were not conducted along standardized routes, observers were encouraged to observe $\geq$10–25 hens per county during each 2-week period of the count. Observations were recorded by county and latitude-longitude coordinates (Graham and George, 2002). Retrospective power analysis of TPWD brood-count data revealed that it had sufficient power ($1 - \beta \geq 0.80$, $\alpha = 0.05$) to detect a 40% annual change at the ecological-region scale during most years (Schwertner et al. 2003).

We grouped each year's data according to ecological region prior to analysis. Data from the Edwards Plateau and Cross Timbers and Prairies were available for 1976–2000, data from the Rolling Plains and Post Oak Savannah were available for 1977–2000, and data from the South Texas Plains were available for 1977–1978 and 1980–2000. We calculated the total number of hens and poults observed per year during the counts in each ecological region. We then calculated an index of RGWT poult production as $n_p/(n_p + n_h)$, where n_p = the number of poults, and n_h = the number of hens observed per year (Table 2).

Climate Data

We selected *a priori* 4 precipitation indices, based on either PMDI or raw precipitation, for analysis: June PMDI, September–June PMDI, June raw precipitation, and September–June raw precipitation. We used precipitation indices for June or periods ending in June because this coincided with peak RGWT hatching across Texas (Beasom 1973, Ransom et al. 1987, Hohensee and Wallace 2001). Therefore, precipitation-induced alterations in RGWT production should have been most pronounced during this period. Also, because precipitation across most RGWT range in Texas

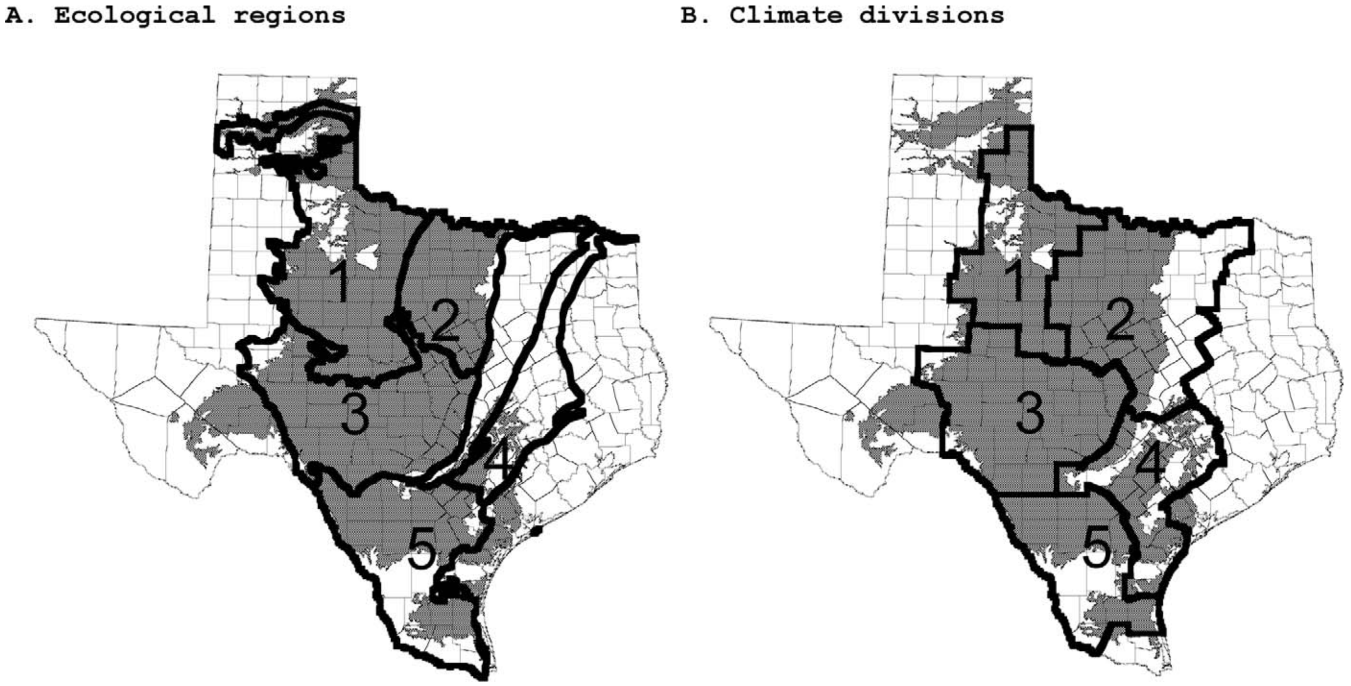

Fig. 1. (**A**) Ecological regions (Gould 1975) and (**B**) climate divisions (National Climate Data Center) of Texas containing significant populations of Rio Grande wild turkey. Names of ecological regions (and climate divisions, where different) are 1 = Rolling Plains (Low Rolling Plains), 2 = Cross Timbers and Prairies (North Central), 3 = Edwards Plateau, 4 = Post Oak Savannah (South Central), and 5 = South Texas Plains (Southern). Gray area indicates approximate range of the Rio Grande wild turkey in Texas, adapted from Texas Parks and Wildlife Department (1997).

exhibits a bimodal pattern, with peaks in early autumn and late spring (Carr 1967), and rainfall prior to the growing season plays an important role in plant growth (Cable 1975), we chose precipitation and drought indices for the previous September–June to access cumulative weather effects.

We obtained PMDI and raw precipitation data for the Edwards Plateau, Low Rolling Plains, North Central, South Central, and Southern Texas climate divisions (http://lwf.ncdc.noaa.gov/oa/climate/onlineprod/drought/xmgrg3.html). The boundaries of these climate divisions matched closely, but not exactly, those of the Edwards Plateau, Rolling Plains, Cross Timbers and Prairies, Post Oak Savannah, and South Texas Plains ecological regions, respectively (Figure 1).

The PMDI is a meteorological drought index that uses deviations from long-term average precipitation and temperature, and the duration of the current dry or wet period, to estimate the severity of a dry or wet period (Heddinghaus and Sabol 1991). Usual PMDI values range between −4.0 and 4.0, although more extreme values occasionally occur. Negative values indicate dry periods, positive values indicate wet periods, and values near 0 indicate near normal conditions. Bridges et al. (2001) determined that 12-month cumulative and monthly PMDI were more correlated with quail abundance than were a number of other precipitation indices, including raw precipitation. We chose June PMDI to represent cumulative weather effects for the months during and immediately preceding the Rio Grande turkey nesting season. September–June PMDI (calculated by summing the PMDI values of each Sep–Jun period) represented cumulative weather effects beginning with the onset of the autumn wet-season prior to breeding.

Unfortunately, PMDI data are readily available

Table 1. Correlations between monthly and 9-month sums of raw precipitation (Precip) and the Modified Palmer Drought Severity Index (PMDI) and Rio Grande Wild Turkey poult production by Texas ecological region (Gould 1975), 1976–2000 (EP = Edwards Plateau, RP = Rolling Plains, CT&P = Cross Timbers and Prairies, POS = Post Oak Savannah, and STP = South Texas Plains). All data were detrended over years.

	June				September–June			
	PMDI		Precip		PMDI		Precip	
Region	r_s	P	r_s	P	r_s	P	r_s	P
EP	0.84	<0.001	0.60	0.002	0.66	<0.001	0.86	<0.001
RP	0.83	<0.001	0.53	0.009	0.27	0.216	0.81	<0.001
CT&P	0.76	<0.001	0.64	0.001	0.48	0.020	0.69	<0.001
POS	0.54	0.008	0.10	0.651	0.43	0.039	0.65	0.001
STP	0.74	<0.001	0.48	0.021	0.31	0.143	0.74	<0.001

Table 2. Raw Rio Grande wild turkey poult production by Texas ecological region (Gould 1975), 1976–2000.

	Region				
Year	EP	RP	CT&P	POS	STP
1976	0.33		0.66		
1977	0.78	0.62	0.77	0.73	0.57
1978	0.51	0.47	0.72	0.16	0.29
1979	0.79	0.80	0.83	0.64	
1980	0.39	0.64	0.74	0.46	0.11
1981	0.84	0.80	0.81	0.71	0.57
1982	0.44	0.67	0.71	0.58	0.40
1983	0.60	0.58	0.66	0.46	0.51
1984	0.21	0.29	0.58	0.23	0.24
1985	0.78	0.74	0.71	0.61	0.68
1986	0.66	0.64	0.67	0.57	0.30
1987	0.77	0.73	0.74	0.57	0.66
1988	0.27	0.18	0.40	0.41	0.12
1989	0.47	0.63	0.61	0.26	0.16
1990	0.66	0.55	0.55	0.72	0.73
1991	0.63	0.77	0.65	0.53	0.62
1992	0.70	0.75	0.59	0.72	0.80
1993	0.39	0.55	0.64	0.52	0.53
1994	0.41	0.40	0.39	0.33	0.56
1995	0.71	0.68	0.53	0.26	0.24
1996	0.17	0.44	0.39	0.23	0.05
1997	0.78	0.84	0.70	0.64	0.67
1998	0.31	0.38	0.49	0.53	0.29
1999	0.60	0.70	0.50	0.41	0.50
2000	0.11	0.24	0.46	0.25	0.22

only at the spatial scale of the climate division (Figure 1B). Calculation of this index for geographic areas that do not closely approximate the size or geographic extent of these divisions requires weather data and specialized knowledge that may not readily be available to wildlife managers. For this reason, we examined total raw precipitation as well. We chose total June precipitation as an index of monthly precipitation at the peak of hatching, and total September–June precipitation as and index of cumulative precipitation prior to an during the breeding season.

Analysis

Because both climate and production data could be serially correlated, we detrended these data using the first differences method to determine year-to-year change in precipitation and production indices (Ott and Longnecker 2001). Because the detrended poult production data from some climate divisions were nonnormally distributed (Ryan and Joiner 1976), we used Spearman rank correlation (Zar 1999) to evaluate how poult production varied with values for each index of precipitation. Correlations were considered significant if $P \leq 0.05$. We compared the correlation coefficients (r_S) of June PMDI, September–June PMDI, September–June total rainfall, and June total rainfall for each climate division to determine which variable was most correlated with RGWT production.

RESULTS

June PMDI and September–June raw precipitation were similarly correlated with poult production in all ecological regions (Table 1). June precipitation was correlated with poult production in all ecological regions except the Post Oak Savannah, although the relationship typically was weaker than for June PMDI or September–June raw precipitation (Table 1). September–June PMDI was correlated with poult production in the Edwards Plateau, Cross Timbers and Prairies, and Post Oak Savannah, but not in the Rolling Plains or South Texas Plains (Table 1).

DISCUSSION

Rio Grande wild turkey poult production showed a positive correlation with precipitation in Texas during 1976–2000. This correlation was stronger with indices that included multi-month cumulative weather data than with June raw precipitation alone. This lends support to the hypothesis that precipitation influences RGWT production in Texas, and this influence arises from the cumulative effects of precipitation over several months rather than individual rainfall events.

Our findings differed from those of Healy and Nenno (1985) and Roberts and Porter (1998*a*), who found that poult survival was negatively correlated with spring rainfall in West Virginia and New York, respectively. They attributed their results to exposure-related mortality among poults. Climatic differences could explain this discrepancy, as poult mortality due to wetting and hypothermia probably was of greater significance in these comparatively cool and wet eastern wild turkey habitats than in Texas.

Quail in Texas also have been found to be influenced by weather, including precipitation. Lusk et al. (2002) found that previous autumn rainfall was the most important variable influencing broad-scale northern bobwhite abundance in Texas. In south Texas, northern bobwhite production was found to be sensitive to both precipitation and temperature, and this relationship was most pronounced with spring weather variables (Guthery et al. 2002). Bridges et al. (2001) used 12-month cumulative PMDI, monthly PMDI, and raw precipitation indices to predict changes in northern bobwhite and scaled quail abundance among years in the Edwards Plateau, Rolling Plains, Cross Timbers and Prairies, South Texas Plains, Gulf Prairies and Marshes, and Trans-Pecos ecological regions of Texas. They found that 12-month cumulative PMDI was highly correlated with northern bobwhite and scaled quail abundance in the Rolling Plains and South Texas Plains ecological regions, but not in the Edwards Plateau, Cross Timbers and Prairies, or Gulf Prairies and Marshes. Only in the South Texas Plains was there a correlation between quail abundance and 12-month (Sep–Aug) raw precipitation, and this correlation was weaker than with 12-month PMDI. Northern bobwhite abundance also was correlated with June PMDI, but not June precipitation, in the Rolling Plains and South Texas Plains ecological regions. Scaled quail abundance was correlated with June PMDI in the Edwards Plateau and South Texas Plains, but with June raw precipitation in the Edwards Plateau only.

We failed to find evidence that PMDI was a better predictor of RGWT production than precipitation alone. Whereas Bridges et al. (2001) concluded that both 12-month cumulative and monthly PMDI measures were much better predictors of quail abundance than precipitation alone, we found that September–June precipitation and June PMDI did a comparable job of predicting changes in poult production among years, and were superior to both June precipitation and September–June cumulative PMDI. This was despite Palmer's (1965) assertion that PMDI was better at capturing moisture-induced variability in vegetation dynamics.

Because raw precipitation data are more readily available for user-defined geographic areas, wildlife managers probably would find these data more useful for predicting RGWT production in Texas. Further, because PMDI was superior to raw precipitation for quantifying weather effects on vegetation (Palmer 1965), yet no better at predicting RGWT production, it is possible that turkey population dynamics in Texas were not related to vegetation in the same way as were northern bobwhite and scaled quail populations. Thus, the mechanism by which precipitation influences turkey production (e.g., vegetation change) merits further study.

MANAGEMENT IMPLICATIONS

Although managers cannot control the weather, understanding how such exogenous variables influence turkey population dynamics is important to understanding the context in which management actions operate. Our results suggest that managers can anticipate RGWT production based on weather variables, and adjust management recommendations accordingly. Moreover, managers can use their knowledge of existing weather conditions, along with an understanding of how precipitation influences factors thought to limit abundance to judge, a priori, the potential efficiency and effectiveness of management practices directed at these limiting factors.

Brood counts typically require intensive manpower in order to collect sufficient data to provide meaningful results. As the demands on conservation agencies increase, rarely with concomitant increases in agency budgets, managers must seek less-expensive alternatives to traditional practices. Further, brood counts typically are conducted during mid- to late-summer, generally after harvest regulations have been made. The close correlation between precipitation and poult production provides managers with a cost effective alternative to brood counts for determining RGWT breeding success in Texas, insofar as brood counts are indicative of RGWT production.

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