RELATIONSHIPS BETWEEN PRIOR RAINFALL AND CURRENT BODY FAT FOR NORTHERN BOBWHITES IN SOUTH TEXAS

Nancy E. Koerth and Fred S. Guthery[1]

ABSTRACT

In South Texas, heavy rainfall ($\geq$30% of mean annual precipitation) during a 1- to 2-month period in April-September was positively correlated (0.0031 < P < 0.0455) with subsequent body fat levels in northern bobwhites (Colinus virginianus). Effects were observed within 2 months and persisted up to 6 months. Rainfall in February was negatively related ($\underline{r}$ = -0.81, P = 0.0076) to body fat levels in April.

INTRODUCTION

Rainfall patterns and amounts influence the density and productivity of gallinaceous birds throughout the Southwest. Fall and/or spring moisture appears generally important, because it is correlated with productivity in wild turkeys (**Meleagris gallopavo**) (Beasom and Pattee 1980), California quail (**Callipepla californica**) (Francis 1970, Leopold et al. 1976), Gambel's quail (**C. gambelii**) (Swank and Gallizioli 1954, Gullion 1960, Hungerford 1964), and bobwhites (D. Wilson, pers. commun.). Spring and summer rainfall also may be correlated with fall age ratios in bobwhites (Kiel 1976) and scaled quail (**C. squamata**) (Campbell et al. 1973).

Relationships between rainfall and body fat levels (BFL) of galliforms in dry regions remain unexplored. The productivity and survival of game birds may vary with body fat (Dimmick 1975, Norman and Kirkpatrick 1984). The objective of the study was to determine relationships between prior rainfall and current BFL of bobwhites in South Texas.

STUDY AREA AND METHODS

Study areas were on ranches in Duval, Dimmit, Webb, Refugio, and Brooks counties in South Texas. Mean annual precipitation ranged from 19 to 35 inches; annual area-specific precipitation ranged from 12 to 52 inches during the study and differed by 22-113% on a given area between years (Koerth 1985). Soils were clays in the Refugio County area, deep sands in the Brooks County area, and mainly sandy loams in other areas. Birds on all areas were fed sorghum and corn from feeders or along roads during fall and winter. Gould (1975) described ecological conditions in the South Texas Plains and Koerth (1985) gave more detail on study areas.

Five to 10 bobwhites were collected monthly from January 1982 to December 1983 from each study area (N = 863). Whole birds less crops and crop contents were ground while frozen, dried at 158°F for 48 hours, and finely reground. Crude fat was extracted from duplicate 0.05-oz. samples for 8 hours with ether in a Goldfisch apparatus (modification of Harris [1970:2301]. If duplicates differed by >10%, additional duplicates were analyzed. The mean value of duplicates differing by < 10% was used in analyses. BFL (dry-matter basis) was calculated as 100 $\times$ (sample fat weight/sample weight).

Monthly rainfall data (U.S. Dep. Commer. 1982, 1983) were obtained from 4 stations < 7 miles and 1 station 25 miles from study areas. Eight independent variables were created from these data: rainfall totals for each of the 6 months preceding the beginning of the month tested, and totals of 3 and 5 months preceding the 6 months.

The dependent variable was a fat index defined as the mean BFL of a sample of birds collected in a specific year-month-area category. For example, if 5 birds were collected in Duval County in January 1982, their mean BFL was a dependent variable. Birds of all ages and sexes were pooled in calculation of the dependent variable because (1) we collected mature-appearing birds and mean fat levels of juveniles and adults seldom differed and (2) area-specific fat levels of males and females were similar in fall and winter (Koerth 1985). Fat levels of sexes sometimes differed in spring and summer, but this did not bias the dependent variable because males and females generally were equally represented in the samples. Sample sizes for calculations of the dependent variable were $\geq$ 5 in 88% of the tests.

Correlation analyses, stratified by months, were used to explore relationships between previous rainfall and current BFL. Potential sample sizes were 10 for each month (2 years $\times$ 5 areas). Actual sample sizes were smaller because of missing records at some weather stations. Because of variation in patterns and amounts of rainfall between years, we assumed that dependent variables from the same study area approximated independence.

RESULTS AND DISCUSSION

Because we explored 96 relationships between previous rainfall and current BFL of bobwhites, we would expect 1-2 significant correlations by chance based on the average of significant **P** values obtained (Table 1). That 9 **r** values were significant (**P** < 0.05) indicates direct or indirect effects of rainfall on BFL. These results occurred despite variation imposed by time, area, land-use practices, and other factors.

Rains during April, May, September, and December were postively correlated with subsequent BFLs (Table 1). However, the December-March relationship was suspect because of a narrow range in X variables (0.2-1.8 inches). The April-July relationship was questionable for the same reason (0.3-2.3 inches) but appeared biologically reasonable, as discussed below. Rainfall appeared to affect body fat within 2 months, and effects persisted up to 6 months.

Concentrated periods (1-2 months) of heavy rain ($\geq$30% of mean annual precipitation) preceded increased BFLs in fall and winter. This phenomenon contributed to the positive relationships between May rain and August, October, and November BFL, and between September rain and January BFL (Table 1). For example, the Duval County area received 79% of mean annual precipitation in May 1982; November body fat levels responded positively (Fig. 1). The Refugio County area received 42 and 50% of mean May rainfall in May 1982 and 1983, respectively; body fat levels in the following

[1]Research Associate and Research Scientist, respectively, Caesar Kleberg Wildlife Research Institute, Texas A&I University. We thank L. J. Welder, C. K. McCan, C. Linecum, J. M. Benavides, R. Eads, and H. A. Fitzsimmons, Jr., for access to study areas. The Caesar Kleberg Foundation for Wildlife Conservation funded the study.

Novembers were low (8.7 and 8.5%, respectively). Mean May rainfall on the Dimmit County area is 3.4 inches; rainfall was 3.7 and 0.9 inches in 1982 and 1983, respectively. Consequently, body fat levels in November 1983 were only 64% of levels in 1982.

Table 1. Monthly relationships between previous rainfall and current mean body fat for bobwhites in South Texas, 1982-83.

Season Current month	N	Month of previous rainfall	r	P
Winter				
Dec	7	Jul	-0.48	0.2800
Jan	8	Sep	0.71	0.0455
Feb	9	Nov	-0.64	0.0608
Spring				
Mar	9	Dec	0.78[a]	0.0128
Apr	9	Feb	-0.81	0.0076
May	8	Dec	0.46	0.2600
Summer				
Jun	8	Jan	-0.84[a]	0.0098
Jul	7	Apr	0.91[a]	0.0046
Aug	7	May	0.91	0.0046
Fall				
Sep	7	Aug	-0.85[a]	0.0163
Oct	7	May	0.78	0.0377
Nov	7	May	0.92	0.0031

[a]Although significant, these relationships are regarded as questionable for reasons explained in the text.

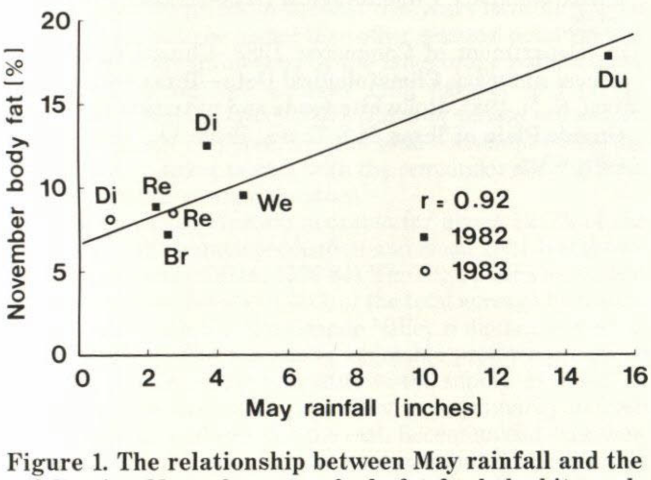

Figure 1. The relationship between May rainfall and the following November mean body fat for bobwhites collected from 5 countries in South Texas (Di = Dimmit, Re = Refugio, We = Webb, Br = Brooks, and Du = Duval).

We hypothesize that rainfall was postively related to BFL during April-October because of direct and indirect effects on the availability and accessibility of food and preformed water. Because of the long growing season in South Texas (> 300 days), rain at virtually any time may result in the emergence of plant sprouts. However, certain minimum levels of precipitation probably are necessary to trigger mass germination (Beatley 1974), consistent with our finding that heavy rainfall during a short period was necessary to actuate the rainfall-body fat relationships. Sprouting plants, which may appear within 2-7 days after precipitation (Gullion 1960), are a relatively rich source of nutrients (Wood 1985) and preformed water (Turner and Kramer 1980:1) in the bobwhite diet (Lehmann 1984:170, Wood 1985, Koerth et al. 1986). Widespread availability of succulent sprouts as a source of dietary water permits broader dispersal of galliforms in arid regions (Gullion 1960) and thus increases the accessibility of foods. Conversely, birds such as Gambel's quail cannot maintain body weight on a dry-seed diet during warm seasons (Gullion and Gullion 1964) and water deprivation reduces the rate of food intake in bobwhites (N. E. Koerth and F. S. Guthery, unpubl. data). Dietary water apparently is important to bobwhites in South Texas because these birds have been observed drinking surface water during July-October (Prasad and Guthery 1986); as many as 468 birds have been observed drinking at a livestock pond in 1 day (Lehmann 1984:87).

Further, the abundance of invertebrate foods varies with the succulence and diversity of herbaceous vegetation (Hurst 1972, Scriber and Slansky 1981, Healy 1985). Thus, plants that sprout and grow after rainfall provide substrate for invertebrates (Mayhew 1966), widely recognized as rich sources of preformed water and protein. Protein eaten in excess of physiological demands can be converted to fat (Sheehy 1955:161).

Lastly, heavy, concentrated rains probably had extended effects on BFL by increasing the germination, emergence, survival, and/or productivity of seed-producing plants important in the summer and fall diet of bobwhites in South Texas. These include crotons (**Croton** spp.) and panicoid grasses (**Setaria** spp., **Paspalum** spp., **Pancium** spp.) (Lehmann 1984:168, Wood 1985).

Of the 3 negative ($P < 0.05$) relationships between rainfall and BFL (Table 1), two appeared to be spurious. The January-June relationship was based on a narrow range of X variables (0-0.9 inches); it seems unlikely that negative effects of January rain would be seen after 5 months had elapsed. The August-September relationship was negative largely because of a sample from the area with clay soils. This area received 12 inches of rain in July 1983, which caused extensive flooding, the probable cause of low fat levels ($\bar{x}$ = 6.2%) of birds collected in September 1983.

The negative correlation between February rain and April BFL (Table 1) could have occurred because of increased energy demands for thermoregulation (see Case and Robel [1974]) during extended periods of cool, wet weather. February is, on average, the second coldest month in South Texas. Although bobwhites can withstand dry cold, they chill easily if feathers become damp (Stoddard 1931:55).

Our findings on potential relationships between rainfall and body fat in bobwhites pertain to a region where monthly and annual precipitation is highly variable (Tucker and Griffiths 1965), mean annual precipitation is < 26 inches, mean annual temperature exceeds 72°F, and gross lake-surface evaporation is 2-3 times higher than mean annual precipitation (Larkin and Bomar 1983). In short, the region is semiarid and moisture may be a limiting factor for many forms of wildlife. Because of the unique quail environment under which we studied, the findings may not hold in other portions of bobwhite range, such as the Midwest and Southeast. However, similar relationships may hold for other gallinaceous birds in the Southwest.

LITERATURE CITED

Beasom, S. L., and O. H. Pattee. 1980. The effect of selected climatic variables on wild turkey productivity. **Natl. Wild Turkey Symp.** 4:127-135.

Beatley, J. C. 1974. Phenological events and their environmental triggers in Mojave Desert ecosystems. **Ecology** 55:856-863.

Campbell, H., D. K. Martin, P. E. Ferkovich, and B. K. Harris. 1973. Effects of hunting and some other environmental factors on scaled quail in New Mexico. **Wildl. Monogr. 34.** 49pp.

Case, R. M. and R. J. Robel. 1974. Bioenergetics of the bobwhite. **J. Wildl. Manage.** 38:638-652.

Dimmick, R. W. 1975. Populations and reproductive effort among bobwhites in western Tennessee. **Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm.** 28:594-602.

Francis, W. J. 1970. The influence of weather on population fluctuations in California quail. **J. Wildl. Manage.** 34:249-266.

Gould, F. W. 1975. Texas plants: a checklist and ecological summary. **Tex. Agric. Exp. Stn., Misc. Publ. 585** (rev.). 121pp.

Gullion, G. W. 1960. The ecology of Gambel's quail in Nevada and the arid Southwest. **Ecology 41**:518-536.

Gullion, G. W. and A. M. Gullion. 1964. Water economy of Gambel quail. **Condor 66**:32-40.

Harris, L. E. 1970. **Nutrition research techniques for domestic and wild animals. Vol.1.** Utah State Univ., Logan. [239pp.]

Healy, W. M. 1985. Turkey poult feeding activity, invertebrate abundance, and vegetation structure. **J. Wildl. Manage. 49**:466-472.

Hungerford, C. R. 1964. Vitamin A and productivity in Gambel's quail. **J. Wildl. Manage.** 28:141-147.

Hurst, G. A. 1972. Insects and bobwhite quail brood habitat management. **Proc. Natl. Bobwhite Quail Symp.** 1:65-82.

Kiel, W. H., Jr. 1976. Bobwhite quail population characteristics and management implications in South Texas. Trans. **North Am. Wildl. and Nat. Resour. Conf.** 41:407-420.

Koerth, B. H., J. L. Mutz, and J. C. Segers. 1986. Availability of bobwhite foods after burning of Pan American balsamscale. **Wildl. Soc. Bull.** 14:146-150.

Koerth, N. E. 1985. **Condition of bobwhites in South Texas.** M.S. Thesis, Texas A&I Univ., Kingsville. 44pp.

Larkin, T. J. and G. W. Bomar. 1983. **Climatic atlas of Texas.** Tex. Dep. Water Resour., Austin. 151pp.

Lehmann, V. W. 1984. **Bobwhites in the Rio Grande Plain of Texas**. Texas A&M Univ. Press, College Station. 371pp.

Leopold, A. S., M. Erwin, J. Oh, and B. Browning. 1976. Phytoestrogens: adverse effects on reproduction in California quail. **Science 191**:98-100.

Mayhew, W. W. 1966. Reproduction in the arenicolous lizard **Uma notata**. **Ecology 47**:9-18.

Norman, G. W. and R. L. Kirkpatrick. 1984. Foods, nutrition, and condition of ruffed grouse in southwestern Virginia. **J. Wildl. Manage.** 48:183-187.

Prasad, N. L. N. S. and F. S. Guthery. 1986. Drinking by northern bobwhites in Texas. **Wilson Bull. 98**:485.

Scriber, J. M. and F. Slansky, Jr. 1981. The nutritional ecology of immature insects. **Ann. Rev. Entomol. 26**:183-211.

Sheehy, E. J. 1955. **Animal nutrition**. MacMillan and Co., Ltd., London, U.K. 732pp.

Stoddard, H. L. 1931. **The bobwhite quail: its habits, preservation, and increase**. Chas. Scribner's Sons, New York, N.Y. 559pp.

Swank, W. G. and S. Gallizioli. 1954. The influence of hunting and of rainfall upon Gambel's quail populations. **Trans. North Am. Wildl. Conf.** 19:283-297.

Tucker, J. E. and J. Griffiths. 1965. Precipitation distribution and the probability of receiving selected amounts over Texas. **Tex. Agric. Exp. Stn. Misc. Publ.** 794. 45pp.

Turner, N. C. and P. J. Kramer, editors. 1980. **Adaptation of plants to water and high temperature stress**. John Wiley & Sons, New York, N.Y. 482pp.

U.S. Department of Commerce. 1982. Climatological data annual summary. **Climatological Data—Texas 87**(13):18-19, 22-23.

U.S. Department of Commerce. 1983. Climatological data annual summary. **Climatological Data—Texas 88**(13):18-21.

Wood, K. N. 1985. **Bobwhite foods and nutrition in the Rio Grande Plain of Texas**. M.S. Thesis, Texas A&I Univ., Kingsville. 60pp.