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Evaluation of Performance Trends in the Tucumcari Bull Test 1961 to 2000¹

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ABSTRACT

Performance testing of beef bulls has occurred at the New Mexico Agricultural Science Center in Tucumcari from 1961 to 2000. During this period, 4579 bulls from 21 different breeds were tested. Bulls were spring-born, fall-weaned, and then grouped four or less to a pen by breed and cooperater. Bulls were fed for 140 days from 1961 to 1986 and then for 112 days from 1987 to 2000 according to the guidelines of the Beef Improvement Federation. Analyses were only conducted on the 112-day data. In 1961, Hereford bulls comprised 74% of the bulls in the test. However, the number of Hereford bulls tested declined at a rate of 1.5 bulls/year while the number of Angus and Charolais bulls tested increased at a rate of 0.8 bulls/year. In 1961, initial weights were 552.1 ± 8.6 lb and the final weights were 799.6 ± 11.1 lb. Initial and final weights in the year 2000 were 720.5 ± 8.2 and 1140.1 ± 10.6 lb, respectively. Greater than 500 Angus, Charolais, Hereford, and Polled Hereford bulls have been tested. Prediction

analyses revealed that Charolais bulls had the greatest ($P < 0.05$) ADG ($3.5 > 3.3 > 3.1 > 2.9 \pm 0.02$ lb/day) relative to Angus, Polled Hereford, and Hereford across years.

Regression analyses revealed a linear increase in growth traits across years. For example, initial weight increased 5.0 lb/yr, 112-day weight increased 7.6 lbs/yr and ADG increased 0.02 lb/day/year, whereas feed to gain ratio declined at a rate of -0.04 lb feed/lb gain/year. Analyses of independent regression lines indicated that Angus and Hereford made greater ($P < 0.05$) increases across years in ADG than Charolais and Polled Hereford ($0.02 > 0.015$ lb/day/year). Breed representation has been dynamic from 1961 to 2000 in the Tucumcari Bull Test with the number of Angus and Charolais bulls increasing each year. Growth traits have been steadily increasing with Charolais being the breed with the greatest performance level while the greatest increase occurred in *Bos taurus* breeds of British ancestry.

Key words: Performance, Growth, Bulls, Breed

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INTRODUCTION

Performance testing typically evaluates a bull's growth performance between weaning and one year of age. Performance testing at centralized locations allows for the comparison of beef bulls from different herds and breeds under standard conditions to identify genetically superior bulls for use in commercial herds (Liu et al., 1993). Generally, a bull's performance ranking at the end of a performance test is determined by measures of growth and efficiency such as ADG, feed to gain ratio, and weight per day of age (LaShell, 1999). Many of the original centralized tests involved cooperative efforts between land grant university extension services and producer-based cattle associations. When performance testing was initiated in New Mexico, most beef cattle operations did not have adequate facilities or data processing capabilities to conduct a performance test. Thus, a centralized performance test involving multiple cooperators was initiated at the New Mexico Agricultural Science Center in Tucumcari in 1961.

The goals of the Tucumcari Bull Test were to compare ability of bulls to gain weight, evaluate weight gain in relation to their sires, and to encourage herd improvement for commercial beef cattle operations or purebred seedstock herds. By the year 2000, 4579 bulls from 152 different cooperators and 21 breeds had been tested. Studying performance trends aids the beef cattle industry to understand how cattle have changed historically and provides insight for future selection strategies. The objective of this study was to evaluate trends in growth performance across and among breeds and evaluate sources of variation in the data collected from 1961 to 2000 in the Tucumcari Bull Test.

MATERIALS AND METHODS

The Tucumcari Bull Test was developed by collaboration of New Mexico Beef Performance Association, New Mexico State University Cooperative Extension Service, producers from New Mexico and surrounding states, and New Mexico Agricultural Science Center in Tucumcari. Although testing was initiated in 1961, the planning process for the test began in 1956.

Differing types of cooperators were defined before the testing program was initiated. Permanent cooperators were defined as those breeders who shared the initial costs of building the facilities or had purchased the rights to pens from former pen owners. Permanent cooperators have responsibility for maintenance, improvement of facilities, and have a vote with regard to decisions involving facilities and procedures governing the performance test. Alternate cooperators were breeders that participate in the test by renting a pen on a yearly basis when permanent cooperators elected not to use their pens. Alternate cooperators have a vote in decisions regarding testing procedures, but are not included in decisions regarding maintenance and improvement of the facilities. Testing was conducted for 140 days from 1961 to 2000. However, from 1987 to 2000, the test was conducted for 112 days. Testing procedures followed the Guidelines for Uniform Beef Improvement Programs as these guidelines evolved from 1961 to 1996 (BIF, 1996). Use of these procedures had been described in other centralized testing programs (Sasaki et al., 1982. LaSalle, 1999).

Performance Testing Procedures. In 2000, bulls had to be born no earlier than January 5 and no later than April 15, and have a 205-d adjusted weaning weight larger than 475 lbs. Bulls were required to be vaccinated for clostridial diseases using a minimum of 7-way vaccine. Bulls were also vaccinated for infectious bovine rhinotracheitis, parainfluenza, pasteurella,

and leptospirosis three weeks prior to delivery and treated for grubs with an appropriate insecticide prior to arrival.

Upon arrival in 2000, bulls were vaccinated with clostridium perfringens antitoxin and then again after being on feed for 56 days. Bulls were delivered to the testing station on a specified day in October and were weighed upon arrival. This weight was recorded as delivery weight. Bulls were then placed three or four to a pen with bulls in a particular pen being of the same breed, from the same cooperator, and potentially from the same sire. The testing facility contains 39 pens. The pens are 12 x 70 feet in size. The pens have shade and rain drainage above the feeding unit which is located on the north side of the pen. Water troughs were shared between two pens and were in the fenceline between the pens. After a three week acclimation period where all bulls were fed an antibiotic enhanced ration, bulls were weighed twice to determine each bulls initial test weight. Bulls were fed the same ration twice daily and allowed *ad libitum* access to feed and water. The test ration was purchased from a reputable feed company based on competitive bids that met the requirements of the ration established each year.

After the initial weight was recorded, bulls were weighed each 28 days through day 112 from 1987 to 2000. Two weights were collected at the end of this test for the final weight. From 1961 to 1986, bulls were tested for 140 days. Thus, the single weight collected on day 112 from 1961 to 1986 was used in analyses. When the test was completed, growth and efficiency measurements such as ADG, feed efficiency, and weight per day of age were determined by the procedures described by the Guidelines for Uniform Beef Improvement Programs from 1961 to 1996. Feed to gain ratio was calculated on a pen basis as all bulls in a pen were assigned a consumption value based on

an average of all weight gained in the pen divided by total amount of feed consumed by that particular pen. This estimation was calculated using metabolic midweight raised to the 0.75 power in a time-constant evaluation described by the Guidelines for Uniform Beef Improvement Programs from 1982 to 1996. The experimental unit for feed efficiency analyses was pen, whereas experimental unit for all other analyses was bull. Birth data was only recorded for each bull from 1982 to 2000 and scrotal circumference was recorded in the breeding soundness exam from 1981 to 2000.

Statistical analyses. Multiple analyses using the procedures of SAS (version 8.1, SAS Institute, Cary NC) were used to evaluate changes in performance from 1961 to 2000. In addition to evaluating number of bulls within breeds, the traits evaluated were birth weight, 205-day adjusted weaning weight, initial weight, 112-day weight, weight per day of age, ADG, scrotal circumference, feed to gain ratio, and adjusted 365-day weight.

The initial analysis evaluated the number of bulls within each breed across years. The slope of the change in each breed was calculated using the equation $y = \alpha + \beta x$, where α is the y intercept and β is the slope. This analysis was conducted only on breeds that had evaluated at least 500 bulls which were Angus, Charolais, Hereford, and Polled Hereford.

Prediction analyses were conducted using the mixed model procedures of SAS to evaluate significance of variation sources affecting growth traits. Main effect sources of variation for growth traits included breed, year, the breed by year interaction with initial age and delivery weight serving as covariates. The term sire was nested within breed and fit as a random variable to account for the potential confounding effects of pen, cooperator, and breed. These analyses were conducted with the data from all bulls and

then repeated just for the breeds having greater than 500 bulls evaluated from 1961 to 2000. When breed or the interaction of breed and year were found to be significant ($P < 0.05$), least square means were separated using the PDIFF function of SAS. Regarding breeds, separations were only among Angus, Charolais, Hereford, and Polled Hereford bulls.

Regression analyses were conducted in order to analyze rate of change of traits. A curve fitting procedure was used to determine if rate of change over time fit a linear, quadratic, or cubic regression model. These analyses were conducted by regressing the dependent variables against year as a linear (dependent variable = year), quadratic (dependent variable = year x year) or cubic (dependent variable = year x year x year) term within the Proc Reg feature of SAS. All breeds were included in these regression analyses. These analyses were repeated for the breeds of Angus, Hereford, Charolais, and Polled Hereford. The independence of the slopes of these regression lines among these four breeds were compared using the procedures described in Steel et al. (1997). To evaluate associative relationships of traits, Pearson's correlation analyses were conducted between growth traits from all breeds and then the analyses were repeated for those breeds having greater than 500 bulls tested.

RESULTS

Breeds, number of bulls, and sires within a breed are described in Table 1. There were 4784 records of bulls that started the test and 4579 records of bulls that had completed the test from 1961 to 2000. Hereford and Angus bulls were the most frequently tested breeds with the Charolais and Polled Hereford breeds also having greater than 500 bulls tested. The number of Angus, Hereford, Charolais, and Polled Hereford bulls tested each year is displayed

Table 1. Breeds evaluated, number of bulls tested per breed, and number of sires represented per breed in the Tucumcari Bull Test from 1961 to 2000.

Breed of Bulls	No. of Bulls	No. of Sires
Angus	1,249	322
Barzona	7	2
Beef Machine	4	1
Beefmaster	19	9
Bralers	4	3
Brangus	100	32
Charolais	642	172
Crossbred	8	5
Galloway	8	2
Hereford	1253	323
Limousin	32	13
Optimizers	4	2
Polled Hereford	561	126
Red Angus	188	69
Red Brangus	7	4
Romagnola	16	6
Salers	132	42
Santa Gertrudis	110	36
Shorthorn	5	3
Simbrah	8	4
Simmental	222	83
Total	4579	1259

in Figure 1. Angus, Charolais and Polled Hereford appear to be becoming more numerous, hence the positive slope of the line across years. Conversely, the Hereford breed having a negative slope experienced a decline in representation.

Independent variables of breed, sire, year and the interaction of breed and year were significant ($P < 0.05$) sources of variation in prediction of growth performance traits. Initial age and delivery weight were also significant ($P < 0.05$) covariates with the exception of initial age in prediction of scrotal circumference ($P > 0.48$), feed to gain ratio ($P > 0.90$) and ADG ($P > 0.21$). Analyses were repeated for those breeds with greater than 500 bulls evaluated. The results paralleled the previous analyses involving all breeds as the independent variables of breed and year and the covariate delivery weight were significant ($P < 0.05$) sources of variation. Initial age in this analysis was still

an insignificant source of variation in prediction of ADG and scrotal circumference.

Since breed was a significant source of variation ($P < 0.01$) in prediction of growth performance traits, mean separation procedures revealed that growth performance differed among Angus, Charolais, Herefords, and Polled Hereford bulls across years (Table 2). Specifically, Charolais bulls had the greatest ($P < 0.05$) levels of growth performance across years. Hereford bulls had the lowest ($P < 0.05$) levels of growth performance across years with the exception of birth weight in which the lowest ($P < 0.05$) level was observed in Angus bulls. Charolais bulls ($P < 0.05$) had lower feed to gain ratios than Polled Hereford bulls which were less ($P < 0.05$) than Angus and Hereford.

Regression analyses indicated that all traits with the exception of scrotal circumference and feed to gain ratio increased ($P < 0.01$) linearly. Feed to gain

ratio decreased ($P < 0.01$) linearly, while scrotal circumference appeared static (Figures 2 through 10). Analyses of independent regression lines suggested that birth weight was somewhat static ($P > 0.10$) among Angus, Charolais, and Hereford bulls across years. However, birth weight in Polled Hereford bulls declined ($P < 0.05$) relative to these breeds. Adjusted 205-day weight rate of improvement was similar ($P > 0.10$) among Angus, Charolais, and Hereford bulls which were greater ($P < 0.05$) than Polled Hereford bulls. Angus bulls had the greatest ($P < 0.05$) increase in initial weight among the four breed groups examined. Charolais and Hereford bulls were similar in their rate of increase ($P > 0.10$) for this trait, but experienced greater ($P < 0.05$) change than Polled Hereford bulls. Angus and Hereford bulls had greater ($P < 0.05$) rates of improvement than Charolais and Polled Hereford in 112-d weight. However, Charolais had greater ($P < 0.05$) rates of increase than Polled Hereford bulls.

Table 2. Least square means of growth traits in Angus, Charolais, Hereford, and Polled Hereford bulls in the Tucumcari Bull Test from 1961 to 2000.

Variable	Angus	Charolais	Hereford	Polled Hereford	Pooled SE
N	1249	642	1253	561	
Birth weight, lb ¹	80.2	94.1	86.2	83.1	0.7
205-d adjusted weaning weight, lb	584.1	648.4	535.3	565.5	3.8
Initial weight, lb	676.3	715.4	616.6	642.2	4.4
112-d weight, lb	1040.5	1111.4	936.6	981.2	6.6
Weight per day of age, lb	2.87	3.14	2.65	2.87	0.02
ADG, lb/day	3.29	3.54	2.87	3.03	0.02
*Feed Efficiency, lb feed/lb gain	8.97 ^a	7.58 ^b	8.95 ^a	8.49 ^c	0.3
Scrotal circumference, cm ²	35.4	35.0	34.3	32.8	0.3
365-d adjusted weight, lb	1045.8	1150.5	960.2	1011.7	6.0

* Super scripts in this row differ $P < 0.05$, In all other rows, numbers across columns differ $P < 0.05$.

¹Birth weight measurements recorded from 1982 to 2000

² Scrotal circumference measurement recorded from 1981 to 2000.

No differences ($P > 0.10$) were observed among breeds in evaluation of weight per day of age. However, Angus and Hereford bulls experienced greater ($P < 0.05$) increase in ADG than Charolais and Polled Hereford bulls. Angus, Charolais, and Hereford bulls experienced similar ($P > 0.10$) rates of improvement in feed to gain ratio and all three breeds improved at a greater ($P < 0.05$) rate than Polled Hereford. Scrotal circumference declined slightly in all breeds of bulls and Angus bulls experienced a greater ($P < 0.05$) rate of decline than Hereford. Finally, Angus and Hereford bulls increased at a greater ($P < 0.05$) rate than the Charolais and Polled Hereford breeds in adjusted 365-day weight.

Pearson's correlation analyses of growth performance traits and scrotal circumference are described in Tables 3 and 4. All traits compared were found to be positively correlated ($P < 0.05$), with the exception of the feed to gain ratio which was found to be negatively correlated to all growth traits. In brief, initial weight was highly correlated with final weight, adjusted 205- and 365-day weight, but moderately correlated to ADG. Weight per day of age was highly correlated with many traits in the test such as 205- and 365-day adjusted weights and 112-day weight.

DISCUSSION

Breed representation was dynamic in the Tucumcari Bull Test from 1961 to 2000 (Figure 1). Representation of Angus, Charolais, and Polled Hereford bulls increased whereas the number of Hereford bulls declined. This could be attributed to the fact that breed preferences have changed and (or) producers have adapted their bull development programs. Another possible explanation for breed representation change may be that some large seed stock producers are not willing to bring their bulls to the test as they can now effectively conduct performance

testing on their own ranches. Knowledge of differences in production traits among breeds allows producers to select for breeds that are suitable for varied production systems (Freetly et al., 1998; Laster et al., 1976 and 1979; Gregory et al., 1979). Analysis of different breeds is required to exploit heterosis through crossbreeding to match genetic potential with diverse markets, feed resources, and climates (Cundiff et al., 1993). Dynamic breed representation could also be a consequence of the fact that not one certain breed excels at all economically relevant traits (Wheeler et al., 2001), and producers are adapting breed composition of their herds to fit particular environments or production systems.

Growth performance has increased linearly from 1961 to 2000 in the Tucumcari Bull Test (Figures 2 to 10). Results are similar to the report of Sullivan and coworkers (1995) where improvements in growth performance were positive and British breeds generally had larger increases in improvement for traits such as ADG, adjusted weaning weight, and adjusted yearling weight than Continental breeds such as the Charolais. As suggested by Liu and Markarechian (1993) and Collins-Lusweti and Curran (1985), British breeds such as Angus and Hereford mature earlier than Continental breeds. Thus, they are physiologically older at the end of a performance test and probably have more room for improvement during this stage of a bull's life than bulls of continental breeds. In these data, continental breeds were larger than British breeds throughout the study (Table 2); thus, these cattle probably had extended growth curves relative to British breeds and less room for improvement in a 112-day test. These findings parallel the recent finding of Cycle VII of the USDA germplasm evaluation studies (Cundiff et al., 1999 and 2003). It should also be noted that Hereford bulls appeared to have the lowest levels of performance in this test (Table 2),

this result was obviously influenced by the large numbers of Hereford bulls tested in the initial years of the test and the limited number of Hereford bulls tested in the latter years of the test. It should also be noted that it was very difficult to account for the variation in these analyses contributed by the fact that a large number of Hereford bulls in the early years of the test were from just a few breeders.

While breed selection can be an important factor in herd improvement, sire selection would typically have a larger effect. If sub optimal sires are used, then rate of improvement would be lessened. A sire comparison was not possible in these analyses as sires were usually only represented once, and sires were not used by multiple producers. In a more numeric sense, age in the Tucumcari study had a significant effect on final test weight. These results agree with the research Batra and Wilton (1972) and Tong, (1982). However, with the stringent birth date requirements in the current study, age differences should have been nullified in the test. This may explain the observation that initial age was not a significant source of variation on ADG.

Study of performance trends in the Tucumcari Bull Test agree with the report of Hughes (2000). This study illustrated that as beef cattle inventory across the United States decreased in the years 1965 to 2000, beef production per cow increased. Hughes attributed this increase to improved weaning and carcass weight trends. While carcass weight was not an available measurement in this study, adjusted 205-day weight increased similar to the data discussed by Hughes (2000).

Selection for increased weight at different stages of life such as at weaning weight (i.e. 6 months) and yearling weight has been positively correlated with increased birth weight (Brinks et al., 1964; Smith et

al., 1976) and increased birth weight has also been associated with increased levels of dystocia (Bellows et al. 1971; Laster et al. 1973). Results from this study concur as birth weight was moderately correlated to adjusted 205- and 365-day weight (Tables 3 and 4). However, birth weight in the Angus, Hereford, and Charolais bulls appeared static and declined slightly in the Polled Hereford bulls across years. This result is most likely due to the need for calving ease in range livestock production systems in New Mexico and surrounding states. There is evidence that selection for reduced birth weight and high yearling weight can improve production efficiency through enhanced maternal performance in beef production systems (Dickerson et al. 1974; MacNeil et al. 2000). However, this type of selection will reduce the rate of genetic improvement in yearling weight relative to mass selection for high yearling weight alone (MacNeil et al. 1998). Most range beef production systems probably place higher priority on maternal traits such as calving ease as these systems are predominately cow-calf operations.

A strong correlation with initial weight and final weight at the end of the testing program was observed (Tables 3 and 4). These results support the previous research of Batra and Wilton (1972) and Tong (1982). However, they do not agree with a previous study conducted by Jensen et al, (1991) in which these traits were not highly correlated. This discrepancy could be due to variation among testing stations (Sasaki et al., 1982). Nonetheless, as one would expect bulls that are large at the beginning of the test were most likely large at the end of the test. However, ADG was only moderately correlated to initial and final weight (Tables 3 and 4). Selection for efficiency requires more effort than direct selection for growth. In the time period of 1961 to 2000, beef cattle in the U.S. increased greatly in size from selection for growth (Hughes, 2001).

Efficiency traits such as ADG, weight per day of age, and feed to gain ratio improved from this type of selection; however, direct selection is typically more effective than indirect selection; thus, in the next 40 years of the beef industry, selection directly for efficiency traits may again cause change in performance trends. Addition of carcass measures through ultrasound and or the implementation of DNA technologies may also influence these future trends.

Scrotal circumference was found to be low to moderately correlated to growth traits and was static to slightly declining from 1982 to 2000 (Table 3 and 4; Figure 9). This is an odd observation as most breed associations have recently reported great improvement in the trend for scrotal circumference EPD (Thomas, 2003). Perhaps this is a reflection of the efforts placed on selection for growth or an indication that when scrotal circumference became a trait of interest in this test, the trait was already at an acceptable level as recently reported in the work of Martinez-Velazquez et al. (2003). Nevertheless, scrotal circumference is a trait of high heritability (Martin et al., 1992). Thus, if consignors wanted to greatly improve this trait they should be able to accomplish this goal in a short time frame.

In conclusion, breed representation in the Tukumcari Bull Test was dynamic from 1961 to 2000 as the numbers of Angus, Charolais, and Polled Hereford bulls increased, and the number of Hereford bulls declined. Growth performance has steadily increased with Charolais having the greatest level of growth performance and Hereford having the lowest levels. While the greatest levels of growth traits were observed in Charolais bulls, the greatest increase in growth traits occurred in the British *Bos taurus* breeds such as the Angus and Hereford. Charolais was the most efficient breed converting feed into gain.

However, their rate of improvement for feed efficiency was similar to the rate of improvements made by the Angus and Hereford. Cumulatively, producers participating in the Tukumcari Bull Test have successfully improved growth performance and feed efficiency, while maintaining birth weight at an acceptable level.

IMPLICATIONS

Linear improvements have been made in growth performance and efficiency measurements in beef bulls performance tested in Tukumcari, New Mexico from 1961 to 2000. Breed representation declined from being primarily Hereford to larger percentages of Angus and Charolais. Knowledge of these trends allows the New Mexico beef industry to understand that breed composition of cow-herds has changed and the cattle have gotten much larger and have greater levels of growth performance.

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Table 3. Pearson's correlations¹ of growth and reproductive traits in the Tucumcari Bull Test from 1961 to 2000 (n = 4579 bulls from 21 breeds).

Birth Wt	Initial Wt	ADG ²	WDA ³	SC ⁴	F:G ⁵	112-d Wt	ADJ ⁶ WW	ADJ ⁷ YW	
1.00	0.26	0.17	0.38	0.14	-0.25	0.29	0.33	0.32	Birth Wt
	1.00	0.37	0.67	0.34	-0.27	0.80	0.67	0.67	Initial Wt ²
		1.00	0.77	0.23	-0.47	0.67	0.37	0.74	ADG ³
			1.00	0.32	-0.44	0.81	0.73	0.95	WDA ⁴
				1.00	-0.01	0.41	0.24	0.31	SC ⁵
					1.00	-0.41	-0.29	-0.45	F:G ⁶
						1.00	0.55	0.84	112-d Wt
							1.00	0.73	ADJ WW ⁷
								1.00	ADJ YW ⁸

¹Comparisons had a significance measurement of P < 0.01.

²Wt = Weight

³ADG = Average daily gain

⁴WDA = Weight per day of age

⁵SC = Scrotal circumference

⁶F:G = Feed-to-gain ratio

⁷ADJ WW = Adjusted weaning weight

⁸ADJ YW = Adjusted yearling weight

Table 4. Pearson's correlations¹ of growth and reproductive traits in the Tucumcari Bull Test, from 1961-2000 for breeds having greater than 500 animals tested (Angus, Charolais, Hereford, and Polled Hereford).

Birth Wt	Initial Wt	ADG ²	WDA ³	SC ⁴	F:G ⁵	112-d Wt	ADJ ⁶ WW	ADJ ⁷ YW	
1.00	0.28	0.17	0.38	0.12	-0.32	0.27	0.38	0.39	Birth Wt
	1.00	0.39	0.67	0.30	-0.33	0.80	0.66	0.68	Initial Wt. ²
		1.00	0.77	0.17	-0.47	0.66	0.38	0.73	ADG ³
			1.00	0.24	-0.48	0.79	0.72	0.95	WDA ⁴
				1.00	0.03	0.33	0.19	0.24	SC ⁵
					1.00	-0.44	-0.33	-0.50	F:G ⁶
						1.00	0.55	0.83	112-d Wt
							1.00	0.74	ADJ WW ⁷
								1.00	ADJ YW ⁸

¹Comparisons had a significance measurement of P < 0.01.

²Wt = Weight

³ADG = Average daily gain

⁴WDA = Weight per day of age

⁵SC = Scrotal circumference

⁶F:G = Feed-to-gain ratio

⁷ADJ WW = Adjusted weaning weight

⁸ADJ YW = Adjusted yearling weight

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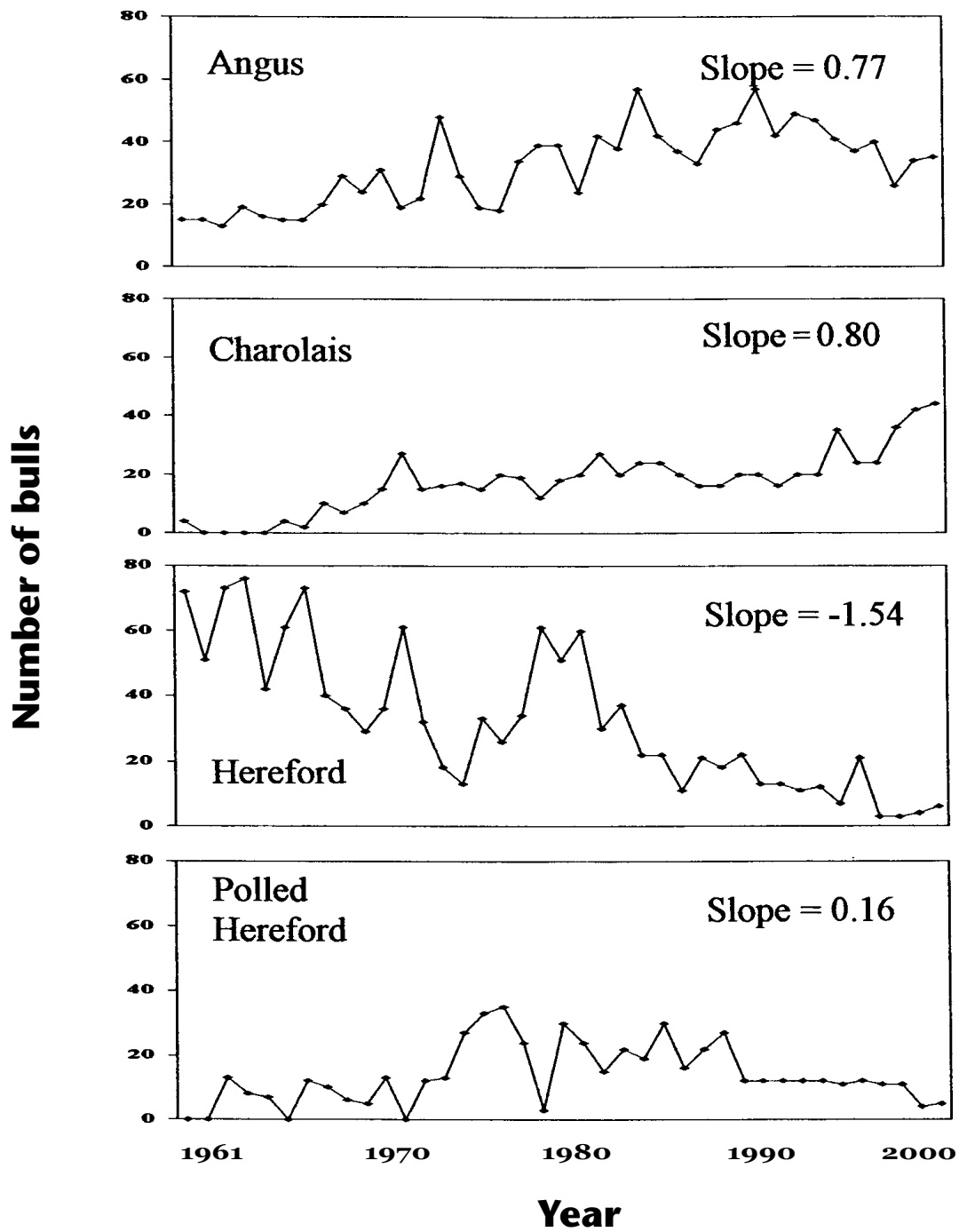


Figure 1. Number of bulls tested in breeds with greater than 500 bulls evaluated in the Tucumcari Bull Test from 1961 to 2000.

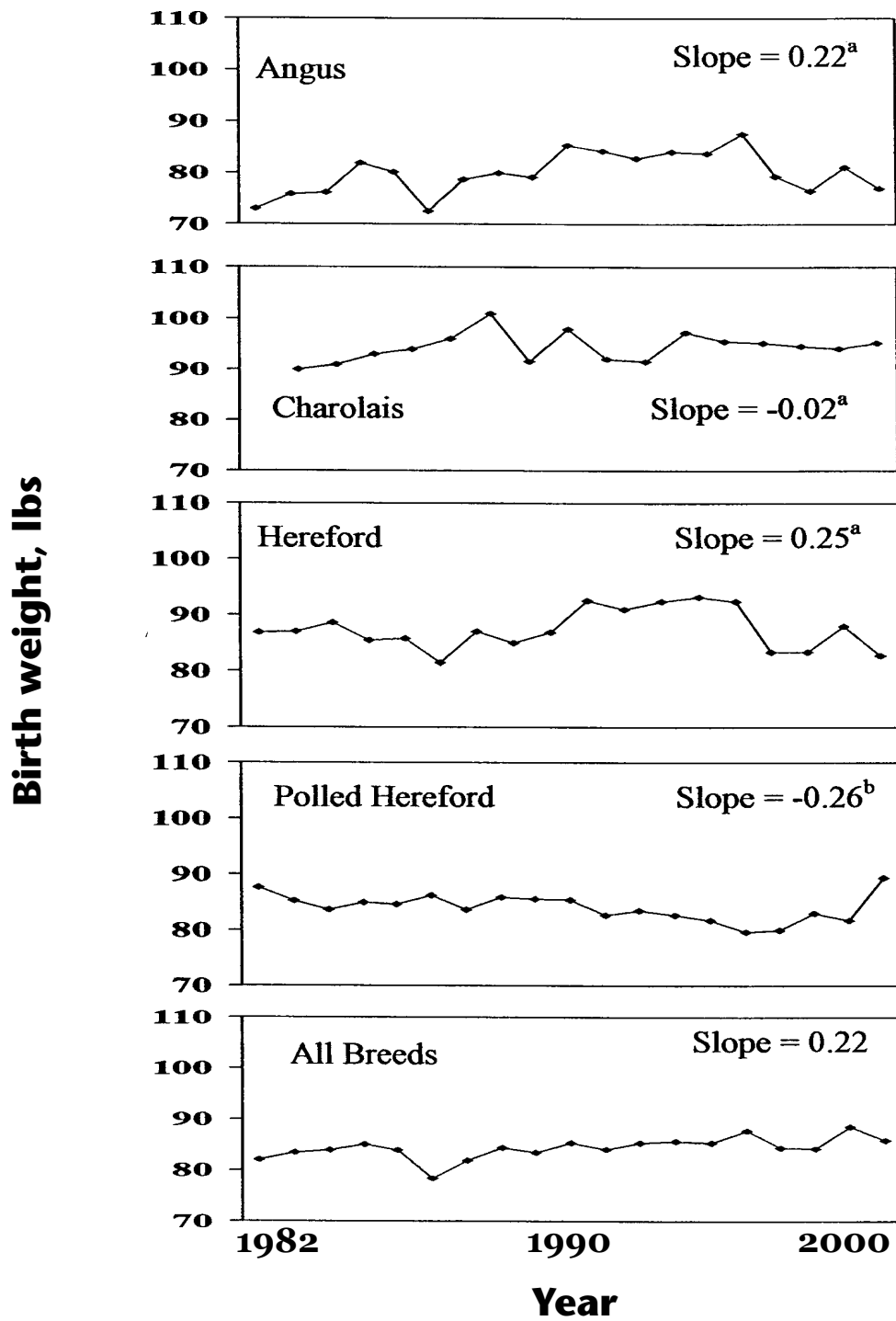


Figure 2. Means of birth weight of all breeds (bottom panel) and those breeds with greater than 500 bulls evaluated (top 4 panels) in the Tucumcari Bull Test from 1981 to 2000. Slope of each line is included in each panel with superscripts differing $P < 0.05$ between panels.

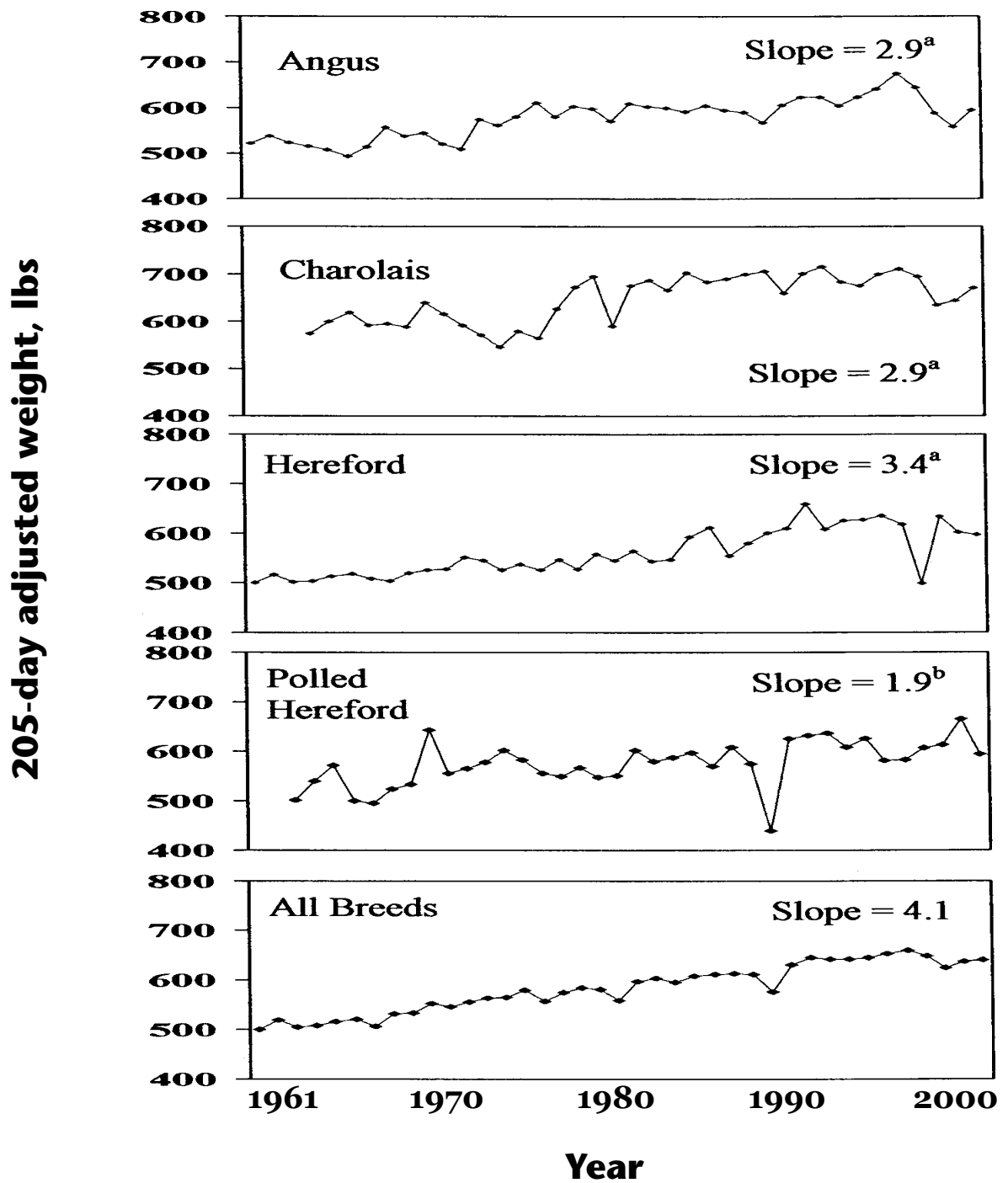


Figure 3. Means of adjusted 205-day weight of all breeds (bottom panel) and those breeds with greater than 500 bulls evaluated (top 4 panels) in the Tucumcari Bull Test from 1961 to 2000. Slope of each line is included in each panel with superscripts differing $P < 0.05$ between panels.

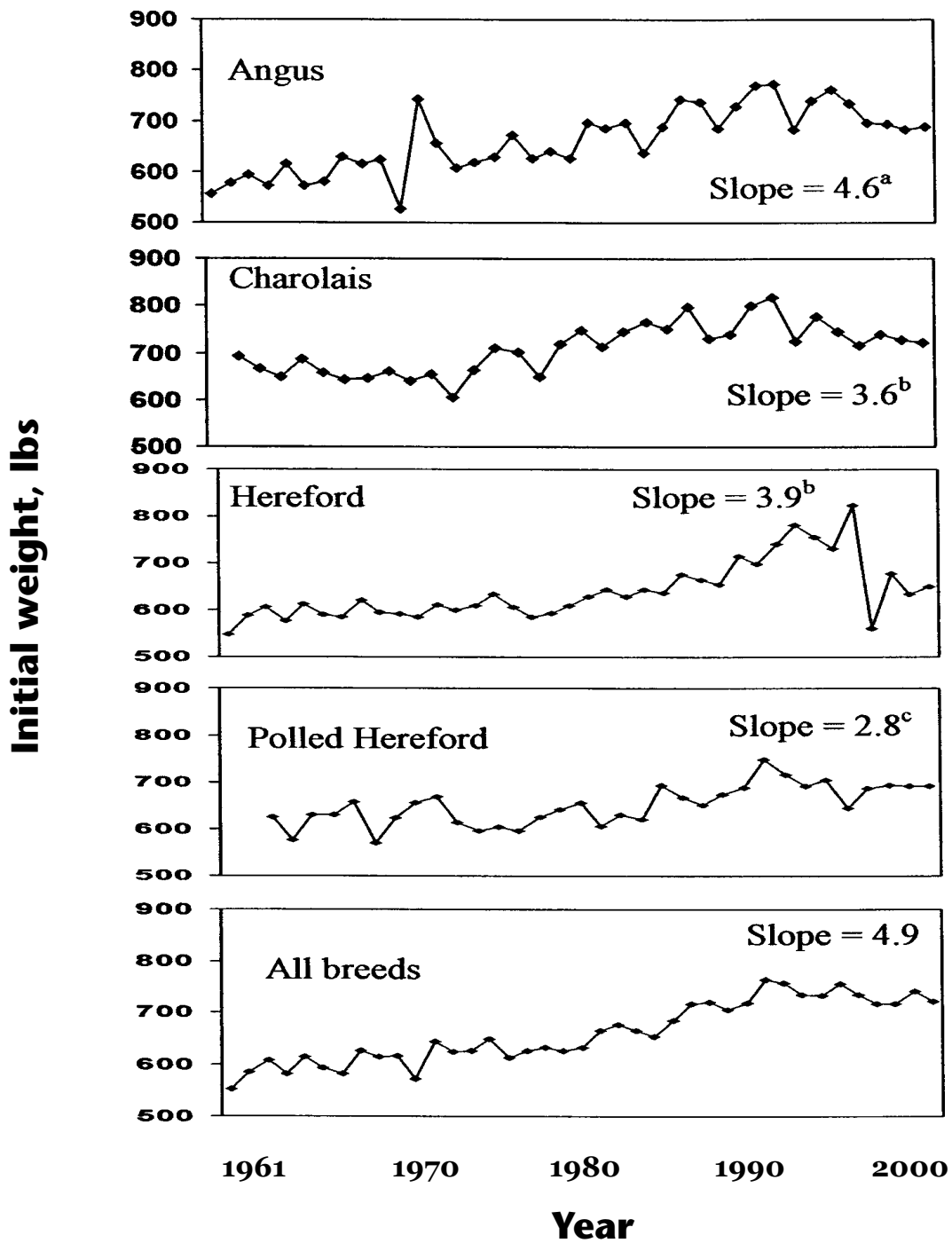


Figure 4. Means of initial weight of all breeds (bottom panel) and those breeds with greater than 500 bulls evaluated (top 4 panels) in the Tucumcari Bull Test from 1961 to 2000. Slope of each line is included in each panel with superscripts differing P < 0.05 between panels.

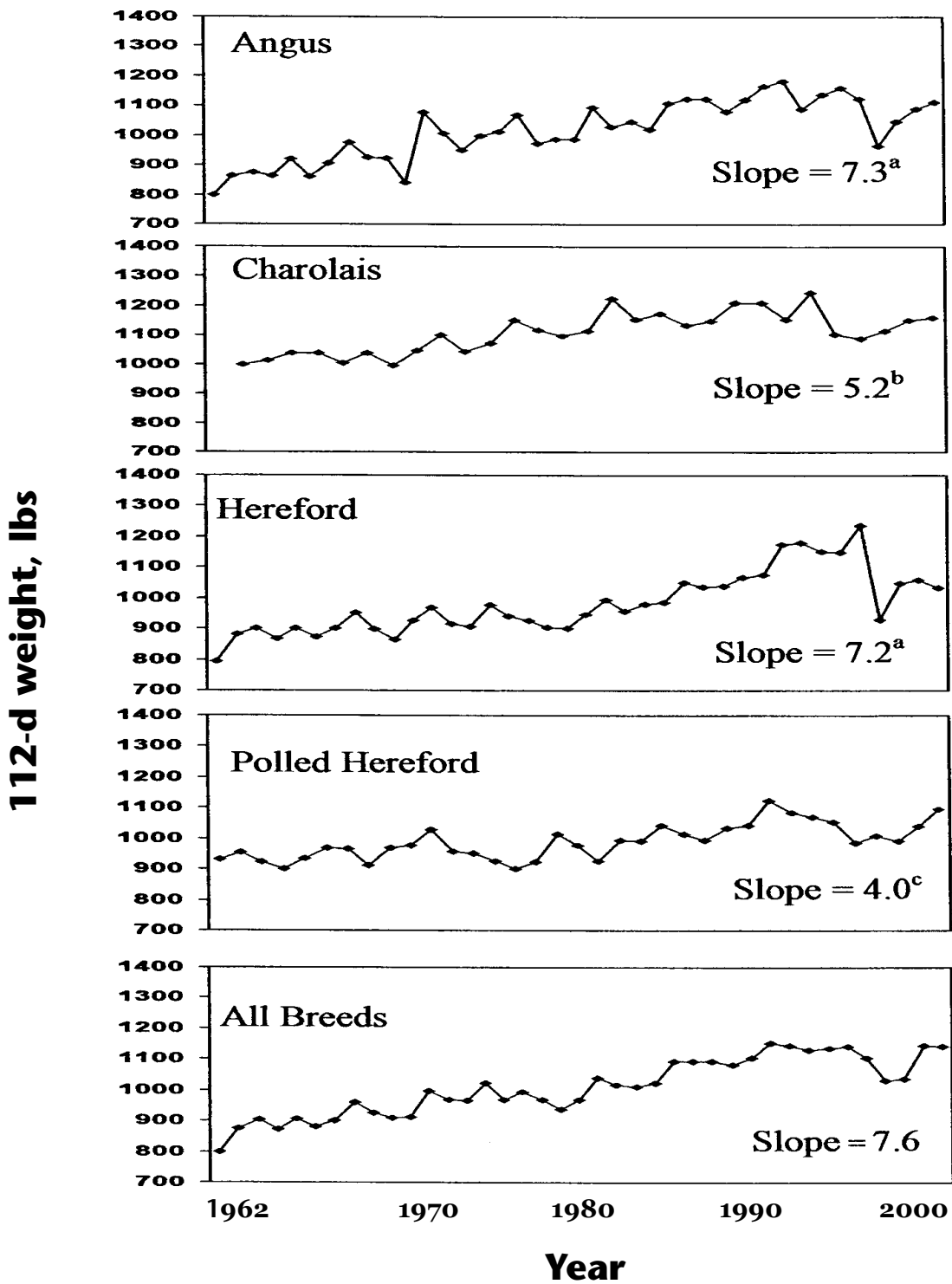


Figure 5. Means of 112-d weight of all breeds (bottom panel) and those breeds with greater than 500 bulls evaluated (top 4 panels) in the Tucumcari Bull Test from 1961 to 2000. Slope of each line is included in each panel with superscripts differing P < 0.05 between panels.

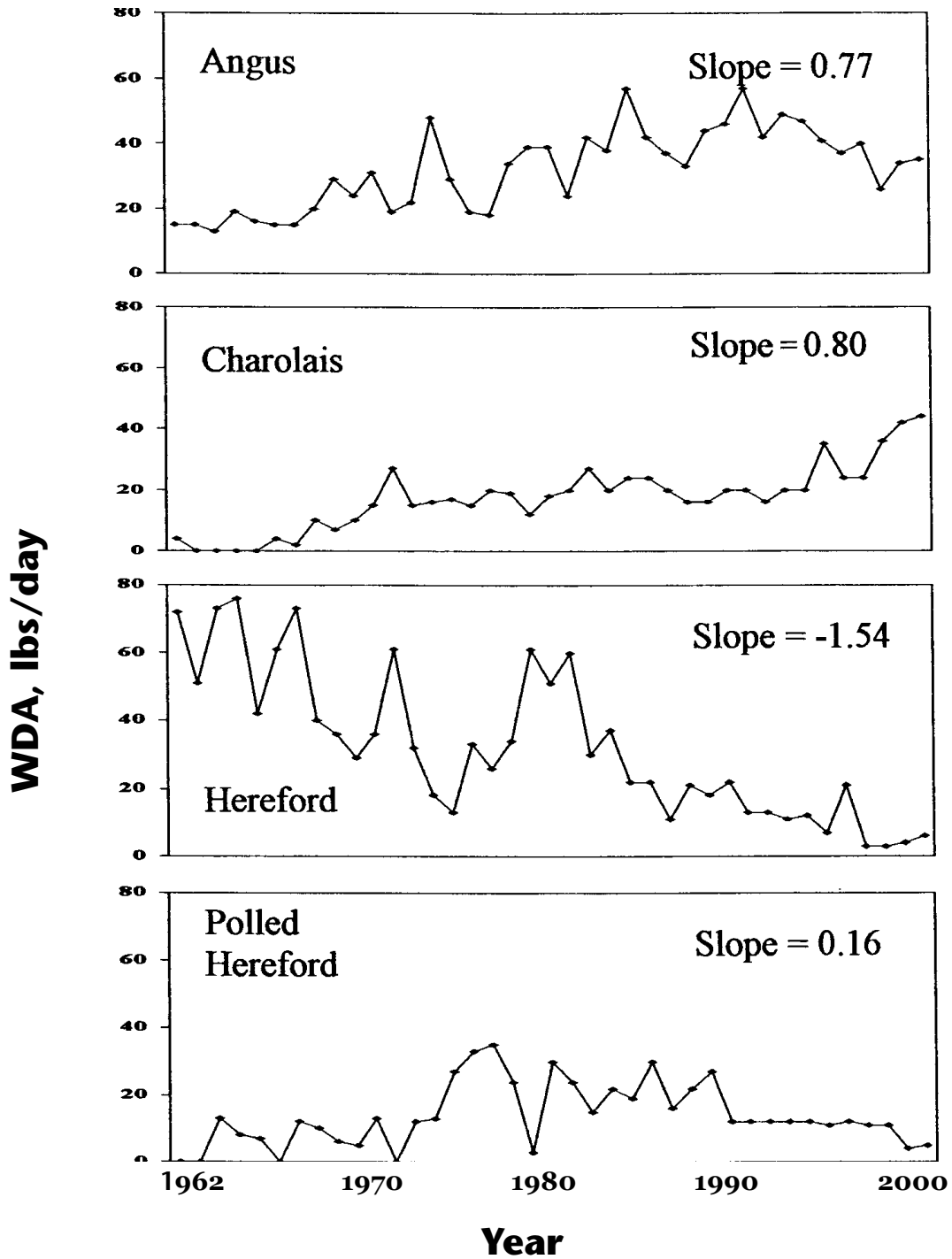


Figure 6. Means of weight per day (WDA) of all breeds (bottom panel) and those breeds with greater than 500 bulls evaluated (top 4 panels) in the Tucumcari Bull Test from 1961 to 2000. Slope of each line is included in each panel with superscripts differing $P < 0.05$ between panels.

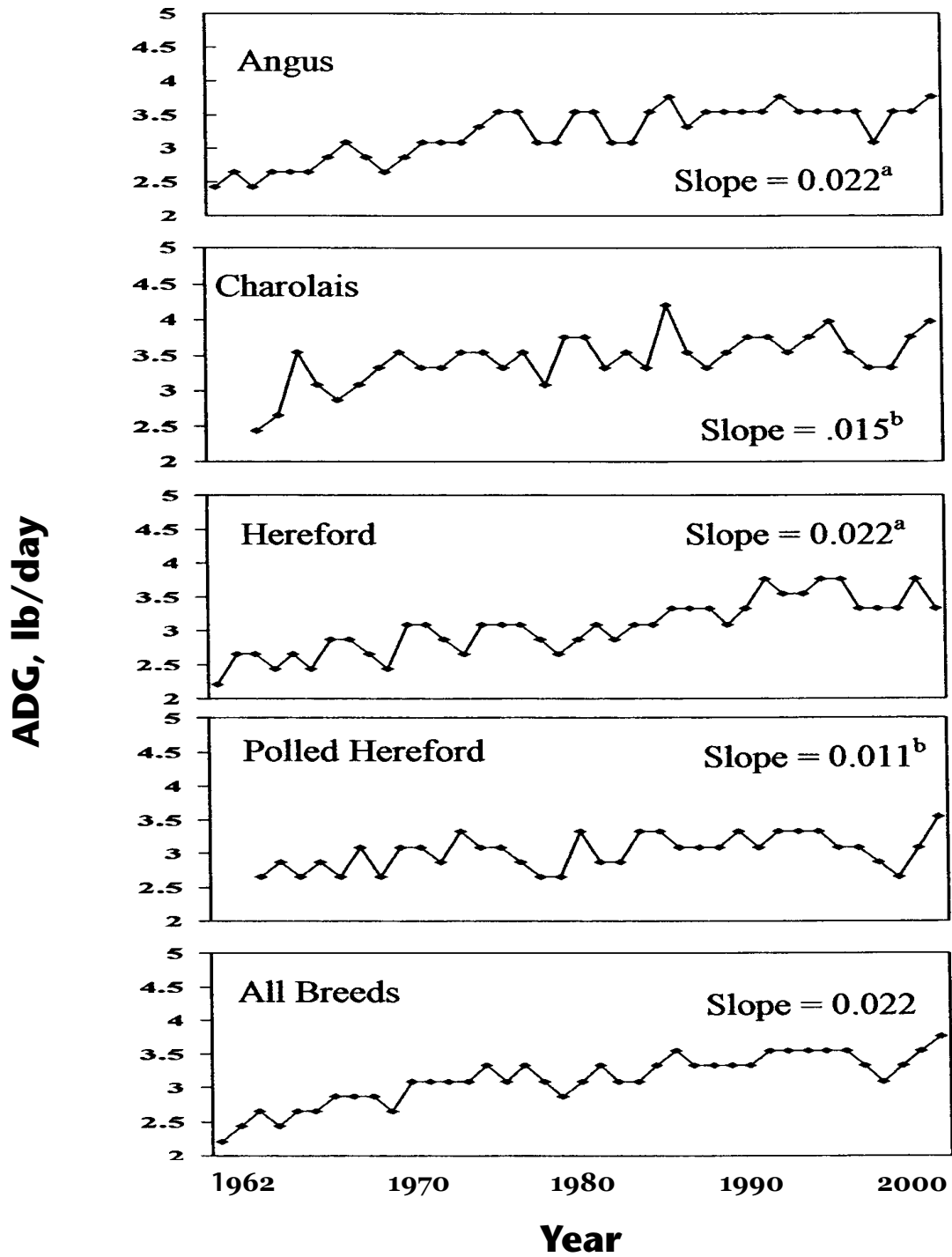


Figure 7. Means of ADG of all breeds (bottom panel) and those breeds with greater than 500 bulls evaluated (top 4 panels) at Tucumcari Bull Test from 1961 to 2000. Slope of each line is included in each panel with superscripts differing P < 0.05 between panels.

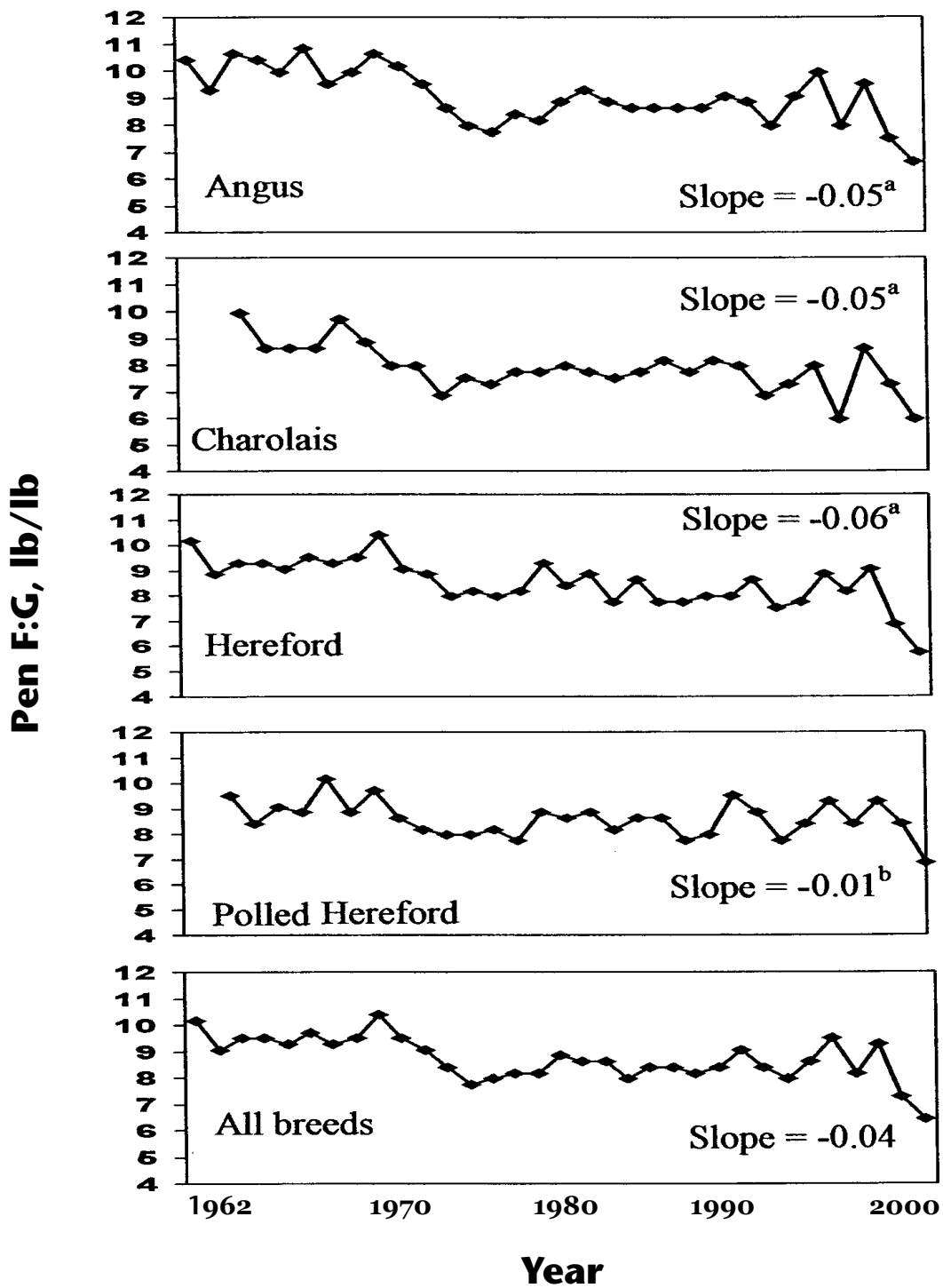


Figure 8. Means of pen feed to gain ratio (F:G) of all breeds (bottom panel) and those breeds with greater than 500 bulls evaluated (top 4 panels) in the Tucumcari Bull Test from 1961 to 2000. Slope of each line is included in each panel with superscripts differing $P < 0.05$ between panels.

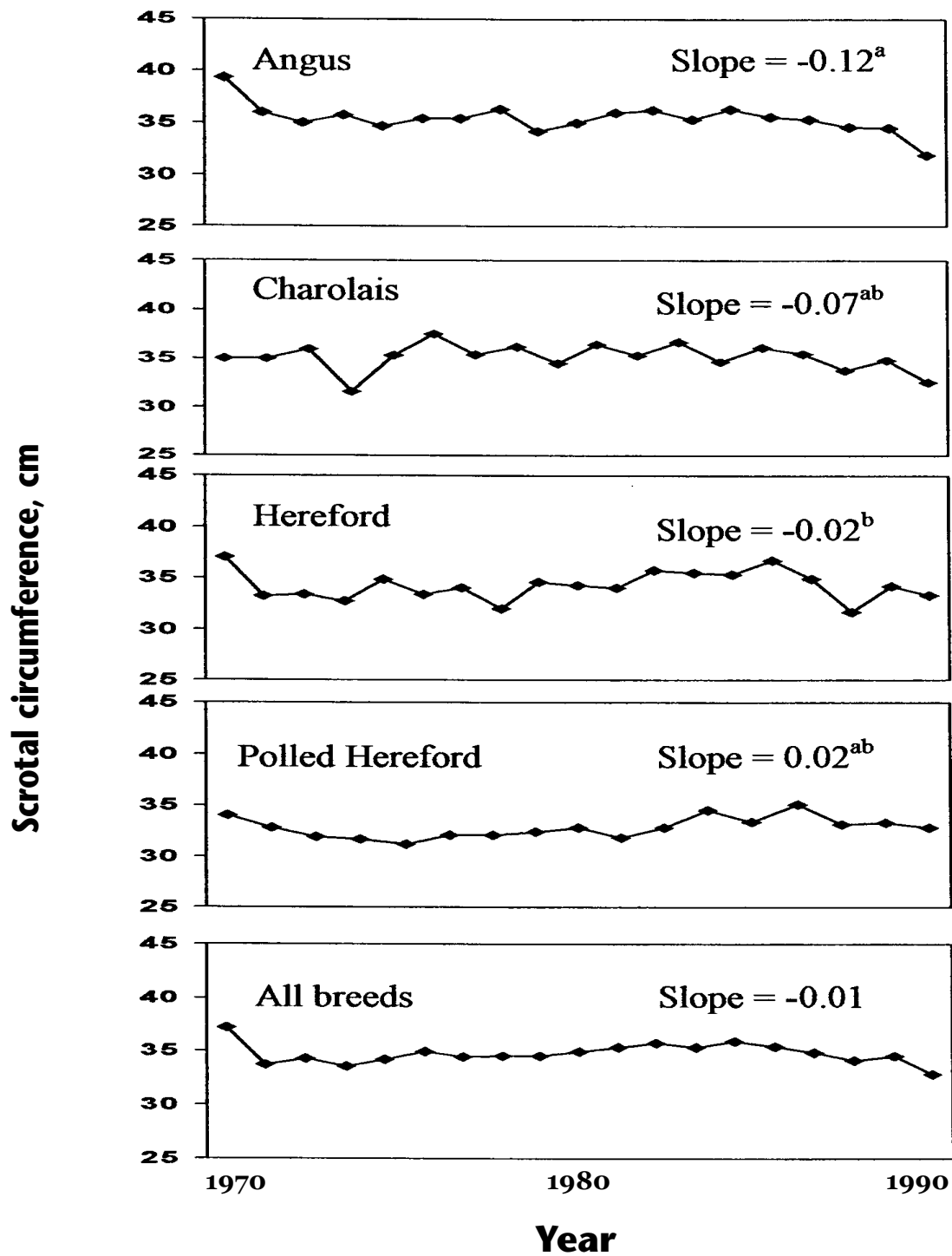


Figure 9. Means of scrotal circumference of all breeds (bottom panel) and those breeds with greater than 500 bulls evaluated (top 4 panels) in the Tucumcari Bull Test from 1982 to 2000. Slope of each line is included in each panel with superscripts differing $P < 0.05$ between panels.

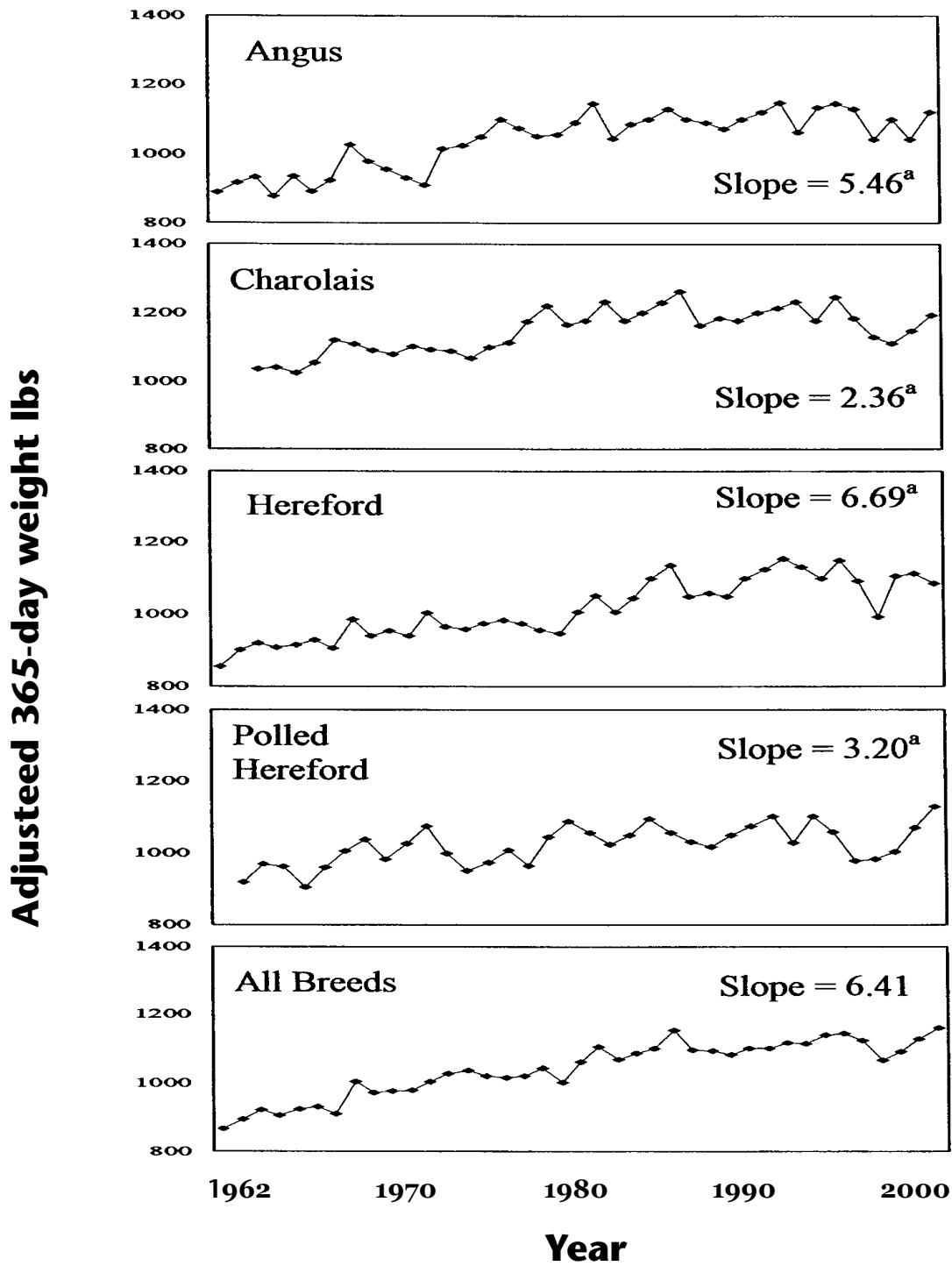


Figure 10. Means of adjusted 365-day weight of all breeds (bottom panel) and those breeds with greater than 500 bulls evaluated (top 4 panels) in the Tucumcari Bull Test from 1961 to 2000. Slope of each line is included in each panel with superscripts differing $P < 0.05$ between panels.

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