Volume 3 1989

Texas Journal of Agriculture and Natural Resources

A Publication of the Agricultural Consortium of Texas

GENERAL INFORMATION

The **Texas Journal of Agriculture and Natural Resources** is published annually by the Agriculture Consortium of Texas (ACT). The ACT is composed of the nine state-supported, four year, nonland grant Universities of Texas which offer degrees in agriculture and or natural resources. These universities are Angelo State University, East Texas State University, Sam Houston State University, Southwest Texas State University, Stephen F. Austin State University, Sul Ross State University, Texas A&I University, Texas Tech University and West Texas State University.

The purpose of the **Texas Journal of Agriculture and Natural Resources** is to publish articles which are research-based and either descriptive or experimental in nature. Articles from the various disciplines of agriculture and natural resources are published in the **Journal** subsequent to critical review and approval of the editorial board. Articles submitted for publication in the **Journal** are to report on work completed in Texas within the last two years by university or other agricultural/natural resource personnel. No article is to be submitted for review if the manuscript is under consideration by another professional journal or magazine. Articles are to be written with critical research analysis but in a fashion that will be easily understood by professional agriculturalists and resource managers. Publication charges are $50.00 per **Journal** page for one (1) to four (4) pages with a minimum charge of $100.00 per article. Additional pages will be charged at the rate of $100 per **Journal** page. Information on manuscript preparation is printed on the inside back cover. Subscription rates are $5.00 per year for domestic and $10.00 per year for foreign subscribers. All communications related to handling of subscriptions should be addressed to the Editor-in-Chief, **Texas Journal of Agriculture and Natural Resources.** W.T. Box 998, West Texas State University, Canyon, TX 79016.

ISSN 0891-5466

Volume 3 1989

ARTICLES

EFFECTS OF SEED TREATMENT AND ENVIRONMENTAL STRESS ON GERMINATION AND ESTABLISHMENT OF 'SABINE' ILLINOIS BUNDLEFLOWER

H.D.C. Msiska[1] and C.A. Call[2]

ABSTRACT

Germination responses of scarified (hot water soak at 175° F for 3 minutes) and unscarified seeds of 'Sabine' Illinois bundleflower (Desmanthus illinoensis) were investigated at substrate water potentials of 0, -2.5, -5.0, -7.5, and -10.0 atmospheres in 50/68, 60/78, and 68/86°F temperature regimes. Scarification and warmer temperature regimes (60/78 and 68/86°F) increased cumulative germination and decreased mean germination time, whereas low water potentials decreased cumulative germination and increased mean germination time. A degraded native pasture in the Post Oak Savannah region was sod-seeded with scarified, unscarified, and a mixture of scarified and unscarified seeds following suppression (herbicide, disking, or untreated) of resident vegetation. Seedling densities were greatest for scarified seeds during the first growing season because of the breaking of seed coat dormancy. However, plant densities were greatest for unscarified seeds by the third growing season because of continual establishment from a dormant seed bank. Seedling and plant densities were greatest for the herbicide (glyphosate) suppression treatment that created vegetation gaps without disturbing the mulch layer or the soil surface.

Key words: Desmanthus illinoensis, seed dormancy, seed scarification, sod-seeding, water stress, temperature stress

INTRODUCTION

Native legumes are either nonexistent or make minor contributions to the forage base and nitrogen economy of millions of acres of rangelands in the Southern Great Plains because of selective removal by past livestock grazing (Sims et al., 1980). Several native legumes, including Illinois bundleflower (Desmanthus illinoensis), have been recently released or are currently being evaluated for range improvement uses by the Soil Conservation Service (SCS) in cooperation with the Texas Agricultural Experiment Station and the Texas Parks and Wildlife Department. Illinois bundleflower, a deep-rooted, warm-season, perennial legume, occurs in nearly all of Texas except the extreme east, west, and south (Rechenthin, 1972). This plant is drought-resistant, winter-hardy, and adapted to a wide variety of soils (Phillips Petroleum Co., 1963).

Recently, considerable effort has been directed toward establishing legumes in grass stands by no-till (sod-seeding) methods (Bryan, 1985; Burton, 1976; Mueller and Chamblee, 1984; Olsen et al., 1981; Skousen and Call, 1987). Most sod-seeding research has emphasized the establishment of introduced, cool- season, annual legumes in cool- or warm-season, perennial grass stands. Consequently, little is known about the establishment of warm-season, perennial legumes in warm-season, perennial grass stands.

Warm-season legume establishment has been beset by seed dormancy problems and fluctuating weather conditions at the time of planting, so good stands are often difficult to achieve (Burton, 1976). Seeds of Illinois bundleflower develop an impermeable seed coat with age (Call, 1985; Latting, 1961). Germinability can be enhanced under controlled enviroment conditions following chemical and mechanical scarification treatments (Call, 1985). However, scarified and unscarified seeds of Illinois bundleflower have not been germinated under a gradient of temperature and substrate water potentials representing the range of enviromental conditions that may be encountered at planting time.

Our objectives were to characterize the germination of scarified and unscarified seed of 'Sabine' Illinois bundleflower under different temperature and substrate water potential regimes in a controlled enviroment and evaluate the establishment of similarly treated seeds when sod-seeded in a native pasture in the Post Oak Savannah region.

MATERIALS AND METHODS

Controlled Environment Study

Seeds of Sabine Illinois bundleflower were obtained from the SCS Plant Materials Center, Knox City, Texas. Seeds were harvested in 1983 and stored at 60°F and 40% relative humidity before germination trails in July through December 1984. Three replicates of 50 undamaged seeds, preconditioned by cutting the seed coat with a razor blade at the end opposite the micropyle, were placed in a 1.0% solution of triphenyl tetrazolium chloride for 24 hours at 78°F in complete darkness to determine viability. Percent viability was determined by evaluating intensity of staining and staining patterns under a 10 x lens (Grabe, 1970).

Lots of 100 scarified (hot water soak at 175°F for 3 minutes) or unscarified seeds were placed on one piece of Whatman No. 1 chromatography paper in 5 x 5.5 x 1.5-inch plastic trays. The chromatography paper was supported by a 0.25-inch thick piece of polyurethane foam with five cotton wicks which extended into a 7.15 ounce reservior of solution. Solutions had water potentials of 0, -2.5, -5.0, -7.5, and -10.0 atmospheres, which were derived by mixing 20,000 MW polyethylene glycol (PEG) with distilled water. Solution water potentials were measured by saturating chromatography paper discs (0.12 inch diameter) and placing them into a Wescor Model C-52 psychrometer sample chamber. Readings were recorded with a Wescor HR 33-T microvotlmeter following a 1 min equilibration period and a 15 sec cooling period. Trays were wrapped with clear polyethylene film to reduce evaporation and stabilize relative humidity.

Trays were placed in controlled environment chambers with night/day temperature regimes of 50/68, 60/78, and 68/86°F and 12-hour photoperiods. During the day period, a light intensity of 1,000 foot-candles was maintained at tray level. Germination was evaluated every other day over a 21-day period. Germination was considered complete when radicle length was 0.25 inches or greater and at least one of the cotyledons was exposed (Copeland, 1978). Germination rates were estimated by calculating the mean time in days taken for viable seeds to germinate (Ellis and Roberts, 1978).

The experiment was arranged in a completely randomized design with three replicates per treatment. The entire experiment was repeated, and data from both trials were combined before statistical analysis. The effects of substrate water potentials and alternating temperature regimes on cumulative germination percentages (adjusted by an arcsine transformation before analysis) and mean germination time values were analyzed by the use of a quadratic response surface ($P<.05$) (Evans et al., 1982).

Sod-seeding Study

The study site was located on the Texas A&M Native Plant and Animal Conservancy, 3 miles west of College Station in the Post Oak Savannah region. The site was dominated by brownseed paspalum (Paspalum plicatulum) and little bluestem (Schizachyrium scoparium). Texas wintergrass (Stipa leucotricha), knot-root bristlegrass (Setaria geniculata), silver bluestem (Bothriochloa saccharoides),

[1]Present affiliation: Ministry of Agriculture, Mzuzu, Malawi
[2]Present affiliation: Department of Range Science, Utah State University, Logan
Former affiliation: Departmentof Range Science, Texas A&M University, College Station
Published with approval of the Director, Texas Agricultural Experiment Station as TA-23937.

and several annual grasses and forbs were minor components of the plant community. Mean minimum temperature in January is 40°F while mean maxium temperature in July is 95°F. Mean annual precipitation is 38.5 inches, with peak rainfall in May and September. Soils are of the Tabor series (fine, montmorillonitic, thermic Udertic Paleustalf), but have been so severely eroded that the fine sandy loam surface horizon has been removed, leaving a heavy clay subsoil exposed. Domestic grazing animals have been excluded from the site for at least 10 years.

Sod suppression treatments (10 x 50 foot plots) imposed on the site 1 week prior to seeding were: 1) single pass with a tandem offset disk to disrupt the sod; 2) 50% suppression (10- inch wide sprayed bands separated by 10-inch wide unsprayed bands) with glyphosate herbicide (N-(phosphomethyl) glycine) applied at a rate of 5 lbs. a.i/acre; and 3) untreated control. Sabine Illinois bundleflower was seeded into the three sod suppression treatments on April 5, 1985 at a 0.5-inch depth on 20-inch wide row spacings (rows located in middle of 10-inch wide herbicide bands) with a Tye Pasture Pleaser. The following seed treatments were used for each sod suppression treatment: 1) 100% of seed lot scarified (hot water at 175°F for 3 minutes), planted at recommended seeding rate (1.5 lbs. pure live seed/acre); 2) 50% of seed lot hot water scarified/50% unscarified, planted at recommended seeding rate; 3) 100% of seed lot scarified, planted at recommended seeding rate; and 4) 100% of seed lot unscarified, planted at twice the recommended seeding rate. All seed treatments were inoculated with Desmanthus spec. 1 inoculum prior to seeding. Phosphorus (as triple superphosphate, 46% P_2O_5) and potassium (as potassium sulfate, 53% K_2O) were applied along the seeded row at 180 and 90 lbs./acre, respectively.

The sod suppression and seed treatments were combined into a 3 x 4 factorial experiment arranged in a completely randomized block design with four replications per treatment combination. Plant density and standing crop were determined from five permanent subplots (40 inches of row length) within each replication of each treatment combination. Plant growth parameters were tested for significance (P<.05) by using the SAS general linear model analysis of variance procedure, and treatment means were separated by Duncan's multiple range test at P<.05 (Ray, 1982).

RESULTS AND DISCUSSION

Controlled Environment Study

In general, hot water scarification and warmer temperature regimes increased cumulative germination (Table 1) and decreased mean germination time (Table 2) of Sabine Illinios bundleflower seed. Low substrate water potentials decreased cumulative germination (Table 1) and increased mean germination time (Table 2), regardless of seed treatment and treatment regime. Highest cumulative germination percentages and most rapid mean germination times were observed at the 0 atmosphere water potential level in the 60/78 and 68/86°F temperature regimes. Under these moisture and temperature conditions, cumulative germination percentages of scarified seeds approached the percent viability of the seedlot (95%), while those of unscarified seeds were significantly (P<.05) lower. Lowest cumulative germination percentages and slowest mean germination times were observed at the -7.5 and -10.0 atmosphere water potential levels in the 50/68°F temperature regime.

Table 1. Cumulative germination (%) of unscarified (UNSC) and scarified (SC) Sabine Illinois bundleflower seeds after a 21-day imbibition period in five osmotic potential solutions under three alternating temperature regimes.

Water potential (atmospheres)	Temperature regime: 50/68°F UNSC	50/68°F SC	60/78°F UNSC	60/78°F SC	68/86°F UNSC	68/86°F SC
0	41(9)[1]	80(10)	50(10)	85(9)	57(10)	91(9)
-2.5	44(8)	47(9)	39(8)	68(7)	36(9)	79(7)
-5.0	13(10)	15(10)	22(10)	50(8)	25(9)	52(8)
-7.5	1(12)	3(12)	9(11)	14(11)	28(10)	23(9)
-10.0	0(13)	12(10)	2(13)	8(12)	10(12)	13(12)

[1]Germination estimates derived by quadratic response surface analysis; values in parentheses following means are one-half the calculated confidence internvals (P<.05).

Table 2. Mean germination time (days) of unscarified (UNSC) and scarified (SC) Sabine Illinois bundleflower seeds after a 21-day imbibitation period in five osmotic potential solutions under three alternating temperature regimes.

Water potential (atmospheres)	Temperature regime: 50/68°F UNSC	50/68°F SC	60/78°F UNSC	60/78°F SC	68/86°F UNSC	68/86°F SC
0	4.2(1.1)[1]	3.5(0.9)	2.0(1.0)	1.4(0.8)	1.8(0.9)	1.0(0.8)
-2.5	5.6(0.9)	7.3(0.8)	3.7(0.8)	3.9(0.7)	3.1(0.8)	2.6(0.8)
-5.0	10.0(1.0)	7.9(0.8)	7.5(0.8)	4.4(0.6)	5.0(0.8)	4.0(0.6)
-7.5	14.4(1.3)	18.4(1.6)	7.2(0.9)	6.0(0.9)	4.9(1.0)	5.2(0.8)
-10.0	14.1(1.4)	5.5(1.0)	6.6(1.1)	7.4(1.2)	5.6(1.2)	5.7(1.0)

[1]Mean germination time estimates derived by quadratic response surface analysis; values in parentheses following means are one-half the calculated confidence intervals (P<.05).

Similar germination responses have been reported in other controlled enviroment studies with Illnois bundleflower and other warm-season, perennial bundleflowers found on Texas rangelands. Call (1985) observed 43 and 82% cumulative germination, respectively, for unscarified and acid scarified (concentrated sulfuric acid for 15 minutes), one-year-old seed of Sabine Illinois bundleflower at a 0 atmoshpere substrate water potential in a 60/78°F temperature regime. Flenniken and Fulbright (1985) reported greater than 90% germination for acid scarified seed of prostrate bundleflower (D. virgatus var. depressus) at temperature regimes of 60/78 and 68/86°F. In the same study, germination was reduced by substrate water potentials of -9.0 atmospheres or lower. Haferkamp et al. (1984) improved the germination of velvet bundleflower (D. velutinus) seed at 0 atmosphere water potential in 50/68, 60/78, and 68/86°F temperature regimes with hot water (175° for 3 minutes) acid (concentrated sulfuric acid for 17 minutes), and mechanical (seed coat cut with razor blade) scarification treatments. Hot-water- scarified seeds reached about 80% cumulative germination in 2 days in the 60/78 and 68/86°F regimes and in 10 days in the 50/68°F regime.

Sod-seeding Study

Because of the variability of the site and treatment responses, only main effects (seed treatments and sod suppression treatments) were statistically significant (P<.05) for plant density and standing crop data. Increases in standing crop were associated with increases in density. Thus, seed treatment and sod suppression treatment effects on plant density will be used to describe the results of the field study.

Illinois bundleflower seedlings emerged for mid-April to mid-May 1985 in response to four major precipitation events (1.0 inch or greater on April 13 and 30 and May 8 and 13) at the study site. Seedling emergence was most rapid for hot-water-scarified seeds, and by the May 17 sampling date, the 100% scarified seed treatment had a significantly (P<.05) greater seedling density than the 50% scarified/50% unscarified seed treatment, which in turn, had a greater density than the unscarified seed treatments (Table 3). Trends in seedling emergence from scarified and unscarified seed in the field followed those of germination of similarly treated seeds in 60/78 and 68/86°F temperature regimes in controlled environments (Table 1). Below-normal precipitation from mid-May through mid-July induced soil cracking (up to 2.5 inches wide), especially along drill rows. Seedling root systems were exposed to the atmosphere, resulting in the dessication of many seedlings. Seedlings with adequate root-soil contact endured the dry period, but seedling numbers were further reduced by an outbreak of grasshoppers before the July 17 sampling date. Grasshoppers were controlled with diazinon [0,0-dimethyl 0-(2- isopropyl-4-methyl-6-pyrimidinyl) phosphorothiote]. Remaining plant did not flower or set seed before leaf senescence in mid- July.

Table 3. Density (plants/40 inches of row length) of Illinois bundleflower over three growing seasons (1985-1987) in a native pasture near College Station, Texas as influenced by seed treatment.[1]

	Sampling date				
	1985		1986		1987
Seed treatment[2]	May 17	July 17	May 21	July 22	May 20
Unscarified, recommended rate	0.6 d[3]	0.3 c	1.6 d	1.8 b	2.3 b
Unscarified, double recommended rate	1.0 bc	0.5 bc	2.1 a	2.2 a	3.0 a
100% scarified, recommended rate	1.5 a	0.7 ab	1.0 c	1.0 c	1.4 c
50% scarified/50% unscarified recommended rate	1.2 b	0.8 a	1.9 ab	1.8 b	2.7 ab

[1]Seed treatment x sod suppression treatment interaction was nonsignificant (P<.05), seed treatment data have been pooled across sod suppression treatments.
[2]Sacrified = hot water at 175°F for 3 minutes; recommended seeding rate = 1.5 lbs. PLS/acre.
[3]Means followed by same letter for each sampling data are not significantly different (P<.05) using Duncan's multiple range test.

Established plants initiated new growth in mid-March 1986, and new seedlings established from remaining dormant seed in drill rows in response to favorable precipitation in May (2.0 inches on May 1, 0.6 inches on May 10, and 1.0 inch on May 15 and 17). The unscarified, double seeding rate treatment had the greatest remaining seed bank and thus the greatest increase in seedling density, followed by the unscarified, recommended seeding rate treatment, the 50% unscarified seed treatment, and the 100% scarified seed treatment (Table 3). Above-normal precipitation in May and June maintained fairly constant plant densities until the end of the second growing season. By the July 22 sampling date, the majority of plants established in the first growing season had flowered and set seed.

Plant densities increased for all seed treatments during the third growing season (1987) due to seedling recruitment from seed produced by established plants and possibly from dormant seed remaining in the drill rows in vegetation gaps in all sod suppression treatments. The 100% scarified seed treatment, which had the highest plant density at the beginning of the study now had the lowest density, due in part, to the lack of a dormant seed bank.

The effects of sod suppression treatments were evident during all three growing seasons. Plant density was significantly (P<.05) greater for herbicide and disking treatments than the untreated control throughout the study period, and density on herbicide-treated plots was greater than that for disked plots during the second and third growing season (Table 4). Herbicide and disking treatments created larger vegetation gaps for plant establishment (Grime 1979) than those occurring naturally in the untreated control. Plant densities were greater in the herbicide treatment than in the disking treatment because of: 1) less soil disturbance and subsequent competition from invading species; and 2) conservation of moisture and moderation of temperature near the soil surface by leaving a mulch in place. Similar, gradual increases in plant density in vegetation gaps have been reported for Sabine Illinois bundleflower sod-seeded in Coastal bermudagrass (Cynondon dactylon) on reclaimed lignite overburden in central Texas (Skousen and Call 1987).

Table 4. Density (plants/40 inches of row length) of Sabine Illinois bundleflower over three growing seasons (1985-87) in a native pasture near College Station, Texas as influenced sod suppression treatment.[1]

	Sampling date				
	1985		1986		1987
Sod treatment[2]	May 17	July 17	May 21	July 22	May 20
Untreated	0.7 c[3]	0.2 c	1.1 c	1.0 c	1.2 c
Disked	1.1 ab	0.6 ab	1.6 b	1.7 b	2.6 b
Herbicide	1.4 a	0.9 a	2.2 a	2.4 a	3.2 a

[1] Sod suppression treatment x seed treatment interaction was nonsignificant (P<.05), sod suppression data have been pooled across seed treatments.
[2]Disked = one pass with tandem offset disk; Herbicide = 50% suppression with glyphosate.
[3]Means followed by same letter for each sampling date are not significantly different (P<.05) using Duncan's multiple range test.

Management Implications

Scarified and unscarified seeds of Sabine Illinois bundleflower germinate over a wide range of temperature and substrate moisture regimes. High cumulative germination and rapid germination rates at 0 and -2.5 atmosphere water potential levels in 60/78 and 68/86° temperature regimes indicate that optimum germination would occur in April and May when adequate moisture was available (as in the sod-seeding study). Scarification accelerates the rate of germination under transiently favorable water conditions that occur more often at the high end of the favorable temperature range for germination.

When renovating pastures with perennial legumes such as Illinois bundleflower, land managers should create vegetation gaps and persistent seed banks. Vegetation gaps that leave a mulch in place without disturbing the soil surface (e.g. banding of glyphosate herbicide) are most desirable since they conserve moisture and modify temperatures in the seeded and do not encourage colonization by invading species that could compete for available resources. The germinability of the seeded species should be high enough to allow for adequate establishment during the growing season, but some dormant seed should be included if the initial stand is diminished by unfavorable environmental conditions. A mixture of scarified and unscarified seed would meet these criteria.

LITERATURE CITED

Bryan, W.B. (1985). Effects of sod-seeding legumes on hill land pasture productivity and composition. Agron. J. 77:901-905.

Burton, G.W. (1976). Legume nutrition versus fertilizer nitrogen for warm-season grasses. In: Biological N fixation in forage-livestock systems (pp. 55-72). Amer. Soc. Agron. Spec. Pub. No. 28, Madison, WS.

Call C.A. (1985). Storage life of Illinois bundleflower and western indigo seed. J. Range Manage. 38:500-503.

Copeland, L.O. (Ed.). (1978). Rules for testing seeds. Proc. Assoc. Offic. Seed Analysts. J. Seed Tech. 3(3).

Ellis, R.H. and E.H. Roberts (1978). Towards a rational basis for testing seed quality. In: P.D. Hebblethwaite (Ed.), Seed production (pp. 605-636). Butterworths, London.

Flenniken, K.S. and T.E. Fulbright (1985). Germination of prostrate bundleflower (Desmanthus virgatus var. depressus). Abstract No. 167. Proc. 38th Ann. Mtg. Soc. Range Manage. Denver, CO.

Grabe, D.F. (1970). Tetrazolium testing handbook. Contribution No. 29 to the Handbook on Seed Testing, Assoc. Offic. Seed Analysts, Wash., D.C.

Grime, J.P. (1979). Plant strategies and vegetation processes. John Wiley & Sons, NY.

Haferkamp, M.R., D.C. Kissock, and R.D. Webster (1984). Impact of presowing seed treatements, temperature and seed coats on germination of velvet bundleflower. J. Range Manage. 37:185-189.

Latting, J. (1961). The biology of Desmanthus illinoensia. Ecol. 42:487-493.

Mueller, J.P. and D.S. Chamblee (1984). Sod-seeding ladino clover and alfalfa as influenced by seed placement, seeding rate, and grass suppression. Agron. J. 76:284-289.

Olsen, F.J., J.H. Jones, and J.J. Patterson (1981). Sod seeding forage legumes in a tall fescue sward. Agron. J. 73:1032-1036.

Phillips Petroleum Company. (1963). Pasture and range plants. Phillips Petroleum Co. Bartlesville, OK.

Ray, A.A. (Ed.) (1982). SAS user's guide: Statistics. SAS Institute. Cary, N.C.

Rechenthin, C.A. (1972). Native flowers of Texas. USDA, Soil Cons. Serv. Temple, TX.

Sims, P.L., C.H. Herbel, R.F. Barnes, and SEA-AR Rangeland Scientists in the Southern Great Plains (1980). SEA-AR range research assessment: Southern Great Plains. Agr. Res., Sci. Educ. Admin., USDA. Washington, D.C.

Skousen, J.C. and C.A. Call (1987). Sod-seeding to modify coastal bermudagrass on reclaimed lignite overburden in Texas. Reclam. Reveg. Res. 6:163-176.

ECONOMIC IMPACTS OF HIGH OLEIC SUNFLOWER PRODUCTION IN THE TEXAS HIGH PLAINS[1]

Foy D. Mills, Jr. and Kary Mathis[2]

ABSTRACT

The production of high oleic acid sunflowerseed (HOS) as an alternative crop in the Texas High Plains and the subsequent impact upon the area and state economy was assessed. Enterprise budgeting showed that dryland HOS production generated positive net returns compared with negative returns for three dryland and six irrigated crops produced in the Texas High Plains. HOS production, when combined with area and state input-output multipliers, resulted in a positive effect on total economic activity, income and employment in the Texas High Plains and the state of Texas.

Key words: High Oleic Sunflowerseed, Alternative Crop, Input-Output Effects, Economic Impact

INTRODUCTION

Unfavorable economic conditions in the Texas High Plains through most of the 1980s have caused many agricultural producers to reassess farming operations. To increase the probability of economic survival, many producers have considered alternative crops in addition to improving production, management and marketing techniques.

A possible alternative crop for area producers, a high oleic acid sunflowerseed (HOS), was planted commercially for the first time in 1985 in Minnesota and the Dakotas and in 1986 on the Texas High Plains.[3] Extracted oil from HOS, considered superior in quality to other oilseed oils in general because of its high oleic oil content, was expected to perform well in industrial applications (e.g., cosmetics, pharmaceuticals, and textiles), lubricant derivatives and specialty food items.

OBJECTIVES

The purpose of this study was to assess the potential of HOS as an alternative crop in the Texas High Plains and the subsequent impact upon the area and state economy. Specifically, the analysis:

1. Adapted the 1986 Texas Agricultural Extension Service (TAEX) enterprise budgets for dryland and irrigated sunflowers to develop costs and returns for HOS.

2. Compared costs and returns for HOS with those for major crops produced in the Texas High Plains.

3. Illustrated the potential sensitivity of HOS production to changes in the market price of the commodity.

4. Determined the impact of HOS production at various acreage levels on the Texas High Plains economy and the Texas state economy with respect to effects on total economic activity, income and employment.

[1]Appreciation is expressed to Drs. Terry Ervin, Bob Davis and Bill Freeman for helpful comments and suggestions on the paper. Funding for the project was provided by Agrigenetics Corporation and the Dean's Office of the College of Agricultural Sciences, Texas Tech University. Texas Tech University College of Agricultural Sciences, Publication No. T-1-279.

[2]The authors are an Assistant Professor, Department of Agriculture, Abilene Christian University, and Professor and Chairman, Department of Agricultural Economics, Texas Tech University, respectively.

[3]The sunflowerseed is a patented product of the Lubrizol Corporation. Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the authors and does not imply its approval to the exclusion of other products that may also be available.

METHODS AND PROCEDURES

Budgeting

Estimations of the dryland and irrigated HOS enterprise budgets were facilitated by modifying the Texas South Plains District TAEX sunflower enterprise budgets (TAEX, 1986). Modifications were made in cultural practices, costs, yields and price. Specific changes included a 20% reduction in diesel fuel cost from $1.00 to $0.80 per gallon and use of a 9.6% interest rate on operating capital (Condra et al., 1987). Yield levels of 12 cwt./acre and 18 cwt./acre for dryland and irrigated HOS were used, respectively. Custom harvesting and hauling charges were adjusted to account for the difference in yield levels. Seed cost was increased from $3.00/lb. for conventional sunflowers to $4.00/lb. for HOS. Seeding rates for dryland production were maintained at the same level but were reduced by 0.5 lbs. for irrigated production. A $10.00/cwt. contract price was used for HOS in the analysis (Gulley et al., 1986).

Additionally, bees were required to insure pollination of the hybrid plant. Farmers have not been charged for the bees by the contracting seed company, but will likely become responsible for this expense in the future. Therefore, the HOS budget was calculated with and without a cost for bees. A $6.25/acre charge was assessed for bee usage (Gulley et al., 1986).

Costs and Returns Comparison

The estimated HOS budgets were compared to the enterprise budgets for the major crops produced in the Texas High Plains. Break-even prices, the market price required for the commodity to cover all variable and fixed production costs, and returns to land and management for the major crops (Condra et al., 1987) were compared to the calculated values for HOS.

Price Sensitivity

Contract prices for HOS have been calculated at a $2.50/cwt. to $3.00/cwt. premium over conventional sunflowerseed market prices (Gulley et al., 1986). To account for this premium range, a minimum contract price of $10.00/wt. was incorporated into the budgets. The actual 1986 contract price for HOS was $11.50/cwt. Therefore, the contract price was varied in $.50/cwt. increments to illustrate the potential sensitivity of HOS production to price changes.

Input-Output Analysis

The estimated HOS yields of 12 cwt./acre, dryland, and 18 cwt./acre, irrigated, were used to determine total production at various planted acreage levels. Planted acreage was graduated in 10,000 acre increments from 10,000 acres to 100,000 acres (Terry and Hein, 1986; Oil Crops, 1986). Appropriate production, income and employment multipliers from input-output analysis (Stoecker et al., 1981, Wright et al., 1983; Jones and Kao, 1985) were multiplied by the 20 different (10 dryland, 10 irrigated) total output levels. A sector multiplier is defined as, "a coefficient indicating the total effect of a change in the entire economy that is associated with a unit change in the particular sector, all other sectors remaining constant" (Wright et al., 1979). Impact upon the Texas High Plains economy and the Texas state economy were estimated with respect to total economic activity, total income and the employment level. Multipliers for the Texas High Plains were: (1) output impact, 2.04, (2) income effect, 0.47 and (3) employment effect, 0.00003. Multipliers for the State of Texas were: (1) output impact, 3.12, (2) income effect, 0.70 and (3) employment effect, 0.000063.

The multiplier effects were considered to be net effects in this analysis. The 50/92 provisions of the Food Security Act of 1985 and the Food Security Improvements Act of 1986 allowed the planting of nonprogram crops on underplanted acres given the approval of the U.S. Secretary of Agriculture. The nonprogram crops were restricted to conserving crops, one of which was sunflowers, under the 1986 Act (Fulton, 1986).

FINDINGS

Table 1 compares HOS and the major Texas High Plains crops in terms of break-even prices and returns to land and management. Only dryland HOS, without the expense for bees, and dryland wheat under program participation, generated positive returns of $1.24/acre and $32.68/acre to land and management, respectively.

The HOS contract price was varied in the enterprise budgets to determine the effects on returns to land and management. Table 2 illustrates the returns to land and management on a per acre basis. Dryland production provided postive returns for each price ranging from $10.00 to $11.50/cwt. except in one case. The exception, the $10.00/cwt. contract price combined with a budgeted bee pollination charge, resulted in a $5.16/acre loss. Irrigated HOS production was not shown in Table 2 because the break-even price was $12.60/cwt. without bees and $12.96/cwt. with bees, both higher than any considered contract price.

Table 1. Market Prices, Breakeven Prices, and Returns for High Oleic Sunflowers (HOS) and Major Crops, Texas High Plains.

Crop	Units	Market Price	Breakeven Price Prog[a]	No Prog[b]	Returns-Land & Mgt. Prog	No prog
Dryland		Dollars		Dollars		Dollars/Acre
HOS	cwt	10.00	—	9.89		1.24
HOS w/bees	cwt	10.00	—	10.43	—	- 5.16
Sunflower	cwt	7.00	—	7.83	—	-12.47
Cotton	lbs	0.48	1.08	1.35	-50.40	-152.31
Sorghum	cwt	3.10	6.08	7.01	-13.76	-44.26
Wheat	bu	2.15	1.85	3.27	32.68	- 3.34
Irrigated						
HOS	cwt	10.00	—	12.60	—	-46.91
HOS w/bees	cwt	10.00	—	12.96	—	-53.29
Sunflower	cwt	7.00	—	9.06	—	- 51.62
Corn	bu	1.90	2.21	3.24	-2.14	-155.11
Cotton	lbs	0.48	0.75	0.99	-29.89	-245.31
Sorghum	cwt	3.10	5.63	7.22	-61.22	-136.22
Soybeans	bu	4.10	8.69	8.69	-124.48	-124.48
Wheat	bu	2.15	3.33	4.89	-25.01	-113.49

[a]Participation in government farm programs.
[b]Not participating in government farm programs.
Source: Adapted from Condra et al., February 1987.

Table 2. Returns to Land and Management for Dryland High Oleic Sunflowers with Different Contract Prices, Texas High Plains, November 1986.

Price	W/out Bees	With Bees
Dollars	Dollars/Acre	
10.50	7.24	.84
11.00	13.24	6.84
11.50	19.24	12.84

Regional and State Economics Impacts

Tables 3 and 4 illustrates the impact of dryland and irrigated HOS production on the Texas High Plains economy at various acreage levels. Similarly, tables 5 and 6 represent the impacts on the Texas state economy. To avoid redundancy in tables 5 and 6, the total production and gross output values were omitted. The tables show that at the maximum estimated production level (i.e., 100,000 acres), for dryland and irrigated acres respectively, the impact on total economic activity was $24.48 million and $36.72 million in the Texas High Plains region; $37.44 million and $56.16 million on the Texas state economy. The total income effect was $5.64 million and $8.46 million for the Texas High Plains; $8.40 and $12.6 million for Texas as a whole. Employment levels at 100,000 acres of production were 360 and 540 additional persons employed on the Texas High Plains; 756 and 1,134 additional persons employed in the state of Texas.

Table 3. Impacts on Total Economic Activity, Income, and Employment in the Texas High Plains, High Oleic Sunflowers, Dryland.

Acres	Total Prod.	Gross Output $10/cwt	Output Impact Mult-2.04	Income Effect Mult-.47	Employment Effect Mult-.00003
	cwt	Dollars	Dollars		Persons
10,000	120,000	1,200,000	2,448,000	564,000	36
20,000	240,000	2,400,000	4,896,000	1,128,000	72
30,000	360,000	3,600,000	7,344,000	1,692,000	108
40,000	480,000	4,800,000	9,792,000	2,256,000	144
50,000	600,000	6,000,000	12,240,000	2,820,000	180
60,000	720,000	7,200,000	14,688,000	3,384,000	216
70,000	840,000	8,400,000	17,136,000	3,984,000	252
80,000	960,000	9,600,000	19,584,000	4,512,000	288
90,000	1,080,000	10,800,000	22,032,000	5,076,000	324
100,000	1,200,000	12,000,000	24,480,000	5,640,000	360

Table 4. Impacts on Total Economic Activity, Income, and Employment in the Texas High Plains, High Oleic Sunflowers, Irrigated.

Acres	Total Prod.	Gross Output $10/cwt	Output Impact Mult-2.04	Income Effect Mult-.47	Employment Effect Mult-.00003
	cwt	Dollars	Dollars		Persons
10,000	180,000	1,800,000	3,672,000	846,000	54
20,000	360,000	3,600,000	7,344,000	1,692,000	108
30,000	540,000	5,400,000	11,016,000	2,538,000	162
40,000	720,000	7,200,000	14,688,000	3,384,000	216
50,000	900,000	9,000,000	18,360,000	4,230,000	270
60,000	1,080,000	10,800,000	22,032,000	5,076,000	324
70,000	1,260,000	12,600,000	25,704,000	5,922,000	378
80,000	1,440,000	14,400,000	29,376,000	6,768,000	432
90,000	1,620,000	16,200,000	33,048,000	7,614,000	486
100,000	1,800,000	18,000,000	36,720,000	8,460,000	540

Table 5. Impacts on Total Economic Activity, Income, and Employment in the State of Texas, High Oleic Sunflowers, Dryland.

Acres	Output Impact Mult-3.12	Income Effect Mult-.70	Employment Effect Mult-.000063
	Dollars		Persons
10,000	3,744,000	840,000	76
20,000	7,488,000	1,680,000	151
30,000	11,232,000	2,520,000	227
40,000	14,976,000	3,360,000	302
50,000	18,720,000	4,200,000	378
60,000	22,464,000	5,040,000	454
70,000	26,208,000	5,880,000	529
80,000	29,952,000	6,720,000	605
90,000	33,696,000	7,560,000	680
100,000	37,440,000	8,400,000	756

Table 6. Impacts on Total Economic Activity, Income, and Employment in the State of Texas, High Oleic Sunflowers, Irrigated.

Acres	Output Impact Mult-3.12	Income Effect Mult-.70	Employment Effect Mult-.000063
	Dollars		Persons
10,000	5,616,000	1,260,000	113
20,000	11,232,000	2,520,000	227
30,000	16,848,000	3,780,000	340
40,000	22,464,000	5,040,000	454
50,000	28,080,000	6,300,000	567
60,000	33,696,000	7,560,000	680
70,000	39,312,000	8,820,000	794
80,000	44,928,000	10,080,000	907
90,000	50,544,000	11,340,000	1,021
100,000	56,160,000	12,600,000	1,134

SUMMARY AND CONCLUSIONS

Appropriate cost and price data were gathered and modified and values generated to evaluate the economic performance of HOS production as compared to the major crops produced in the Texas High Plains. Subsequently, estimated production values from the budgets were used to determine the potential total production at various acreage levels. Appropriate production, income and employment multipliers were applied to each output level to determine the impact upon the economics of the Texas High Plains and the state of Texas.

Results revealed dryland HOS production without the bee charge (at assumed yield level and contract price) generated postive net returns compared with negative returns for three dryland and six irrigated crops produced in the Texas High Plains. Additionally, simulated HOS production had a positive effect on total economic activity, income and employment in the Texas High Plains and the state of Texas.

Analysis results only considered average yields, estimated production costs for a single growing season, one schedule of contract prices and one series of total production levels. Changes in any of these variables would affect the results obtained in this study.

REFERENCES

Condra, Gary D., Jesse Reyes, Don Ethridge, and Dean Hughes. A Regional Profitability Analysis of Field Crop Production in Texas. Ag. Econ. Dept., Texas Tech University. College of Ag. Sciences Publication No. T-1-247. February 1987.

Fulton, Tom. Provisions of the Food Security Improvements Act of 1986. USDA, Economics Research Service, National Economics Division. ERS Staff Report No. AGES860312, April 1986.

Gulley, James, Larry Price, and James Hopkins. Low and High Oleic Sunflower Production—Personal Interview. Gro-Agri Seed Company. November 3, 1986.

Hein, Dennis, and Michael Hein. High Oleic Sunflower Oil Uses—Personal Interview. SVO Enterprises Corporation. November 10, 1986.

Jones, Lonnie L., and Robert S. Kao. Economic Impact of Agricultural Production in Texas: A Handbook of State and Regional Estimates, Major Production Regions (TAEX Districts). Dept. of Ag. Econ., Texas Ag. Exp. Stat., Texas A&M University. Departmental Technical Report No. 85, January 1985.

Stoecker, Arthur L., Mickey L. Wright, and David L. Pyles. An Input-Output Model of the Texas High Plains Economy in 1977. Texas A&M and Texas Tech University, Coop. Res. Unit, Dept. of Ag. Econ., College of Ag. Sciences, Texas Tech University and Texas Department of Water Resources. College of Ag. Sciences Publication No. T-1-199, August 1981.

Texas Agricultural Extension Service (TAEX). Texas Crop Enterprise Budgets: Texas South Plains District. Texas A&M University System. Bulletin B-1241 (CO2), 1986.

United States Department of Agriculture. Oil Crops: Situation and Outlook Yearbook. USDA, Economic Research Service. July/August 1986.

Wright, Mickey L., Albert H. Glasscock, and Roy Easton. The Texas Input-Output Model, 1979. Texas Department of Water Resources. LP-189, March 1983.

RESPONSE OF MORMON-TEA TO BURNING[2]

Sara H. Schweitzer, Loren M. Smith, and Henry A. Wright[1]

ABSTRACT

Mormon-tea (Ephedra antisyphilitica C. A. Mey) is a beneficial , evergreen browse plant for livestock and wildlife. On 25 February 1986, a 60-acre unit of the Texas Tech Experimental Ranch, Garza County, Texas, was subjected to a prescribed burn to determine survival and response of Mormon-tea. Ninety-six percent of burned plants and 100% of control (unburned) plants survived. Burned plants produced more ($\underline{P} < 0.01$) basal sprout biomass than control plants.

Key words: Mormon-tea, Ephedra, prescribed fire, browse

INTRODUCTION

Forty species of Ephedra are distributed over the desert or semidesert regions of Asia, northern Africa, and North America. Mormon-tea (E. antisyphilitica C. A. Mey) is found from extreme southwestern Colorado, through Arizona, New Mexico, western Texas, and northern Mexico (Correll and Johnston 1970). This species is a drought-tolerant, densely branching shrub with jointed photosynthetic stems and branches and persistent scale- like leaves. Mormon-tea is often grazed heavily by livestock and is the primary source of green browse for wildlife during winter months in certain areas (USDA Forest Service 1937, Cumbie 1952, Correll and Johnston 1970).

Although fire kills longleaf Ephedra (E. trifurca) (Thornber 1907), its effect on Mormon-tea is not documented. Our objectives were to determine the survival of Mormon-tea following a winter prescribed burn and to evaluate the subsequent response of surviving plants.

STUDY SITE

This study was conducted on a 60-acre range site on the Texas Tech Experimental Ranch, 6 miles southeast of Justiceburg, Garza County, Texas. About 75% of the average annual precipitation (19 in) occurs from May to October (Richardson et al. 1965).

MATERIALS AND METHODS

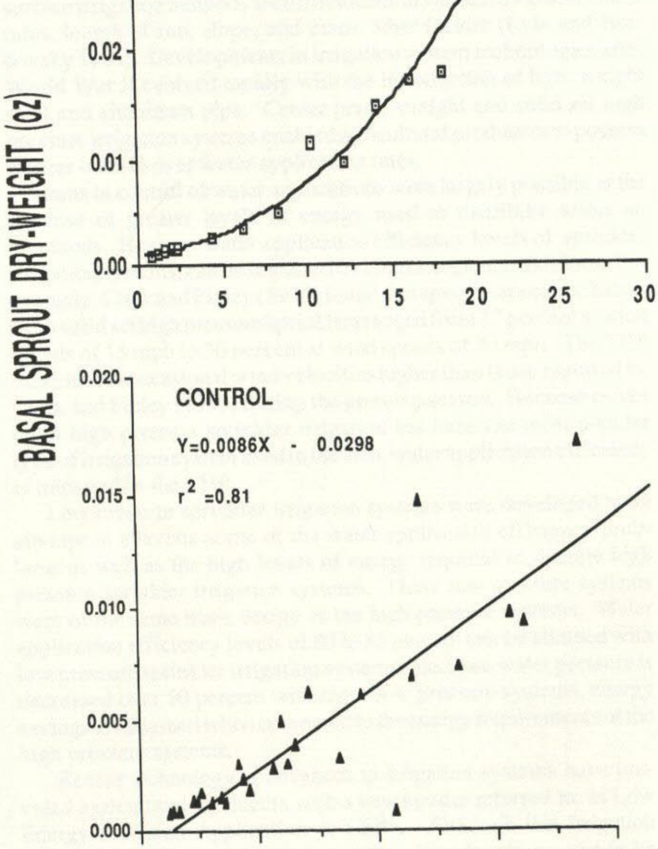
Precipitation was recorded throughout the study using a standard rain gauge. Twenty-eight Mormon-tea plants were randomly selected and marked with metal, fire-resistant stakes before burning the study site. Twenty-nine control plants were marked in unburned areas adjacent to the burned site. Sample size was restricted by available time and plants.

A prescribed burn was conducted on 25 February 1986. Relative humidity ranged from 20 to 40%, temperature rose from 63 to 84°F, and wind speed averaged 5 mph during the burn. Fine fuel, composed primarily of tobosagrass (Hilaria mutica [Buckl.] Benth.), averaged 1,500-2,500 lb/ac. Two months after the burn, surviving burned and control plants were counted. Plants were evaluated weekly for survival.

Weekly measurements of the number and length of basal sprouts on burned and control plants were recorded from 6 April to 21 June 1986 to evaluate the response of the plants to burning. Control plants exhibited basal sprouting, and secondary growth on aerial stems. Only new growth as basal sprouts was directly comparable between burned and control plants because burned plants were completely top-killed.

In early July, basal sprouts from burned and control plants were clipped to ground level and measured to the nearest 0.1 in. These basal sprouts were taken to the laboratory, freeze-dried, and weighed (dry-weight, oz).

Basal sprout dry-weight (dependent variable, Y) was regressed on basal sprout length (independent variable, X) for burned and control plants, and best-fit regression models were determined based on maximum coefficient of determination (r^2) values (Fig. 1). Regression models predicted basal sprout dry-weight given basal sprout length. Basal sprout dry-weight biomass of burned and control plants was determined 4 months after the burn using the regression models. Biomass of burned and control plants was compared using a Wilcoxon rank sum test (Hollander and Wolfe 1973).



BASAL SPROUT LENGTH (in)

Figure 1. Basal sprout day-weight regressed on basal sprout length to determine best-fit regression equation to allow calculation of basal sprout biomass of burned and control plants 4 months after burning.

---

[1]Authors are enviromental scientist, U.S. Army Corps of Engineers, Norfolk District, Fort Norfolk, 803 Front Street, Norfolk, Virginia 23510; professor and Horn professor and Department Chairman, Department of Range and Wildlife Management, Texas Tech University, Lubbock, Texas 79409.

[2]Financial support for this study was provided by the Graduate School and the College of Agricultural Sciences (T-9-483), Texas Tech University. G. W. Reeves, D. G. Sheeley, and A. P. Leif provided field assistance.

RESULTS AND DISCUSSION

The study site received 11.5 in of rainfall during the collection period, 23% above the 52-year mean. Above normal moisture after the burn and during the growing season may have positively influenced plant survival. Although there was 100% top-kill of burned plants, 96% (n=28) survived and initiated new basal sprout growth by 30 March 1986. All control plants (n=29) survived and produced basal sprouts and secondary growth from aerial stems.

Based on maximum r^2 values, the best-fit regression model for burned plants was $Y = 0.0026x^{1.40}$ ($r^2 = 0.98$), and for control plants was $Y = 0.0086x - 0.0298$ ($r^2 = 0.81$), where Y = predicted dry-weight (oz) of basal sprout at x = length (in).

Burned plants produced more ($\underline{P} < 0.01$) new basal sprout growth (mean $\pm$ SE = 0.24 ± 0.03 oz/plant) than control plants (0.001 ± 0.0004 oz/plant). Basal sprouts on burned plants were more accessible to browsers than those on control plants because there was no interference from crown stems.

Mormon-tea successfully survived burning and produced new growth as basal sprouts under the conditions of this study. Although control plants also produced basal sprouts, fewer resources were allocated to such production, perhaps due to allocating resources to new growth on aerial stems. Because this project was restricted to one site and the enviromental parameters present during the year of study, the response of Mormon-tea to burning warrants further research. However, this study indicated that ranch managers may successfully burn range sites in the winter to reduce litter buildup and undesirable brush species without killing a desirable, evergreen browse species such as Mormon-tea.

LITERATURE CITED

Correll, D.S. and M.C. Johnston. 1970. Manual of the vascular plants of Texas. Texas Res. Found., Renner.

Cumbie, B.G. 1952. Branch abscession in the joint-fir, Ephedra. M.S. Thesis, Texas Technological College, Lubbock.

Hollander, M. and D.A. Wolfe. 1973. Nonparametric statistical methods. John Wiley & Sons, New York.

Richardson, W.E., D.G. Grice, and L.A. Putman. 1965. Soil survey of Garza County, Texas. USDA, Soil Conservation Service.

Thornber, J.J. 1907. Destruction of range weeds. Ariz. Agr. Exp. Stn. 18th Ann. Rep.

USDA Forest Service. 1937. Range plant handbook. USDA Forest Service, Washington, D.C.

ECONOMIC FEASIBILITY OF CONVERSION TO A LOWER ENERGY PRECISION APPLICATION IRRIGATION SYSTEM IN THE TEXAS HIGH PLAINS

Jeffrey D. Hutton, Eduardo Segarra, R. Terry Ervin and James W. Graves[1]

ABSTRACT

The objective of this study was to determine the farm level economic feasibility of converting a standard 1/4 mile center pivot low pressure sprinkler irrigation system to a low energy precision application (LEPA) irrigation system for corn production in the Texas High Plains. It was found that the irrgation system results in increased water use efficiency, which further results in increased corn yields. Thus, LEPA is a viable irrigation option to producers in the Texas High plains because the benefits from its use outweigh the costs.

Key Words: Economic Feasibility, Irrigation, LEPA

INTRODUCTION

The 31-county Texas High plains (THP) land resource area is located in the southern portion of the Great Plains Region of the United States. Due to average rainfall in the THP ranging from 10 to 20 inches per year, agricultural activities use supplementary irrigation. Most of the water used for irrigation of agricultural crops in the THP is drawn from the Ogallala Formation, a major underground aquifer covering 220,000 square miles and extending over parts of the states of Colorado,Kansas, Nebraska, New Mexico, Oklahoma, and Texas (High Plains Associates 1982).

Agricultural production increased in the THP as a result of the widespread use of irrigation practices in agriculture since the 1940's. However, declines in water tables ranging from 50 to 200 feet have occurred in the area because the Ogallala Formation is a closed basin with little or no recharge (Lee 1987; Mapp 1988).

Deeper water tables have induced rising water extraction costs resulting in significant changes in irrigated acres of the four major crops (corn, cotton, sorghum,and wheat) grown in the THP area. For example, combined irrigated acreage of those four crops declined from a high of 4.8 million acres in 1976 to 3.2 million acres in 1985, a reduction of over 33 percent. In particular, acres of corn and sorghum (about 90 percent of which were irrigated declined by 40 percent from 1975 to 1985 (Lansford, Harman, and Musick 1987). Those changes have occurred mostly from the lower profitability levels per unit of production when compared to other production areas in which irrigation is used extensively (Mapp 1988). Thus, because of declining water tables and increased energy costs, efficient utilization of irrigation inputs availble to producers in the THP area has become a key component in the profitability of enterprises and firm survival.

In this paper, the conversion of a center pivot low pressure sprinkler irrigation system to a low energy precision application (LEPA) irrigation system for corn production in the area is investigated. The conversion of a center pivot low pressure sprinkler system to a LEPA irrigation system is achieved by the attachment of flexible tubing which extends downward having a nozzle on the end of the low pressure system.

The primary objective of this study is to determine the farm level economic feasibility of that conversion. Although the adoption of a LEPA irrigation system could result in reduced consumption of water to obtain crop yields similar to those resulting from other irrigation systems, we assume that producers continue to use the same amount of water and consider the benefits of increased yields due to the LEPA system. Issues of contemporary social interest such as implications of adopting LEPA to conserve underground water resources for use by future generations are not addressed.

The Low Energy Precision Application (LEPA) Irrigation System

Irrigation could be considered to be the least efficient operation involved in the production process of irrigated agricultural crops (Lyle and Bordovsky 1981). Also, because irrigation activities are high consumers of energy, they are amoung the most expensive activities in the production process. The amount of energy used in irrigation depends on two factors: quantity of water pumped (gallons/minute) and depth from which water is extracted. Nearly two thirds of the irrigation systems in the THP are powered by the use of natural gas while the remainder are powered by electricity. Low water application efficiency and excess energy consumption impair profitability and thus, regional competitiveness in agricultural production (e.g., comparative advantage). However, these conditions may be beyond agricultural producers control, who rely on current irrigation system technologies available.

Precise control of water applications to the root zone of plants with surface irrigation methods are difficult due to variabiltiy in soil intake rates, length of run, slope, and many other factors (Lyle and Bordovsky 1981). Developments in irrigation system technologies after World War II evolved rapidly with the introduction of light weight steel and aluminum pipe. Center pivot, straight and solid set high pressure irrigation systems enabled agricultural producers to possess greater control over water application rates.

Gains in control of water applications were largely possible at the expense of greater levels of energy used to distribute water on croplands. Howevr, water application efficiency levels of sprinkler irrigation systems, can be impaired by climatological conditions. For example, Clark and Finley (1975) found that spray evaporation losses from solid set high pressure sprinklers ranged form 17 percent at wind speeds of 15 mph to 30 percent at wind speeds of 20 mph. The THP experiences occasional wind velocities higher than those reported by Clark and Finley (1975) during the growing season. Because center pivot high pressure sprinkler irrigation has been the most popular type of irrigation system used in the area, water application efficiency is impaired in the THP.

Low pressure sprinkler irrigation systems were developed in an attempt to alleviate some of the water application efficiency problems as well as the high levels of energy required to operate high pressure sprinkler irrigation systems. These low pressure systems were of the same basic design as the high pressure systems. Water application efficiency levels of 80 to 85 percent can be attained with low pressure sprinkler irrigation systems. Because water pressure is decreased over 50 percent with these low pressure systems, energy savings are attained when compared to the energy requirements of the high pressure systems.

Recent technological advances in irrigation systems have provided agricultural producers with a new system referred to as Low Energy Precision Application or LEPA. Although this irrigation system is still in experimental stages, it has already proven to be efficient when compared to other low pressure irrigation systems (Lyle and Bordovsky 1982). This system can be added onto the existing low pressure system by adding flexible tubing to the pipe drops on the low pressure system. The tubing extends down to approximately twelve to sixteen inches above the ground. Although the tubes have a nozzle on the end similar to the nozzles in other low pressure systems, LEPA nozzles spray water in a more horizontal

[1]Jeffrey D. Hutton, at the time of the study was a senior in agricultural economics, Eduardo Segarra and R. Terry Ervin are Assistant Professors and James W. Graves is a professor in the Department of Agricultural Economics, Texas Tech University. Publication No. T-1-283 of Texas Tech University College of Agricultural Sciences.

manner (for details on LEPA specifications see Lyle and Bordovsky 1981; Stoecker and Lloyd 1984).

One of the two major advantages of LEPA over other low pressure irrigation systems is that evaporation losses are cut resulting in water application efficiency in excess of 98 percent. The other advantage is that LEPA requires only five to ten pounds of end pressure, whereas other low pressure irrigation systems require fifteen to twenty pounds.

Conversion of a Center Pivot Low Pressure Sprinkler System to a Low Energy Precision Application Irrigation System

Two partial budgets were used along with a cost analysis to evaluate the conversion of a standard 1/4 mile center pivot low pressure sprinkler irrigation system to a LEPA irrigation system for corn production. The study area was Dallam county bordering New Mexico and Oklahoma in the north-west corner of the Texas panhandle. The budgets included fuel costs for both centerpivot low pressure sprinkler and LEPA irrigation systems. The budget for LEPA also included additional labor and maintenance costs associated with the operation of the 1/4 mile radius irrigation system. Because levels of other variable inputs in corn production for both irrigation systems were assumed to be the same, costs such as fertilizer, labor, insecticide, herbicide, and harvesting were not included in those budgets. Also, LEPA evaporation loss reduction information provided by the Texas Agricultural Experiment Station in Bushland, Texas, was considered in the economic evaluation of the system conversion (Devin 1977 and New 1987).

County wide per acre average fuel cost under both low pressure and LEPA irrigation systems for corn was estimated through primary data collected from personal records of several farmers in Dallam county (Crossland 1988, Moore 1988, and Snead 1988). Other variables such as per acre average amounts of water applied and corn yields were collected from farmers' records and used in the budgets. Conversion costs of LEPA were obtained from Peeples Irrigation in Dalhart, Texas. The total cost of that conversion for a standard 1/4 mile center pivot sprinkler system is $7,082.53 (Table 1).

Table 1. Itemized Conversion Costs of a Standard 1/4 mile Pivot Low Pressure Irrigation System to LEPA, Dallam County, Texas, 1988.

Item	Cost
260 Gooseneck pipes	$ 585.00
260 3'drops	756.60
260 Steel Collars	192.40
260 PVC collars	231.40
2080 Feet LEPA hose	1,352.00
520 LEPA hose clamps	94.64
520 3/4" H.B. x3/4" M.P.T.	169.00
130 Low flow regulators	633.75
130 Medium flow regulators	456.30
520 Stainless steel ties	60.84
260 Lepabird sprikler heads	1,250.60
Labor to install LEPA	1,300.00
TOTAL CONVERSION COST	$ 7,082.53

Source: D. Peeples, Peeples Irrigation, Dalhart, Texas. 1988.

The annual irrigation fuel cost for operating the 1/4 mile radius (125.66 acres) low pressure sprinkler irrigation system for corn production, assuming 26 inches of water application over the growing season was $6,844.57. Coupling the annual irrigation fuel cost of $6844.57 with the additional annual labor and maintenance costs of $40.00 and $197.24, respectively, for the 1/4 mile radius LEPA system, and assuming the application of 26 inches of water, the resulting cost of operation for the LEPA irrigation system is $7,081.81. This is equivalent to $54.46 per acre, or $2.09 per acre inch of water applied. The associated per acre average yield of corn was 191 bushels.

The primary difference between the LEPA and other irrigation systems is that the LEPA system prevents water evaporation which further results in increased corn yields. Assuming an average wind speed of 13.65 mph and an average temperature of 90 degrees, it was found that water application efficiency can be increased from an average of 74.02 percent under the low pressure sprinkler irrigation system to 98 percent under the LEPA irrigation system. This results in an increase in corn yields of 20 bushels per acre (Devin 1977; New 1987).

Assuming the 1987-88 corn price for Dallam county, this increase in corn yield provides an additonal $68.80 per acre for an increase in annual total gross revenue to land, risk, overhead and management of $8,645.41 over the low pressure sprinkler irrigation system. Adjusting this for the additional LEPA labor and maintenance operation costs of $237.24 results in a total gross return increase of $8,408.17 for LEPA when compared to the low pressure sprinkler irrigation system. Table 2 is provided to assist in the understanding of the cost comparision between systems. The cost of other variable inputs of production must be subtracted from the gross revenue figures above to estimate the "profit" above variable cost for corn production in the 1/4 mile radius area.

Corn prices will not always remain at the 1987-88 values and output price variability must be considered by agricultural producers in their decision to convert their low pressure sprinkler systems to LEPA. Alternative valuations of the additional annual gross revenue generated by the adoption of the LEPA irrigation system under alternative corn prices are illustrated in Figure 1. This figure illustrates that as the corn price increases the additional annual gross revenue generated by the adoption of LEPA also increases.

Given the associated conversion costs and the increase in corn yields due to LEPA, it can be found that a minimum corn price of $2.82 (cost of LEPA, $7,082.53, divided by total area benefiting from LEPA, 125.66 acres, then that ratio divided by additional corn yield, 20 bushels) will generate enough additional gross income in one year to pay for the irrigation system conversion. However, agricultural producers may not want to invest that much money in a single year. For this reason it is useful to discuss financing alternatives available to producers from which they could choose.

Table 2. Partial Budgets Comparing the Low Pressure to the LEPA System

System	Yield	Operating Cost(OC)	Total Gross Revenue(TGR)	TGR-OC	Change in Revenue
Low Pressure	191	$6,844.57	$82,563.64*	$75,719.07	
LEPA	211	$7,081.81	$91,209.05	$84,127.24	$8,408.17

*Assumes $3.44 as the 1987-88 average corn price. Therefore, TGR for the low pressure system is the product of number of acres (125,66), yield (191), and crop price (3.44).

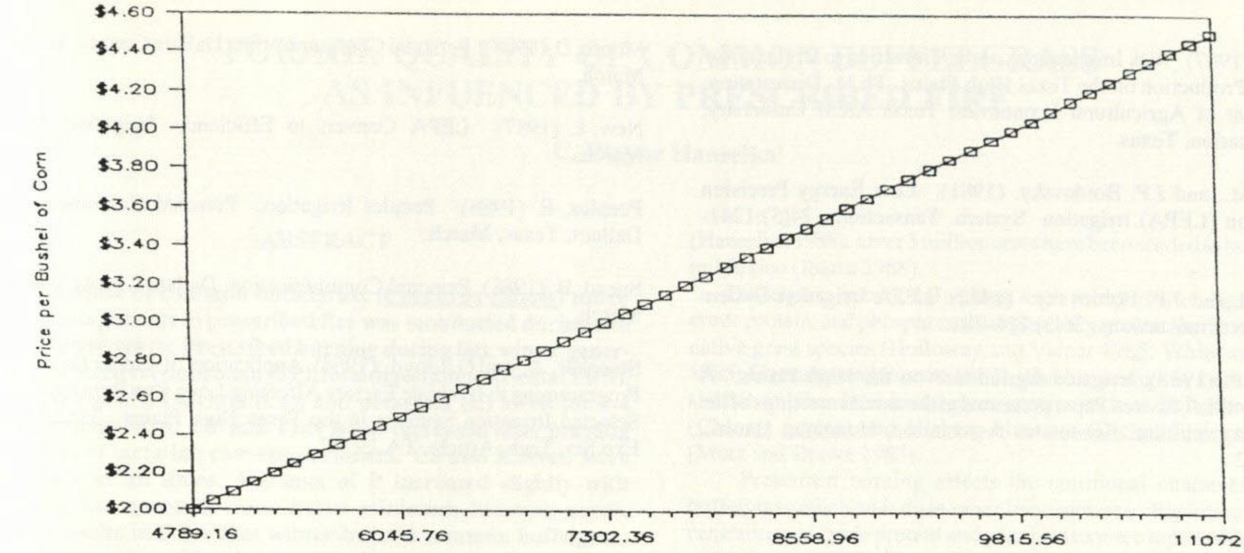


Figure 1. Annual Total Gross Returns Increases Across Alternative Corn Prices Due to LEPA's Increased Water Efficiency in Corn Production for a 1/4 mile Circle, Dallam County, Texas.

If an agricultural producer can only afford to invest ten percent of the $7082.53 cost required for the conversion of the irrigation system, he/she would need to borrow ninety percent of the cost, or $6374.28. Figure 2 illustrates alternative scenarios for repayment of that loan presenting annuity payments which depend on the length of the loan (from one to eight years) and the interest rate being used (from six to twenty percent). Thus, for a given interest rate on the loan, as the length of time of the loan increases the level of the annuity payment decreases. Conversely, for a given time period or length of the loan as the interest on the loan increases the level of the annuity payment increases. The loan repayment scenarios assume a ten percent down payment. Therefore, in determiming the most appropriate purchase plan, agricultural producers should consider: (1) how much he/she is willing to pay as a down payment; (2) what levels of interest rate he/she can obtain for the loan; and (3) what are his/her time preferences with respect to the length of the loan.

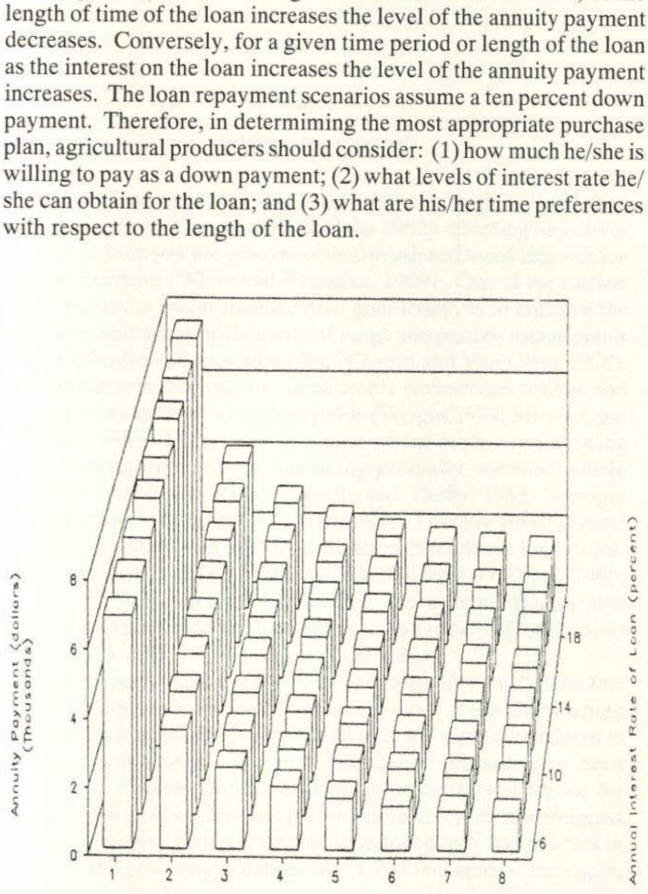


Figure 2. Annuity Payment Scenarios of the $6,374.28 Loan for the Conversion of the Irrigation System According to Alternative Lengths of the Loan and Interest Rates.

CONCLUDING REMARKS

The primary objective of this study was to determine the farm level economic feasibility of converting a standard 1/4 mile center pivot low pressure sprinkler irrigation system to a LEPA irrigation system for corn production in the THP. Enterprise budgets were developed for both irrigation systems. Considering the costs involved in the conversion, it was found that because of increased water application efficiency obtained with the LEPA irrigation system resulting in increased corn yields, the irrigation system conversion is economically feasible because associated increases in annual gross revenues would be more than sufficient to cover conversion costs. Although some drawbacks are associated with the use of LEPA, such as increased awareness of row spacing, increased maintenance costs, and labor requirements when compared to other irrigation systems, LEPA is a viable option to farmers in the THP because the benefits from its use outweigh the costs.

There are few LEPA systems currently in use. Widespread adoption of LEPA in the THP would add to agricultural water efficiency, resulting in a more rational utilization of the underground water resources available not only to agricultural producers, but to the remainder of users in the area as well.

REFERENCES

Clark, R.N. and W.W. Finley. (1975). Sprinkler Evaporation Losses in Southern Plains. Amer. Soc. Agric. Eng. Paper No. 75-2573, Amer. Soc. Agric. Eng., St.Joseph, MO.

Crossland, B. (1988). Personal Communication, Dallam County, Texas, March.

Devin, R.L. (1977). Effect of Sprinkler Design on Evaporation Loss in Dallam County, Texas. Report for Agricultural Business 5597, West Texas State University.

High Plains Associates. (1982). Six-State High Plains-Ogallala Aquifer Regional Resources Study. A report to The U.S. Dept of Commerce and the High Plains Study Council, Austin, Texas, March.

Lansford, V.D., W.L. Harman, and J.T. Musick. (1987). The Texas High Plains: Adjustments to Changing Economic and Resource Conditions, 1970-85. Texas Agricultural Experiment Station Miscellaneous Publication No. Mp-1637, College Station, TX.

Lee, J.G. (1987). Risk Implications of the Transition to Dryland Agricultural Production on the Texas High Plains. Ph.D. Dissertation, Department of Agricultural Economics, Texas A&M University, College Station, Texas.

Lyle, W.M., and J.P. Bordovsky. (1981). Low Energy Precision Application (LEPA) Irrigation System. Tansactions, 24(5);1241-1245.

Lyle,W.M.,and J.P. Bordovsky. (1982). LEPA Irrigation System Evaluation. Transactions, 26(3):776-781.

Mapp, H.P. (1988). Irrigated Agriculture on the High Plains: A Future Decline? Invited Paper presented at the annual meetings of the Western Agricultural Economics Association, Honolulu, Hawaii, July 10-12

Moore, D. (1988). Personal Communication, Dallam County, Texas, March.

New, L. (1987). LEPA Convert to Efficiency. Irrigation Age, March.

Peeples, E. (1988). Peeples Irrigation. Personal Commucation, Dalhart, Texas, March.

Snead, B. (1988). Personal Communication, Dallam County Texas, March.

Stoecker, A., and G. Lloyd. (1984). Application of Linear Dynamic Programming to Evaluate Factors Affecting Long Run Returns from Selected Irrigation Systems in the Texas High Plains. Texas Ag. Exp.Sta. Tech, Article, TA 19782.

FORAGE QUALITY OF COMMON BUFFELGRASS AS INFUENCED BY PRESCRIBED FIRE

C. Wayne Hanselka[1]

ABSTRACT

Response of common buffelgrass (Cenchrus ciliaris) nutritional components to prescribed fire was monitoried during two consecutive years. Prescribed burning during late winter generally increased crude protein (CP), total digestible nutrients (TDN), phosphorus (P), Calcium (Ca), and potasium (K) levels for 3-4 months post-burn. CP and TDN levels increased after burning in excess of lactating cow requirements. Ca and K levels were adequate at all times. Amounts of P increased slightly with burning but generally were below minimum livestock needs. These results indicate that winter-burned common buffelgrass pastures can provide high quality forage to grazing animals during spring months. Animals with high nutritional needs can use burned buffelgrass regrowth to their advantage during this critical period of the year.

Key Words: forage quality, common buffelgrass, prescribed fire, crude protein, total digestible nutrients, phosphorus.

INTRODUCTION

There is a long history of man's use of fire on rangelands (Nelson and England 1978; Hanselka 1980; Pyne 1982). Burning objectives have varied from pasture renovation and brush and weed suppression to parasite control (White and Hanselka, 1989). One of the earliest objectives, and a major management goal today, is to enhance the palatability and nutritional quality of range and pasture forage plants by the application of prescribed fire (Chapin and Van Cleve 1978).

Burning removes mature, unpalatable herbaceous foliage and litter and often increases herbage yields (Wright 1974, Mayeux and Hamilton 1988). Many browse plants sprout profusely following burning producing regrowth containing generally elevated, albeit, short-lived nutritional levels (Dewitt and Derby 1955; Springer 1977; Rasmussen et al. 1983; Wood 1988). There is also a general increase in livestock and wildlife utilization of regrowth forages following fire (Klett et al. 1971; Oefinger and Scifres 1977; Drawe 1980; Mutz et al. 1985). Increased utilization and a higher quality diet translates into increased productivity from range cattle (Anderson et al. 1970; Kirk et al. 1974; McGinty et al. 1983).

Erratic forage quantity and quality are major limiting factors that affect beef production in South Texas. Low calf crops and weaning weights, breeding failures, and late calves in the region are related to low nutritional planes. Several "improved" grasses have been planted in an effort to provide a more stable nutritional regime for livestock. The most successful of these has been common buffelgrass (Cenchrus ciliaris. Buffelgrass was introduced into South Texas in the 1940's and presently occupies over 1,700,000 acres in the region (Hanselka, 1988). Over 3 million acres have been seeded to buffelgrass in Mexico (Ibarra 1988).

Buffelgrass nutritional values, such as dry matter digestibility, crude protein, and phosphorus, are generally greater than in the major native grass species (Holloway and Varner 1985; White and Wolfe 1985; Gonzalez and Everitt 1982). Quality is slightly better than or similar to other introduced grass species such as Bell Rhodesgrass (Chloris gayana) and Kleberg bluestem (Dicanthium annulatum (Mutz and Drawe 1983).

Prescribed burning affects the nutritional characteristics of buffelgrass much as it does other bunchgrasses. Elevations in concentrations of crude protein and phosphorus were reported by Everitt and Mayeux (1983). Burned buffelgrass has been used by livestock more than 2.5 times heavier than non-burned pastures due to improved palatability and increased quality of regrowth following fire (Hamilton and Scifres 1982; Hamilton 1985). White and Wolfe (1985) quoting Chamred, 1984, reported greater average daily gains on heifers that were grazed on burned buffelgrass pastured as compared to those grazed on non-burned pastures.

The objective of this study was to determine the influence of prescibed fire on the level of certain nutritional levels in common buffelgrass. The longevity of any changes was also monitored.

METHODS AND MATERIALS

Descriptions of Sites

This study was conducted at three locations within the Rio Grande Plains of Texas. Pastures on the Cerrito Prieto and the Howell Ranches were monitored in 1986. The Cerrito Prieto Ranch is located 10 mi south of Encinal in Webb county. Sampling was initiated on a gray sandy loam range site composed of Copita series soils. Topography is gently rolling with less than a 3% slope. The Howell Ranch is located ca. 7 miles west of Premont in Jim Wells County. The study pasture was composed of loamy sand and tight sandy loam sites with soils in the Delfina series.

The Montemayor Ranch, 15 miles east of Benavides in Duval county, was the study site in 1987. Samples were taken from a fine sandy loam site. Soils on this site are in the Delmita series.

Each pasture originally supported dense communities of mesquite-dominated (Prosopis-Acacia) mixed brush. Each had been root plowed and raked with the brush stacked and burned. Common buffelgrass was then broadcast seeded in the pasture. The ages of the buffelgrass stands ranged form 2 to 19 years.

Prescribed Burning and Sampling Procedures

Late winter burns were selected to increase forage quality during the spring calving period when a higher nutritional plane was necessary. This is also the season of the year when most range burning occurs in South Texas for the purpose of brush suppression (Hamilton and Scifres 1982). The Premont and Encinal sites were burned in February, 1986 and the Benavides site was burned in Febuary, 1987. Twelve foot wide fire lanes were disced completly around each pasture. Burns were installed as headfires following backfiring on the downwind side of the pastures Weather and fuel conditions for each burn are shown in Table 1. Over 90% of the fine fuel (standing crop and litter) on each pasture was removed by the fires. Precipitation data was collected at each site.

---

[1]Author is Range Specialist, Texas Agricultural Extension Service, Rt. 2, Box 589, Corpus Christi, Tx. 78410. The cooperation of personnel of the Howell, Montemayor, and the Cerrito Prieto Ranches is acknowledged. Gene Spaniel, Gilbert Gonzales, and George Gonzales, County Extension Agents, provided technical assistance. Forage samples were analyzed at the TAEX Forage Testing Laboratiory, College Station. Fieldwork expenses were partially offset by support form G.E. Pogue Seed Co.

Table 1. Weather and fuel conditions during prescribed burning of common buffelgrass.

Location	Area (Ac)	Burn Date	Air Temp. (F)	Relative Humidity (%)	Wind Speed-Direction (MPH)	Fuel load (lb/Ac)
Premont	75	Feb. 1986	60	40%	0-7 (North)	4000
Encinal	25	Feb. 1986	58	42%	8-10 (North)	2550
Benavides	80	Feb. 1987	55	48%	6-10 (SE)	3543

Five buffelgrass sub-samples of leaves and stems were hand-plucked, at random, simulating grazing, from several plants in the pasture immediately prior to burning. Similar samples were then collected monthly thereafter from the burned pasture and from an adjacent non-burned (control) area for the next 12 months. The samples were oven-dried at 100° F for 48 hours and sent to the Forage Testing Laboratory at Texas A&M University for analysis.

Each sample was analyzed for crude protein (CP), total digestible nutrients (TDN), phosphorus (P), potassium (K), and calcium (Ca). Crude protein was determined by the Kjeldahl method. TDN contents were estimated from acid detergent fiber methods; P was determined by digestion and analyzed with an Intercoupled Plazma Unit (ICP); and K and Ca were determined through block digestion methods and analyzed by atomic absorption spectrometry.

Subsample data were pooled from each location by month. Burned and control values were compared by a Students' t-test and all statistical comparisions were made at the .05 probability level.

RESULTS AND DISCUSSION

Chemical composition of plants is influenced by a variety of morphological, physiological, environmental, and management factors. These include parts of the plant (e.g. stem and leaf); age of plant material; amount and timing of precipitation; air and soil temperatures. Animal nutrition from ranges and pastures will thus fluctuate with varying conditions, season of the year, and plant species composition.

The Texas Rio Grande Plain has a bimodal rainfall pattern with peak monthly total in May and September. July-August and December-January are usually dry periods. Rainfall amounts and distribution in 1986 and 1987 generally followed these trends (Figure 1). However, the summer and early fall of 1986 were relatively dry. Likewise, the fall and winter of 1987 were extremely dry. These dry periods were reflected by changes in crude protein, total digestible nutrients. and mineral levels of common buffelgrass, whether burned or not burned.

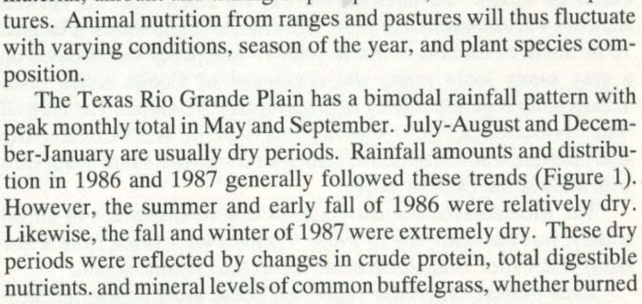


Figure 1. Bimonthly cumulative precipitation totals from Encinal and Benavides, 1986 and 1987.

Crude Protein

Protein, interacting with forage digestibility, in the diet of range cattle is important because it affects forage intake. Cows without adequate protein will have lowered rumen activity, which will reduce forage consumption and, in turn, reduces the availability of all nutrients to the animal. Burning common buffelgrass resulted in a short-term increase in CP content during both years of the study (Figure 2).

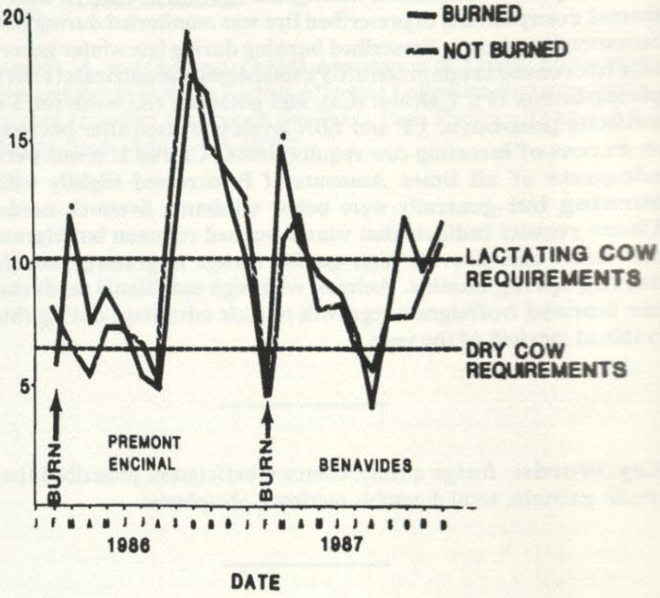


Figure 2. Crude Protein levels (%) in common buffelgrass, 1986 and 1987. (*Significant difference from control at P < 0.05 level)

Crude protein levels significantly increased during March, 1986, to 12% in the burned pasture as compared to 7% in the control pasture. CP levels from the burned pasture remained elevated over non-burned forages through June when plant maturity and summer drought resulted in similar CP levels in both pastures. Similar trends occurred following burning in 1987. CP content of the burned pasture was significantly higher in March compared to the nonburned pasture. Pastures were again similar by May. Another peak in CP content was recorded in the burned pasture following late summer rains in 1987, but was not statistically significant.

CP values were generally sufficient to meet the requirements of a dry cow. Noticeable exceptions occurred in burned and non- burned pastures during the summer and winter stress periods. Levels exceeded requirements for lactation cattle only following burning and/or rainfall peaks.

TOTAL DIGESTIBLE NUTRIENTS

Lack of total feed (mainly energy) is one of the most common deficiencies of breeding cattle during the winter and during the frequent droughts in South Texas. This can cause excessive loss of body weight, delayed breeding, improper fetus development, lowered tolerance to cold weather, and lowered parasite and disease resistance. This may be the result of heavy stocking rates but, more often, is the result of low energy levels in the forage. A high percentage of TDN allows quick passage of forage through the rumen. Burning apparently had little or no effect on TDN content of common buffelgrass (Figure 3). A non-significant increase was recorded following the burn in 1988 but this quickly leveled out in response to rainfall by May. No differences were noted for the remainder of the study. TDN levels from both burned and control pastures ranged between 40% and 60%, except in February, 1987.

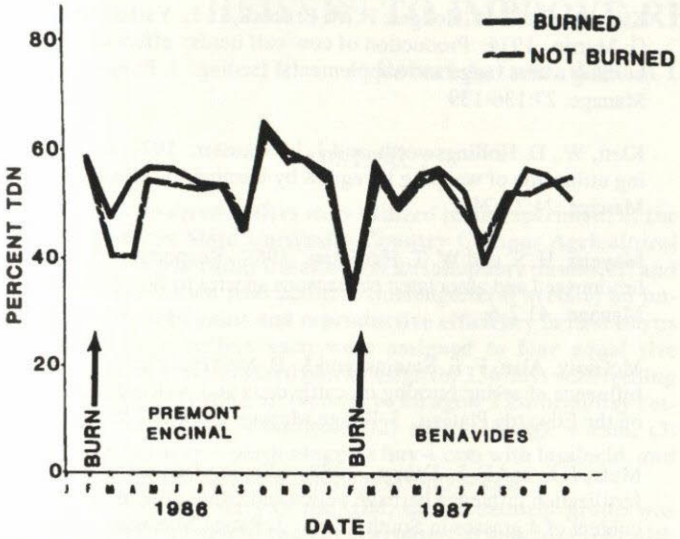


Figure 3. Total digestible nutrient content (%) of common buffelgrass from burned and non-burned pastures, 1986-1987.

Phosphorus

Lack of phosphorus is the major mineral deficiency in Texas. Grass forage plants do not provide a stable supply to meet beef cattle requirements (Everitt et al. 1980; Huston et al. 1981); however brush intake may offset this deficiency. Phosphorus levels were enhanced in the growing season following prescribed fire for 3-4 months with significant increases immediately following the burn (Figure.4). During this same period, phosphorus in non-burned buffelgrass remained below requirements for a dry cow. Phosphorus levels responded to rainfall events whether the grass had been burned or not. However, increases were not as great in non-burned pastures.

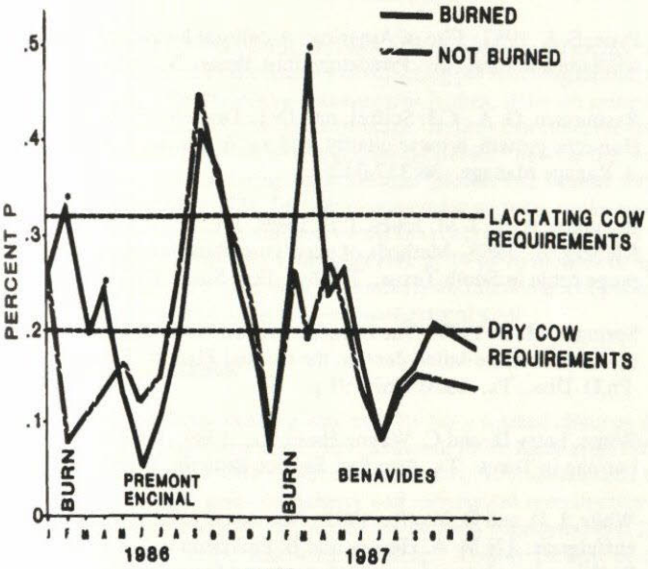


Figure 4. Phosphorus content (%) in burned and non-burned common buffelgrass. (*Significant difference from control at P<0.05 level).

Other Minerals

Potassium is generally not lacking in South Texas forages. However, during a wet winter in highly weathered forage, potassium may be limiting (Hinnant and Kothman 1982) and livestock reproduction impaired. Potassium was present in adequate amounts in both pastures at all times during the study. A low value of .63% occurred in Jan, 1987, but increased to a high of 3.58% in October of 1987 in the non-burned pastures. The burned pasture generally contained slightly higher levels of potassium.

Calcium in buffelgrass forages likewise varied from month to month in response to growth events. However, it is usually not a problem since most of the area soils are calcareous. Burning did not appear to affect calcium content of buffelgrass foliage. Levels, in general, were adequate to meet animal needs on both pastures.

Conclusions and Management Implications

Prescribed burning of common buffelgrass did not result in any long-term nutritional advantages. Short-term increases in crude protein and phosphorus were noted but other minerals and total digestible nutrients remained similar between burned and non-burned pastures. These data follow trends from many areas and species in the published literature. In most situations, any nutritional advantage disappears within 3-4 months post-burn.

However, when higher forage quality is combined with greater availability of green forage on burned pastures, the influence is magnified. For example, spring standing crops of buffelgrass on non-burned pastures consisted of 4076 lb/ac. Of this, 2500 lb/ac (61%) were dry, mature stems and leaves with only 1576 lb/ac (39%)of new green foliage (Hanselka, unpubl. data). The burned pasture produced 2948 lb/ac of green foliage during this same time frame and 90% of the old, dry foliage was removed by fire. The burned pastures "greened up" approximately one month earlier than the non-burned pasture. Ibarra (1988) reports similar responses in Sonora, Mexico.

This access by grazing animals to fresh, quality forage translates into potentially improved animal performance. McGinty et al. (1983) recorded a higher percentage of grass in steer diets on a burned range than in diets on an non-burned range in Central Texas. Livestock weight gains were significantly higher on the burned pastures. White and Wolfe (1985) reported similar results from South Texas and Kirk et al. (1974) drew similar conclusions from long-term studies in Florida.

The burning of buffelgrass pastures can thus provide an increase in the quantity of quality forage to animals with high nutritional requirements during a critical period of theyear. First calf heifers or cows needing a higher nutritional plane as a prerequisite to rebreeding, can use regrowth on burned pastures to their advantage.

Although burning tended to increase phosphorus content of common buffelgrass, levels were too erratic to provide a dependable supply of phosphorus to meet minimum beef cattle requirements. Stress periods and resulting non-growth of grasses caused P levels to drop to very low levels. Since these periods are common in South Texas, it is advisable to provide phosphorus supplement free choice, yearlong to range cattle (Reynolds et al. 1953).

Burning did have positive short-term effect on common buffelgrass quality. Generally, dry weather and poor growing conditions negated this advantage by the summer months. During winter, dry seasons, and/or extended drought, beef cattle should be supplemented based upon requirements, management needs, and forage quality.

In general, the result from this study follow the conclusions of a review by Huston (1980). Regrowth of burned buffelgrass is usually higher in some nutrients and the diets of animals grazing burned pasture should reflect an increased nutrient content. Also, the burning of buffelgrass stands which have excessive amounts of old growth and litter will give the greatest net benefit on diet quality. Benefits of improved diet quality and increased animal productivity are relatively short-lived so the greatest livestock response to burning will be in animals in a high productive state (growing, lactating, rebreeding, etc.)

If these constraints are considered in a buffelgrass forage management program, then prescibed burning has the potential to improve cattle production on South Texas ranches.

LITERATURE CITED

Anderson, Kling L., E.F. Smith. and C.E. Owensby. 1970. Burning blustem range. J. Range Manage. 23:81-92.

Chapin III, F.S. and K. Van Cleve. 1981. Plant nutrient absorption and retention under differing fire regimes. IN Fire regimes and ecosystem properties: Proceedings of the Conference. USDA-FS General Technical Report WO-26. p. 301-321.

DeWitt, J. B. and J. B. Derby, Jr. 1955. Changes in nutritive value of browse plants following forest fires. J. Wild. Manage. 19:65-70.

Drawe, D.L. 1980. The role of fire in the Coastal Prairie . IN C. W. Hanselka (ed.). Prescribed range burning in the Coastal Prairie and eastern Rio Grande Plains of Texas. Tx Agr. Ext. Service Bull. p. 101-113.

Everitt, J. H., M. A. Alaniz, A. H. Gerbermann, and W. W. Gausman. 1980. Nutrient content of native grasses on sandy and red sandy loam range sites in South Texas. USDA-ARS, ARR-S-7. 30p.

Everitt, J. H. and H. S. Mayeux. 1983. Nutritive contents of two grasses and one browse species following rangeland burning in South Texas, Southwestern Naturalist, 28:242-244.

Gonzalez, C. L. and J. H. Everitt. 1982. Nutrient contents of major food plants eaten by cattle in the South Texas Plains J. Range Manage. 35:733-736.

Hamilton, W. T. 1985. Buffelgrass: brush mangement/fire. IN M. A. Hussey and B. Pinkerton (eds.) Buffelgrass: adaption, management, and forage quality. Tx. Agr. Exp. Stat. MP 1575. P. 39-52

Hamilton, W. T. and C. J. Scifres. 1982. Prescribed burning during winter for maintenance of buffelgrass. J. Range Mange. 35:9-12.

Hanselka, C. Wayne. 1980. The historical role of fire on South Texas Rangelands. In C. W. Hanselka (ed.) Prescribed by range burning in the coastal prairie are eastern Rio Grande Plains, Tx. Agr. Ext. Service Bull. p 5-18.

Hanselka, C. Wayne. 1988. Buffelgrass: South Texas wonder grass. Rangelands 10(6):279-281.

Hinnant, R. T. and M. M. Kothmann. 1982. Potassium content of 3 grass species during winter. J. Range Manage. 35:211-213.

Holloway, J. W. and L. W. Varner. 1985. Meeting the nutrient requirements of beef cattle. IN L. D. White, D. E. Guynn, and T. R. Troxel (eds.). Proceedings 1985 Intl. Ranchers Roundup. Tx. Agr. Ext. Service Bull. p. 276-285

Huston, J. E. 1980. Livestock response on burned range. IN L. D. White (ed.) Prescibed range burning in the Edwards Plateau of Texas. Tx. Agr. Ext. Service Bull. p. 17-21

Huston, J. E., B. S. Rector, L. B. Merrill, and B. S. Engdahl. 1981. Nutritional value of range plants in the Edwards Plateau region of Texas. Tx Agr. Exp. Stat. B-1357. 16 p.

Ibarra, F.A. 1988. Personal Communication.

Kirk, W. G., E. M. Hodges, F. M. Peacock, L. L. Yarlett, and F. G. Martin. 1974. Production of cow-calf herds: effect of burning native range and supplemental feeding. J. Range Manage. 27:136-139

Klett, W., D. Hollingsworth, and J. L. Schuster. 1971. Increasing utilization of weeping lovegrass by burning. J. Range Manage. 24:22-24.

Mayeux, H. S. and W. T. Hamilton. 1988. Response of false broomweed and associated herbaceous species to fire. J. Range Manage. 41:2-6.

McGinty, Alan, F. E. Smeins, and L. B. Merrill. 1983. Influence of spring burning on cattle diets and performance on the Edwards Plateau. J. Range Manage. 36:175-178.

Mutz, J. L. and E. L. Drawe. 1983. Clipping frequency and fertilization influence herbage yeilds and crude protein content of 4 grasses in South Texas. J. Range Manage. 36:582-585.

Mutz, J. L., T. G. Greene, C. J. Scifres, and B. H. Koerth. 1985. Response of Pan American balsamscale, soil, and livestock to prescribed burning. Tx. Agr.Exp.Stat.Bull. B-1492. 14 p.

Nelson, J.G. and R. E. England. 1978. Some comments on the causes and effects of fire in the northern grasslands area of Canada and the nearby United States, 1750-1900. IN C.M. Bourassa and A. P. Brackebusch (eds.). Proceedings of the 1977 Rangeland Management and Fire Symposium. Mont. For. and Cons, Exp. Stat. Bull. p. 39-47.

Oefinger, R. D. and C. J. Scifres. 1977. Gulf cordgrass production, utilization, and nutritional value following burning. Tx. Agr, Exp. Stat. Bull. B-1176. 19p.

Pyne, S. J. 1982. Fire in America: A cultural history of wildland and rural fire. Princeton Univ. Press., N.J. 654 p.

Rasmussen, G. A., C.J. Scifres, and D. L. Drawe. 1983. Huisache growth, browse quality, and use following burning. J. Ranage Manage. 36:337-342.

Reynolds, E. B., J. M. Jones, J. H. Jones, J. F. Fudge, and R. J. Kleberg, Jr. 1953. Methods of supplying phosphorus to range cattle in South Texas. Tx. Agr. Ecp. Stat. B-773. 16 p.

Springer, M. D. 1977. The influence of prescribed burning on nutrition in white-tailed deer on the Coastal Plain of Texas. Ph.D. Diss., Tx. A&M Univ. 91 p.

White, Larry D. and C. Wayne Hanselka. 1989. Prescibed range burning in Texas. Tx. Agr. Ext. Service Bulletin, B-1310 8 p.

White, L.D. and D. Wolfe. 1985. Nutritonal value of common buffelgrass. IN M. A. Hussey and B. Pinkerton (eds.) Buffelgrass: adaptation, management, and forage quality. Tx. Agr. Exp. Stat. MP-1575. p. 13-24.

Wood, G. W. 1988. Effects of prescribed fire in deer forage and nutrients. Wildl. Soc. Bull. 16:180-186.

Wright, H. A. 1974. Range burning. J. Range Manage. 27:5-11.

EFFECTS OF SUPPLEMENTATION WITH LASALOCID AND SYNCHRONIZATION WITH MELENGESTERAL ACETATE ON HEIFERS TO IMPROVE REPRODUCTIVE EFFICIENCY[1]

Robert A. Lane, William L. Nobles, and F. Doug Blackard[2]

ABSTRACT

Forty crossbred heifers were utilized in an experiment at the Sam Houston State University Country Campus Agricultural Complex to determine the effects of an ionophore (lasalocid) and a synchronization feed additive (melengesteral acetate) on improving weight gains and reproductive efficiency in first estrus heifers. Ten heifers each were assigned to four equal size paddocks in a randomized block design for 136 days with feeding treatments consisting of; (1) oat/rye forage + 2 lbs/head/day cottonseed meal(csm) + lasalocid, (2) oat/rye forage + csm, (3) dormant pasture + bermudagrass hay + csm with lasalocid, and (4) dormant pasture + bermudagrass hay + csm.

The last nine days of the trial, each treatment group was randomly divided into two equal groups (20 animals each) with all heifers fed .5 mg/hd/d of melengesteral acetate (MGA) in the csm. One group was then injected with 25 mg each of prostaglandin to encourage heat sychronization. All animals were inseminated via artifical insemination techniques 80 hrs. later.

Analyses of variance indicate that the oat/rye forage was responsible for greater weight gains and larger frame sizes regardless of lasalocid supplementation. The synchronization treatment did not result in improved conception rates among the heifers via artifical insemination techniques, however 70% of the heifers were bred within 60 days following the treatment period.

Key words: Melengesteral acetate, lasalocid, forage, estrus synchronization

INTRODUCTION

Productivity of beef cattle depends on reproductive efficiency and is often measured by the number of offspring per breeding animal per unit of time. Reproductive management in turn, relies on using the resources available to the best advantage. Heifers that conceive early in their breeding season have a greater probability of weaning more and heavier calves during their lifetime (Burris and Priode, 1958; Lesmeister et al., 1973). In most management systems, replacement heifers are bred for production of the first calf at approximately 24 months of age, thus they must conceive at 14 to 16 months of age. Management techniques affecting puberty and attainment of puberty must be considered an important management goal.

Heifer Management

Rate of gain from weaning until puberty has a marked effect on age at first estrus (Wiltbank et al. 1969; Lamond, 1970; Fleck et al. 1980; Lemenager et al. 1980). Short and Bellows (1971) determined the effects of weight gains on puberty and subsequent reproduction in heifers assigned to gain .23, .45, or .68 kg daily during the first 152 day wintering period following weaning. Twenty percent of the heifers fed the low level supplement failed to show estrus during the first 20 day period compared to 62% and 60% for heifers from the moderate and high groups, respectively. These results do not mean that excessive feeding is desirable. In addition to incurring unnecessary cost, Arnett et al. (1971) summarized data indicating that overfeeding of heifers had a detrimental effect on fertility and milk production.

Because puberty is correlated with body weight, Lamond (1970) suggested the use of a target weight concept to assure adequate nutrition to reach a given body weight in developing replacement heifers.

Nutrition

Most cattle will spend their lives grazing medium to low quality forages. Large numbers of cattle will also receive substantial proportions of their feed requirement from crop aftermath, winter cover crops, and by-products from grain and oilseed processing. An understanding of the factors that affect the ability of a ruminant to utilized such feed sources is essential. A wide variety of forage species are utilized and great differences in quality can occur within a single forage species due to management practices, climate, and other factors. Each of these may affect the growth of a young animal.

As most forage plants mature, they increase in fiber content and generally become lower in protein. Because the fibrous fractions of a forage are less digestible and require more time for digestion than the non-fibrous fractions, forage intake and total energy intake generally decline as forage matures.

It takes less time for rumen bacteria to digest less fibrous material or higher quality feeds. Because the rumen is filled to capacity with most forage diets, any factor that speeds the passage of the diet through the rumen will allow the animal to consume more feed. The digestibility of less fibrous forage is also higher and the combination of higher intake and higher digestibility greatly increases the total energy intake of ruminants fed high quality forages. The intake of digestible energy can be as much as 3 times higher for very high quality hay than for poor quality forage (Neumann and Lusby, 1986).

Supplementation can improve the performance of cattle consuming forages. The primary consideration in utilizing any supplement is the performance and profitability which can be obtained from such. Protein supplementation can increase total energy intake by increasing the rate of digestion of the forage, allowing the forage to move more quickly through the rumen. Since rumen fill is the major factor limiting intake of most forages, a decreased retention time permits more forage to be consumed allowing the animal to maintain or gain more weight (Neumann and Lusby, 1986).

Feed Additives

Studies have shown that feeding ionophores will hasten puberty in heifers (Moseley et al. 1977). Moseley et al. (1982) found that this effect was not due to increased gain or body weight, which tends to agree with the findings of Bushmich et al. (1980) who reported monensin, an ionophore, enhanced ovarian response to gonadotropic stimulation. These findings are important since they indicate another tool that can be utilized in heifer management. The research also suggests metabolic- endocrine relationships may be acting in the bovine and that other ionophores, such as lasalocid (Bovatec™) may also have positive effects on puberty and/or reproduction. Monensin and lasalocid are antibiotic feed additives. The term ionophore refers to the compound's capacity to aid the passage of cations across lipid membranes of cells (Bergen & Bates, 1984). Monensin and lasalocid have been approved for use in replacement heifers to improve feed efficiency and rate of weight gain.

Considerable research has shown that ionophores will increase rate of gain in cattle grazing forages of sufficient quality to permit

[1]Contribution from the Division of Agricultural Sciences and Vocational Education, College of Education and Applied Sciences, Sam Houston State University, Huntsville, Texas 77340.

[2]Associate Professor, former Lecturer currently Extension Agent with Colorado Agricultural Extension Service and Farm Manager, respectively, in the Division of Agricultural Sciences and Vocational Education.

gains. The result is that some types of microorganisms are selectively eliminated in the rumen and other types are left to proliferate. Ionophores alter rumen fermentation causing dose-related decreases in acetate and increases in propionate in cattle fed either low or high roughage diets. This shift in volatile fatty acids (VFA) is associated with a decrease in methane production, and no accumulation of gaseous hydrogen (Muir 1985), resulting in a selective effect of rumen bacteria. This shift reduces energy losses during fermentation and makes the digestion process more efficient. Ionophores also tend to increase retention time of most feedstuffs in the rumen thus less feed is required to obtain the same amount of gain as compared to an animal not receiving the ionophore.

Hormonal Control

Induction of a fertile estrus in prepuberal heifers given various hormonal treatments has been reported (Neville and Williams, 1973; Short et al. 1976; Burfening, 1979). Success rates have been variable and appears to be associated with age and weight of the heifer. Melengesteral acetate (MGA), a synthetic progesterone, has been found to induce early estrus in heifers. Melengesteral acetate is utilized by the feedlot industry as a feed additive to suppress estrus in feedlot heifers and as yet is not approved by FDA for breeding cattle. Research indicates that before estrus can occur, the heifer's body must be near puberty, fully sexually developed and ready to take over the cycle by itself. Recent studies have indicated that MGA fed to heifers for seven and nine days improved conception rate when prostaglandin was administered on the last day MGA was fed (Boyd & Corah, 1986; Patterson et al. 1986).

OBJECTIVES OF STUDY

The objectives of this study were to determine (1) the effects of 200 mg/hd/day of lasalocid, fed with a cottonseed meal carrier, on growth and development of crossbred heifers grazing two different forage based diets, (2) the effects of .5 mg/hd/day of MGA fed for nine days followed by a prostaglandin injection on synchronization of heifers to improve first service conception rate, (3) the effects of both lasalocid and/or MGA on initiating puberty in heifers and (4) the feasibility and practicality of utilizing an ionophore and synchronization feed additive in a commercial beef cattle operation breeding first estrus heifers.

MATERIALS AND METHODS

Forty crossbred heifers (1/4 and 3/8 brahman) were utilized in this study beginning in the fall of 1987. At weaning, all heifers were weighed and vaccinated for seven strains of clostridia. The heifer calves were orally wormed with Safeguard™ (phenbendizole) and treated for external parasites with Co-Ral™, a liquid systemic. They were then placed on a coastal bermudagrass (Cynodon dactylon) pasture prior to treatment application. Heifers were divided into four treatment groups based on 205 day weight, adjusted for sex of calf and age of dam, and frame score as recorded on November 1, 1987. The four treatment groups consisted of; (1) oat/rye pasture + 2 lbs/head/day cottonseed meal (csm) + 200 mg/hd/day lasalocid, (2) oat/rye pasture + csm, (3) dormant warm season pasture (bermudagrass) and cottonseed meal (csm) with lasalocid and free choice bermudagrass hay (9% crude protein), and (4) dormant pasture + bermudagrass hay and csm. Heifers were group fed the concentrate in the morning and allowed to graze and/or consume hay ad libitum.

Heifer weight and frame scores were determined for 6 different periods of a 136 day trial. The last nine days of the trial, each treatment group of heifers was randomly divided into equal groups. All forty crossbred heifers were fed .5 mg/head/day of MGA in the supplement. On the ninth day the MGA was withdrawn from the supplement and five heifers per treatment group were injected with 25 mg of prostaglandin (lutylase). All heifers were artificially inseminated 80 hours following the prostaglandin injection with Brangus semen. Each heifer was artificially inseminated again at 21 days after first service. Brangus bulls were used as clean-up bulls for the following 40 days after the last MGA feeding.

Results were determined by the use of randomized block design with or without lasalocid on two forage types as blocks and MGA with or without prostaglandin as treatment groups. Analyses of variance were employed to determine statistical significance of heifer weight across time, frame size across time, number of heifers bred at first and second service and number of heifers bred at 60 days post-MGA feeding. Duncan's multiple range test was used as a means separation technique.

RESULTS AND DISCUSSION

An analysis of variance did not indicate any significant differences between feeding treatment groups when comparing mean hip heights at each date of measurement throughout the treatment period (Table 1). However, when the initial frame size (hip height) is subtracted from the final size, animals grazing the small grains pasture made greater gains in height than those on dormant pasture and hay (Figure 1). Lasalocid supplementation did not affect this characteristic. Animals allowed free choice small grains pasture grew an average of 4.3 inches over the treatment period compared to 3.0 inches for those consuming dormant perennial grasses and free-choice bermudagrass hay; a difference of 1.3 inches. This can only be attributable to variations in protein content of available forage since all animals were allowed as much forage as they could consume and allowed free-choice minerals. The high protein content of small grain forage (>15% crude protein) allows for a greater rate of passage, thus greater total feed consumption than the poorer quality bermudagrass hay (approximately 9% crude protein). Digestible energy also varies from one forage species to another, but not to the extent of protein content.

Table 1. The effect of lasalocid supplementation on mean heifer frame sizes (hip height) when pastured on small grain forage or dormant warm season grass plus free-choice bermudagrass hay, Huntsville, Texas, 1987-88.

Feeding Treatment*	Date					
	12/20/87	1/21/88	2/25/88	3/23/88	4/5/88	5/5/88
	inches to hip					
SG+L	45.80	47.35	48.18	49.03	49.47	50.05
SG-L	45.65	47.48	48.20	49.15	49.71	50.05
H+L	46.20	47.33	47.90	48.23	49.10	49.40
H-L	46.40	47.10	47.70	48.10	48.80	49.13

*SG - Small grain pasture (oat-rye mixture)
H - Bermudagrass
L - Lasalocid supplementation in a cottonseed meal carrier

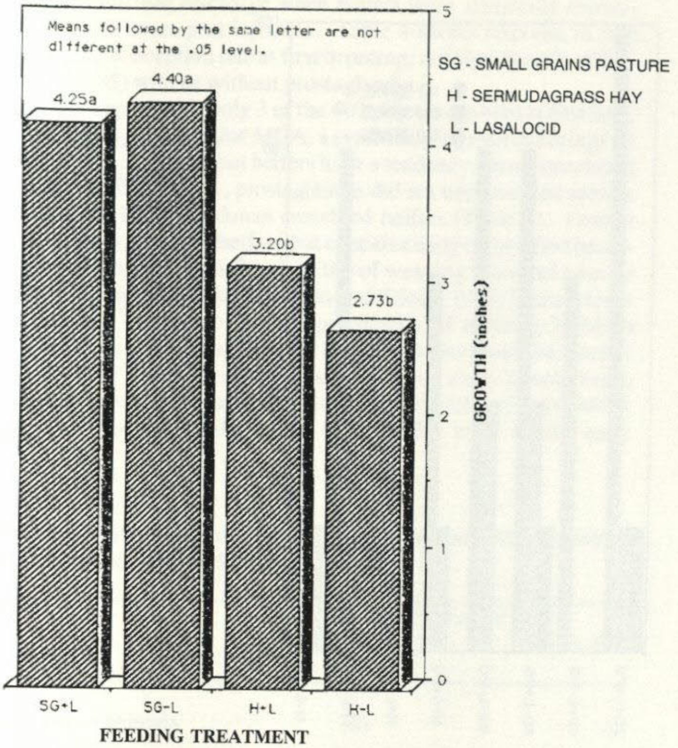


Figure 1. Gains in hip height of heifers as affected by forage and supplementation with lasalocid.

Similar results were seen with gains in weight. Though no differences were attributable to lasalocid in a cottonseed meal carrier, heifers grazing the small grains pasture gained an average of 253.50 lbs over the treatment period compared to a 130.75 lb gain for hay-fed heifers (Figure 2). Differences in body weights between forage treatment groups became detectable about 60 days into the trial (Table 2). The same general response was seen throughout the study period. Little information is available concerning lasalocid supplementation with high forage diets; especially diets of grazing weanling beef heifers. Improvements in performance of growing animals fed high forage diets (Guiterrez et al. 1982; Spears and Harvey, 1984) suggest an application for beef cows, but reports have been inconsistent (Berger et al., 1981). In the case of feedlot rations of high energy, lasalocid administered at 200mg/hd/day, dramatically improved average daily gain and feed efficiency of steers and heifers. But heifers on different types of roughages have been inconsistent in performance. Jacques et al. (1987) found that beef cows grazing poor to low quality forage were not affected by the addition of lasalocid and that weight gain and forage intake were not affected. In this study, it was noted that neither medium nor high protein forage with lasalocid had an affect on weight gain in beef heifers. Though not quantitatively measured, it was observed that the small grain pasture with heifers receiving lasalocid was more completely denuded of forage than that in which lasalocid was not fed. It was noticed that animals fed lasalocid were willing to consume plant parts (stem and inflourescence) that the other animals considered undesirable or unpalatable. However, this did not result in improved gains, likely due to the poor nutritive values of those plant parts. These results show that the ionophore lasalocid did not improve weight gains or body frame size when added to two very different forage-based diets.

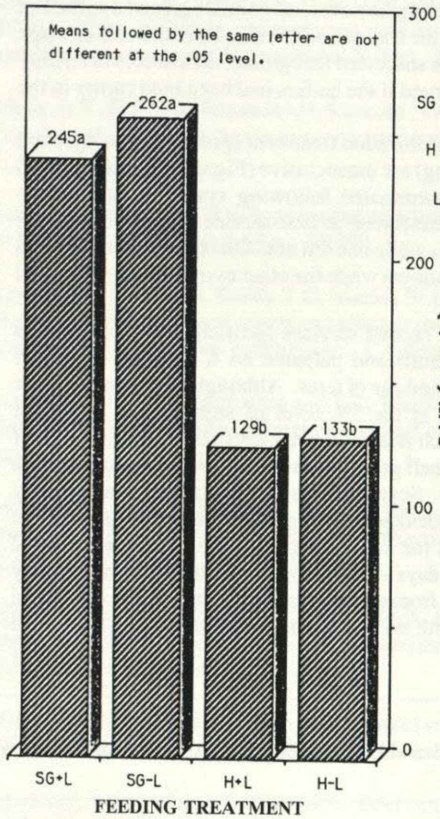


Figure 2. Weight gains in heifers as affected by forage and supplementation with lasalocid.

Table 2. The effect of lasalocid supplementation on mean heifer weights when pastured on small grain forage or dormant warm season grass plus free-choice bermudagrass hay, Huntsville, Texas, 1987-88.

Feeding Treatment*	Date					
	12/20/87	1/21/88	2/25/88	3/23/88	4/5/88	5/5/88
	pounds					
SG+L	536.5	576.5	660.5a**	684.5a	765.0a	781.5a
SG-L	540.0	586.5	671.5a	707.0a	788.0a	802.0a
H+L	546.5	559.5	594.5b	582.5b	668.0b	675.5b
H-L	537.0	547.0	581.5b	574.0b	670.5b	669.5b

*SG - Small grain pasture (oat/rye mixture)
H - Bermudagrass
L - Lasalocid supplementation in a cottonseed meal carrier

**Means followed by the same letter are not significantly different at the .05 level according to Duncan's multiple range test.

Intake and digestibility of protein deficient forages is usually depressed resulting in energy deficiency as well as protein deficiency. In this study cottonseed meal was fed to all treatment groups to maintain the protein needs of the animal, but it was obvious ($p < .05$) that additional protein and energy from the small grain pastures improved rate of gain. For adequate fermentation by rumen microorganisms, 8% crude protein is required (Neuman and Lusby, 1986). Adding high protein supplements to a forage diet that is deficient in protein can greatly increase forage intake. Thus, the more feed the animal consumes, the greater the weight gain achieved.

The initial condition score for the heifers was approximately 5.5 for all test groups. Upon completion of the feeding trial there was considerable difference between the condition of heifers on small grain pasture and those on dormant pasture with hay (Table 3). Though heifers on small grain pasture were in considerably better condition when observed at the end of the study, improvements in fertility were not evident (Figure 3). As noted in Table 3, heifers on small grain pasture gained at almost double the rate of those on bermudagrass. Apparently however, all animals gained a sufficient amount of weight over the trial period to bring them to a similar stage of sexual maturity. It is suspected that greater differences in fertility would have been observed if the heifers had been bred earlier in the trial.

Results of the synchronization treatment (prostaglandin injection following MGA feeding) are inconclusive (Figure 3). Of the total 40 animals artificially inseminated following synchronization treatment, only 3 heifers conceived at first service. Two received the prostaglandin injection while one did not. One of these animals was from a hay feeding treatment while the other two were from the small grain pastures.

After the first and second services (artificial), all heifers were exposed to clean-up bulls and palpated on 6 June and 7 July to determine conception and age of fetus. Although means could not be statistically separated at the 5% level of significance, important trends were noted which warrant further research. Eighty percent of the heifers from the small grain pastures conceived during their first year of sexual activity. Seventy percent of the heifers receiving hay and csm with no lasalocid added were diagnosed as pregnant while only 50% of those on the same forage diet but receiving lasalocid conceived within 60 days of the prostaglandin treatment. Eighty percent of the animals from the two small grain treatments conceived during this period, with no significant differences detected due to lasalocid. These rates of conception in a controlled breeding season are considered desirable for 14-16 month old heifers, especially those with Brahman influence.

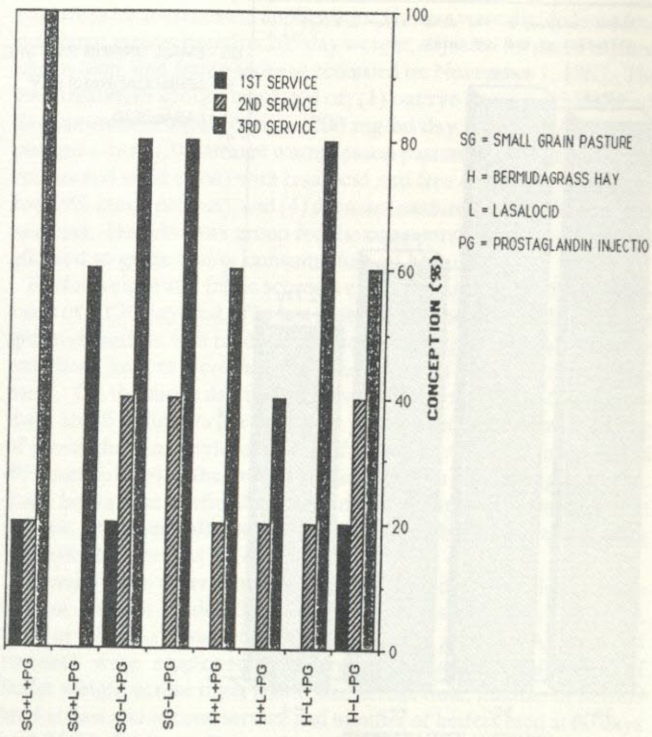


Figure 3. Conception rate as affected by forage, lasalocid, and prostaglandin.

In this study, heifers that did not respond to melengesteral acetate treatment were considered not to have reached puberty. Heifers synchronized with MGA with or without prostaglandin were not different in mean weight or hip height at the time of breeding. Heifers responded to both treatments as indicated by cervical dilation and

Table 3. The effects of lassalocid supplementation on average daily gain and animal condition under two forage-based systems.

	Small grains		Bermudagrass hay	
	with lasalocid	without lasalocid	with lasalocid	without lasalocid
Number of animals	10	10	10	10
Average daily gain, lbs	1.80a*	1.93a	.95b	.97b
Initial condition score	5.4**	5.5	5.5	5.5
Final condition score	6.50	6.25	5.75	5.50

*Means followed by the same letter are not significantly different at the 5% level.
**Scale of 1 to 9; 1 - very thin, 9 - very fat.

cervical mucosal discharge when heifers were artificially inseminated at 80 hours post injection. Table 4 shows response to first estrus and conception rate at first breeding; not significantly different ($p < .05$) with or without prostaglandin.

In this experiment, only 3 of the 40 heifers were bred at first heat. It is well documented that MGA, a synthetic progesterone brings on early estrus in heifers, but heifers have a tendency not to conceive at first heat. In this study, prostaglandin did not improve first service conception rate in brahman crossbred heifers (Table 4). From a production viewpoint, heifers that conceive early in their first breeding season have a greater probability of weaning more and heavier calves during their lifetime (Burris and Priode, 1958; Lesmeister et al. 1973). The feasibility and practicality of utilizing MGA to synchronize heifers to shorten the breeding season could be a useful tool in beef cattle operations. An additional study is now being designed in which a treatment group of heifers will not receive MGA prior to breeding to determine if the MGA itself affects early conception.

Table 4. Heifer response to melengesterol acetate (MGA) with or without a prostaglandin injection (PG).

	Treatment	
	MGA + PG	**MGA-PG**
Number of animals	20	20
Mean weight, lbs	725.25	720.50
Mean hip height, in	48.94	48.31
Sexual response	17	15
Sexual response, %	85	75
1st service conception	1	2
2nd service conception	4	3
Natural service conception	7	11
Animals bred within 60 days following treatment	12	16
Percent bred	60	80
Heifers with no cyclic activity	1	2

CONCLUSION

While it is evident from these data that the overall level of protein nutrition was a more important determinant of gains in weight and frame size in weanling heifers, these results indicate that even those heifers fed only bermudagrass hay with 2lbs. of cottonseed meal per day made sufficient gains to reach puberty at 14-16 months of age. Lasalocid did not improve the rate of gain of the heifers on either high or medium quality forage-based diets. A seventy percent conception rate in heifers of this age is considered to be an acceptable level of fertility in beef heifers.

This study has been extended to determine possible differences in birthing difficulties of these treatment groups and conception rates during their second year of sexual activity. Additional study using larger treatment groups must be conducted to determine the impact of MGA on conception rates of first and second calf heifers.

LITERATURE CITED

Arnett, D.W., G.L. Holland and R. Totusek. 1971. Some effects of obesity in beef females. J. Anim. Sci. 33:1129.

Bergen, W.G. and D.B. Bates. 1984. Ionophores: their effect on production efficiency and mode of action. J. Anim. Sci. 58:1465.

Boyd, G.W. and L.R. Corah. 1986. Synchronization of estrus in cyclic and noncyclic heifers and cows using melengesteral acetate and prostaglandin. J. Anim. Sci. 63(Suppl. 1):353.

Burfening, P.J. 1979. Induction of puberty and subsequent reproductive performance. Theiriogenology 12:215.

Burris, M.J. and B.M. Priode. 1958. Effect of calving date on subsequent calving performance. J. Anim. Sci. 17:527.

Bushmich, S.L., R.D. Randel, M.M. McCartor and L.H. Carroll. 1980. Effect of dietary monensin on ovarian response following gonadotropin treatment in prepuberal heifers. J. Anim. Sci. 51:692.

Fleck, A.T., R.R. Schalles and G.H. Kiracofe. 1980. Effect of growth rate through 30 months on reproductive performance of beef heifers. J. Anim. Sci. 51:816.

Lamond, D.R. 1970. The influence of undernutrition on reproduction in the cow. Anim. Breed Abstr. 38:359.

Lemenager, R.P., W.H. Smith, T.G. Martin, W.L. Singleton and J.R. Hodges. 1980. Effects of winter and summer energy levels on heifer growth and reproductive performance. J. Anim. Sci. 51:837.

Lesmeister, J.L., P.J. Burfening and R.L. Blackwell. 1973. Date of first calving in beef cows and subsequent calf production. J. Anim. Sci. 36:1.

Moseley, W.J., M.M. McCartor and R.D. Randel. 1977. Effects of monensin and growth and reproductive performance of beef heifers. J. Anim. Sci. 45:961.

Moseley, W.M., T.G. Dunn, C.C. Kaltenbach, R.E. Short and R.B. Staigmiller. 1982. Relationship of growth and puberty in beef heifers fed monensin. J. Anim. Sci. 55:357.

Muir, L.A. 1985. Mode of action of exogenous substances on animal growth-an overview. J. Anim. Sci. 61:154.

Neumann, A.L. and K.S. Lusby. 1986. Beef cattle. John Wiley and Sons, Inc., New York.

Neville, W.E. and D.J. Williams III. 1973. Estrus, ovulation and conception in hormone treated prepuberal Hereford heifers. J. Anim. Sci. 36:540.

Patterson, D.J., L.R. Corah and J.R. Brethour. 1986. Effect of estrus synchronization melengesteral acetate and prostaglandin in first service conception rates in yearling beef heifers. J. Anim. Sci. 63(Suppl. 1):353.

Short, R.E. and R.A. Bellows. 1971. Relationships among weight gains, age at puberty and reproductive performance in heifers. J. Anim. Sci. 32:127.

Short, R.E., R.A. Bellows, J.B. Carr, R.B. Staigmiller and R.D. Randel. 1976. Induced or synchronized puberty in heifers. J. Anim. Sci. 43:1254.

Wiltbank, J.N., C.W. Kasson and J.E. Ingalls. 1969. Puberty in crossbred and straightbred beef heifers. J. Anim. Sci. 29:602.

EVALUATION OF BIAS IN ANTLER MEASUREMENTS OF HARVESTED WHITE-TAILED DEER ON A SOUTH TEXAS RANCH

Charles A. DeYoung[1]

ABSTRACT

I evaluated bias in antler measurements of harvested white-tailed deer (Odocoileus virginianus) aged by the tooth replacement and wear method. Antler measurements of harvested deer were compared to measurements of randomly captured deer aged by the cementum annuli technique on a south Texas ranch. There was little difference in the antler measurements of harvested versus captured deer.

Key words: Antlers, deer harvest, Odocoileus virginianus, white-tailed deer

INTRODUCTION

Age-class antler measurements from harvested bucks are important in white-tailed deer management programs (Brothers and Ray, 1975:145). Such records allow the manager to assess trends in antler quality through time. These trends may be correlated with the population's relationship with carrying capacity. Antler measurements also permit comparison of the performance of different populations.

When managers collect age-class antler measurements, they assume deer are aged without bias and represent the age class structure of the population. Recent research has cast doubt on the validity of both assumptions (DeYoung, 1989; DeYoung, unpublished data).

Typically, harvested deer are aged by the tooth replacement and wear technique (Severinghaus, 1949). DeYoung (1989) demonstrated that this technique results in overaging of young deer and underaging of older deer and suggested the cementum annuli technique had less bias. Additionally, bucks harvested in quality or trophy management programs may not be representative of their age-class. DeYoung (unpublished data) found antler measurements of bucks over 2.5 years overlapped significantly. Thus, when managers protect small-antlered bucks with the goal of letting them attain mature age, mature bucks with small antlers are protected as well. Antler measurements of harvested, mature bucks may be greater than the same-aged bucks in the population because small-antlered, mature bucks are not in the harvested sample.

To determine if the antler size of deer in harvest records are representative of the population, I evaluated antler measurements of harvested bucks aged by tooth replacement and wear versus bucks live-caught at random from the same population and aged by the cementum annuli technique.

MATERIALS AND METHODS

Deer sampled in the study came from the 7,500-acre Zachry Randado Ranch 25 mile southwest of Hebbronville in Jim Hogg and Zapata counties. The ranch supports a diversity of shrubs generally less than 10 feet tall and with an average canopy coverage of 35% (Drawe and Higginbotham, 1980). Common shrubs were whitebrush (Aloysia lycoiodes), honey mesquite (Prosopis glandulosa), guajillo (Acacia berlandieri), and creosote bush (Larrea divaricata). Common herbaceous species included buffelgrass (Cenchrus ciliaris), Riddel daisy (Aphanostephus riddellii), lantana (Lanatana macropoda), and false ragweed (Parthenium confertum). The ranch is enclosed by an 8-foot high fence that limits deer movement.

The deer herd is managed for trophy bucks using the guidelines described in Brothers and Ray (1975). Harvested bucks (N = 118) were killed by hunters from 1979-1986. Although the range of years differed in the harvest versus live-caught samples (1985-1987), there was no evidence that antler development differed due to varying rainfall or other effects on nutrition. Additionally, mature bucks, whose antler growth is less effected by enviroment, predominated in the harvest samples. Harvested bucks were aged by experienced persons using the tooth replacement and wear method (Severinghaus, 1949). Antler measurements were made with a flexible tape and included number of points over 1 inch, inside spread, left main beam length, and left basal circumference (Nesbitt and Wright, 1981:351). The ranch does not keep records on yearling bucks because only those with spike antlers were killed. Therefore, bucks considered in this study were 2.3-years-old or older.

Bucks were also sampled by live-capture using a helicopter and drive net (Beasom et al., 1980) or net gun (DeYoung, 1988). Before each capture, the helicopter pilot was briefed on the purposes of the study and carefully instructed to always capture the first buck encountered, regardless of size. Leon et al. (1987) found no age bias in deer encountered during low-level helicopter surveys in south Texas. Because the search pattern and altitude employed in the captures was similar to that used by Leon et al. (1987), the capture samples should approach a random sample of the population.

An incisor tooth was extracted from each captured buck, and age was determined by the number of cementum annuli by Matson's Laboratory, Milltown, MT. Antler measurements were made as described above and the bucks subsequently were released at the capture site. Bucks were caught during October 1985, 1986, and 1987, and during January 1987. For comparison with the harvest sample, only bucks 2.3 years and older (N = 87) were considered.

For each age class and antler measurement combination, means from the harvest sample and the live-caught sample were compared using t-tests. Additionally, for each antler measurement the harvest sample and the live-caught sample were tested for differences among age classes using one-way ANOVA. Tukey's test was used for post-hoc comparsions.

RESULTS AND DISCUSSION

Points in 6-year-old and basal circumferences for 3- and 7-year-old deer differed ($P < 0.05$) for harvested versus live- caught bucks (Table 1). All of the remaining comparisons for antler measurement-age combinations were not significant ($P > 0.05$). Five of eight 6-year-old bucks in the live-captured (population) sample had 8 or fewer points.

Overall there was little difference between antler measurements for harvested and live-caught bucks. This seemed inconsistent with the results of DeYoung (1989), where bias in wear aging was demonstrated, and DeYoung (unpublished data), where an unrepresentative harvest of mature deer was predicted. It appears that the lack of much difference between the buck samples resulted from the fact that antler measurements differ little among many of the age classes (Table 1).

All of the ANOVAs showed a significant ($P \leq 0.001$) effect of age-class on antler measurements. However, in each analysis, many of the means did not differ (Table 1). For example, for points of harvested deer, there was no difference ($P > 0.05$) between 3-year-old and older deer. Thus, I concluded that although there is bias in the

[1]Professor of Wildlife Management, Caesar Kleberg Wildlife Research Institute, Texas A&I University, Kingsville, TX 78363. I thank J.P. Zachry, A. Brothers, and the many people who participated in deer captures. The H.B. Zachry Co. and the Caesar Kleberg Foundation for Wildlife Conservation funded the study.

Table 1. Antler measurement means by age class of male white-tailed deer harvested by hunters (1979-1986) and captured at random from the population (1985-1987) on the Zachry Raandado Ranch, south Texas. Means within rows followed by the same letter are similar (P > 0.05).

Sample[a]	2	3	4	5	6	7	7+
Points (number)							
Harvest	7.5A	9.0AB	9.7B	10.8B[b]	11.0B	10.4B	10.4B
Population	7.9A	9.9BC	9.3ABC	10.4B	8.6AC	9.6ABC	9.0ABC
Spread (inches)							
Harvest	12.9A	15.0AB	16.5BC	17.6C	18.7C	17.6C	17.6C
Population	13.4A	16.6B	16.4B	17.5B	18.3B	18.7B	18.9B
Beam (inches)							
Harvest	15.7A	18.1B	19.6BC	21.7CD	22.5D	21.8D	21.8D
Population	15.4A	19.0B	20.0BC	21.5BC	21.1BC	21.6C	20.3BC
Base (inches)							
Harvest	3.3A	3.6A[b]	4.1B	4.6C	4.7C	4.3BC[b]	4.5BC
Population	3.5A	4.2B	4.2B	4.6BC	4.5BC	4.6BC	4.8C
Sample size							
Harvest	8	12	16	29	14	23	16
Population	28	7	18	11	8	11	4

[a]Age based on tooth replacement and wear for harvested bucks and cementum annuli for population (live-captured) bucks.
[b]Antler measurement means differed (P < 0.05) between harvest and population samples within this age class.

frequency of deer among age-classes in the harvest, there is little difference in the antler measurements versus live-caught deer because many of the age- classes do not differ from each other.

Antler measurements of harvested bucks need to be evaluated on additional areas. However, on the Zachry Ranch, it appears that these measurements differ little from the measurements of the population.

LITERATURE CITED

Beasom, S.L., W. Evans, and L. Temple. 1980. The drive net for capturing western big game. Journal of Wildlife Management. 44:478-480.

Brothers, A., and M.E. Ray, Jr. 1975. Producing quality whitetails. Fiesta Publishing, Co., Laredo, TX. 244pp.

DeYoung, C.A. 1988. Comparison of net-gun and drive-net capture for white-tailed deer. Wildlife Society Bulletin. 16:318- 320.

DeYoung, C.A. 1989. Aging live white-tailed deer on southern ranges. Journal of Wildlife Management. In press.

Drawe, D.L., and I. Higginbotham, Jr. 1980. Plant communities of the Zachry Ranch in the South Texas Plains. Texas Journal of Science. 32:319-332.

Leon, F.G., III, C.A. DeYoung, and S.L. Beasom. 1987. Bias in age and sex composition of white-tailed deer observed from helicopters. Wildlife Society Bulletin. 15:426-429.

Nesbitt, W.H., and P.L. Wright. 1981. Records of North America big game. The Boone and Crockett Club, Alexandria, VA. 409pp.

Severinghaus, C.W. 1949. Tooth development and wear as criteria of age in white-tailed deer. Journal of Wildlife Management. 13:195-216.

THE FINANCIAL SITUATION OF U. S. FARMS BY CLASS AND TYPE

Emilio Barbieri, Donald M. Nixon
James D. Arnold and Joseph E. Rossman[1]

ABSTRACT

This is a study of the financial profile and situation of U.S. farm operators in 1986. Difficult conditons in the farm sector have placed a number of farmers under financial stress. While some farms of all sizes have been experiencing financial stress, these problems have been most pronounced for small family-sized commercial farms. The degree of financial stress is based on the farm's debt/asset ratio and its cash flow. Analysis of the accounting statements of the farming sector for 1986 shows that assets and debts were lower causing a reduction in owner equity. This drop in equity indicates a decline in the wealth position of farmers. For analytical purposes, family-size commercial farms were those that sell between $40,000 and $500,000 of farm products per year. Such farms account for nearly a third of all farms and half of all sales of farms products.

INTRODUCTION AND REVIEW OF LITERATURE

Agriculture is not a homogeneous industry. It is composed of small family farms, large corporate organizations, credit firms, credit and processing firms, wholesalers, transportation networks and food and fiber retailers (Lee et al., 1980).

Farms can be classified according to economic classes (Edwards et al., 1985). Because of changes in these numbers through time, we can refer to them as the expanding, declining, and noncommercial sectors. The expanding sector included 350,000 farms in 1960, increasing to 1,012,000 by 1986. These farms accounted for 43 percent of all farms, produced over 93 percent of the value of agricultural output, and received 83 percent of the government support payments. Off farm income was $10,078 per farm. Average total income per farm, including off farm income and government payments amounted to $33,000.

The declining sector of agriculture includes those farms with annual product sales between and $2,500 and $20,000. Those farms decreased in numbers from 1.8 million in 1960 to 766,000 in 1986 (USDA, Agricultural Statistics 1986). This group of farms produced 6 percent of the agricultural output, 10 percent of the net income in agriculture, and received 15 percent of the government payments. Total income for these farms was $20,151 per farm in 1986.

Another distribution can be made according to the sources of income (Brooks, 1985). In 1984 of the 2.3 million farms, 1.6 million were small with less than $40,000 in annual sales. Operators of these farms are not often considered "farmers" because they rely on off-farm income as a principal source of income. The commercial farm sector is of extreme importance because it accounts for most of the agricultural production and is composed of almost 700,000 farms (Agrcultural Outlook, 1987).

Still another classification of farms can be made on the basis of commodities produced and sold (Remund, 1985). For a farm to be classified as a particular type, more than 50 percent of its gross sales must come from one commodity.

Financial conditions can also be measured in terms of asset/debt ratios (the amount of debt owed relative to the value of assets owed) and net cash flow (the amount of net cash income from all sources that can be used to meet family living expenses and debt payment needs),(Devino, 1981).

Cash flow by farm sales class in 1985 shows that the percentage of farms with negative cash flow values actually declined since 1981. The same analysis by farm type shows that livestock farms had the highest percentage of operators with negative cash flow because these farms had the lowest average gross farm income of any farm type. Greenhouse and dairy farms had the lowest percentage of farms with negative cash flow (Johnson, 1986).

Most of the publications concerning the Agricultural sector, like the Census of Agriculture, Agricultural Statistics, and periodic surveys conducted by the U.S. Department of Agriculture (USDA), provide only aggregate data. Items analyzed include the number of farms, land in farms, value of land and buildings, values of machinery and equipment, characteristics of operators, inventories, prices paid and received by farmers, etc. But, different farm types use different production practices and make unique decisions on financing, marketing, purchasing, and government program participation. Yet, the economic data base for agriculture gives the false idea of a homogeneous farming sector. Therefore, information about the financial situation and well being of different farm classes may not be reliable when obtained from aggregate statistics.

The objectives of the study will be a) to analyze the financial aspects of different farm classes, according to their annual product enterprise sales, b) to examine the economic situation of the major farm crop types in the U.S.

MATERIALS AND METHODS

Farm classes were classified in two categories, noncommercial farms, those with annual sales below $40,000, and commercial farms, with annual sales above $40,000. The latter were divided into a) small farms, with $40,000 to $100,000 annual sales, b) midsize farms, with $100,000 to $500,000 annual sales, and c)large farms, with $500,000 and more in annual sales.

Each farm was also assigned into an enterprise category which was determined to be the major source of sales for that farm. Enterprise categories utilized for this study were as follows: cash grain,tobacco/cotton, vegetable/fruits, nursery/greenhouse, beef/hog/sheep, dairy, and poultry.

A balance sheet and an income statement were constructed for each farm class and for the whole agricultural sector. The ratios obtained from the financial statements were statistically compared to determine which farm class was in a better economic and financial situation. Financial statements, a balance sheet and income statement, were constructed and ratios developed to establish and compare financial positions for each of the major farm enterprise types in the U.S. Data assembled came from various U.S. government publications (see literature cited).

Statistical and financial analysis were used to determine whether economic differences existed between sales classes and farm crop types. The statistical analysis used was the paired t-test. The financial analysis included assets to debts and debt to equity ratios.

A farm has favorable income status when it has positive net cash income; a favorable solvency status occurs when its debt to asset ratio is less than 0.40. A debt to asset ratio of 0.40 indicates that debts represent 40 percent of the assets. An equity to value ratio of less than 40-50% would be scruitinized with extreme care by lenders (Lee etal., 1988).

[1]Graduate Student, Professor of Agricultural Economics, Professor of Plant Science, Associate Professor of Economics and Finance, Texas A&I University, Kingsville, TX 78363.

RESULTS AND DISCUSSION

Non-commercial farms have been experiencing financial problems. According to this study they represent 70.7 percent of all farms, share 10.0 percent of cash receipts and receive 11.3 percent of government payments (Table 1). These farms usually have off-farm income sources and are ordinarily part-time operations. Most of them qualify for loans and can repay them on the basis of the off-farm income. Thus, they don't depend on their agricultural production as much as commercial farms do (Brooks, 1985).

Table 1. Distribution of farms by sales class.

Value of Sales Class	1986	Share of cash receipts	Share of government payments
	Number (1,000)	Percent	
less than $40,000	1,569 (70.7 pct.)	10.0	11.3
$40,000 - 99,999	293 (13.1 pct.)	15.6	22.2
$100,000 499,999	338 (15.1 pct.)	41.7	54.1
$500,000 - and over	40 (1.8 pct.)	32.7	12.4
U.S.	2,241 (100 pct.)	100.0	100.0

Source: USDA, Agricultural Chartbook, June 1987.

Commercial farms presented a varied financial picture. In 1986, there were approximately 672,500 farms accounting for almost 30 percent of all farms and 81 percent of all sales of agricultural products. Table 2 shows that 41,697 farms were technically insolvent, meaning that they owed more than their assets were worth. An additional 48,422 farms had debt/asset ratios between 70 and 100 percent; 137,870 farms had debt/asset ratios between 40 and 70 percent. Most of these farms had problems meeting principal payments because the debt asset ratios are generally above 40 percent which indicates a weak financial positon.

Table 2. Number of farms with financial problems and portion of debt, January 1, 1987.

Debt/asset ratio	Number of farms	Portion of all farm debt
Over 100 pct. (technically insolv.)	41,697 (6.2 pct.)	9.3%
70-100 pct (extreme financial problems)	48,422 (7.2 pct.)	11.1%
40-70 pct. (serious financial problems)	137,870 (20.5 pct.)	25.9%
Under 40 pct. (no financial problems)	443,875 (66.0 pct.)	17.9%
All commercial farms	672,538 (100.0 pct)	64.2%
Non-commercial farms	1,569,000	35.8%

The net worth of farm operators average $640,375 on January 1, 1987, but ranged from a low of $162,000 for farms with less than $40,000 in annual sales to nearly $1.7 million for farms with sales in excess of $500,000 (Table 3).

Table 3 also suggests that for all farms , land and buildings were about 70 percent of total assets. Land and buildings decreased as a portion of total assets as farm size increased. Also, for farms with sales of less than $40,000, land, equipment, and livestock accounted for 98 percent of total assets.

Table 3. Farm balance sheet by sales class. January 1, 1987

	SALES CLASS			
Item	$500,000 and over	$100,000 to $499,000	$40,000 to $99,000	$40,000 or less
	Thousands			
Farm assets	2,335	665	320	182
Land, build.	1,526	427	217	146
Farm equip.	296	119	56	22
Livest. inv.	281	63	27	11
Crop invent.	135	46	17	2.6
Purch. inputs	14	2	0.5	0.2
Other assets	80	9	2	0.7
Farm debt	650	204	67	20
PCA	62	15	4	1.3
FmHA	67	27	13	4.3
Banks	179	55	19	0.7
FLB	153	51	13	4.6
Merchants & dealers	11	3	1	0.4
Other farmers	10	2	0.5	0.2
Other indiv.	58	23	7	3
CCC	50	17	4	0.7
Any other	56	11	3	1.2
Net worth	1,685	461	253	162
Selected ratios				
Debt/equity	0.38	0.44	0.26	0.12
Debt/asset	0.27	0.30	0.20	0.10

Source: Agricultural Statistics

Sources of debt also varied by class of farm. Farms with sales of $40,000 or less obtained a larger share of debt from FmHA, FLB and individual lenders. More than half of debt on farms with sales over $500,000 was owed to banks and FLB's (Table 3).

While the average debt/asset ratio for all farm operators was 0.22, they ranged from 0.10 for the smallest farmers to 0.30 farms with sales of $100,000 to $499,000, the highest ratio.

As Table 4 shows, the net cash margin after interest and principal increased (item 9) with the size of farm. Average non-farm income is relatively stable across farm size except for class $100,000-499,999 which increased; cash balance, (item 12), decreased for the most part in direct proportion to the size of farm.

Table 4. Income statement by sales class, January 1, 1987

Item	$500,000 and over	$100,000 to $499,999	$40,000 to $99,999	$40,000 or less
	Sales Class			
	Thousands			
1.Crop, livestock sales	1,021	395	53	37
2.Other farm inc.	166	70	12	7.5
3.Gross farm inc.	1,188	470	65	45
4.Operating exp.	872	318	46	45
5.Net cash before interests	315	150	20	2
6.Total int. exp.	77	47	7	7
7.Net cash after interests	237	10	12	2
8.Principal payment	43	27	4	2.5
9.net cash margin after interests and principal	194	72	7	-9
10.Non-farm income	21	26	19	20
11.Family living				

Source: Agricultural Statistics

According to Table 5, vegetable/fruit, and dairy farms had the largest levels of assets per farm. Vegetable/fruit farms had the largest net worth of any farm type. Cash grain producers, followed by dairy producers, had the highest debt/asset and debt/equity ratios. Nursery/greenhouse and beef/hog/sheep farms had the lowest debt/asset and debt/equity ratios.

Table 5. Balance Sheet by type of farm, January 1, 1987.

Item	Cash Grain	Tobacco Cotton	Vegs. Fruits	Nursery Green ho.	Beef Hog Sheep	Dairy	Poult.
	Thousands						
Farm asst.	340	213	451	294	304	392	223
Land, build.	218	158	355	179	228	227	175
Equipment	75	39	60	33	30	67	25
Livestock	10	7	2	1	34	72	16
Crop invest.	33	6	13	36	7	17	2
Inputs	1	0.4	0.6	1	0.6	1	0.7
Other asst.	3	2	18	43	19	59	34
Farm Debt	106	52	92	48	49	107	54
PCA	7	4	7	8	4	12	6
FmHA	15	10	9	3	7	19	10
Banks	25	13	25	15	16	28	15
FLB	24	10	22	7	10	14	13
Merch. Deal.	2	1	0.7	1	7	2	1
Other farm.	2	0.4	2	2	0.5	1	1
Other ind.	10	2	13	7	6	14	5
CCC	14	3	2	1	2	3	2
Any other	6	6	9	3	4	2	2
Net worth	234	161	359	246	255	285	169
Ratios							
Debt/asset	0.31	0.24	0.20	0.16	0.16	0.27	0.24
Debt/equity	0.45	0.32	0.25	0.19	0.19	0.37	0.31

Source: Agricultural Statistics

Table 6. Cash income statement by type of farm, January 1, 1987

Item	Cash grain	Tobacco cotton	Vegs. fruits	Nursery green ho.	Beef Hogs sheep	Dairy	Poult
	Thousands						
1.Crop,livest. sales	66	50	124	194	46	116	208
2.Other farm income	26	12	7	6	9	5	3
3.Gross farm income	92	63	131	200	55	127	211
4.Oper. exp. less int.	47	45	100	116	47	87	162
5.Net cash before int.	35	17	31	83	8	34	50
6.Tot. int.	11	6	10	5	5	12	5
7.Net cash after int.	26	11	21	78	2	22	44
8.Princ. pay	6	3	5	3	3	7	3
9.Net cash after int. and prin.	17	8	15	75	1	16	40
10.Non farm income	18	16	29	36	27	9	14
11.Family liv. expense	15	15	15	15	15	15	15
12.Cash balance	20	9	28	97	11	9	40

Source: Agricultural Statistics

Beef/hog/sheep farms had the lowest net cash margin after interest (Table 6, item 7),because these farms had the lowest gross farm income ($55,000) (item 3) of any type. Nursery/greenhouse followed by poultry farms had the highest net cash margin (item 7) and the highest cash balance (item 12).

This study divided the agricultural sector by farm sales classes and by crop types; a statistical analysis was run to examine which of the changes between 1985 and 1986 could be statistically significant. A paired t-test was conducted to establish where significant changes occurred in the distribution of farms across sales classes (Table 7) and crop types (Table 8). Using the two-tailed, 1-percent alpha level, significant changes were found for all sales classes and crop types between those two years. This formal test of statistical significance agrees with the more casual observation of absolute changes in farm numbers. Overall, the test indicated that the change in total number of farms was significant at the 1-percent level.

Table 7. Distribution of number of farms by sales class, 1985 and 1986

Sales class	Mean	Std error	T-statistic
$500,000 and over	10083	2.89	3492.85 **
$100,000 - 499,999	33500	1.67	20100.40 **
$40,000 - 99,999	57882	5.36	10789.96 **
less than $40,000	67511	8.82	7655.07 **

**** Represents significance at the 1 percent level, for two tailed test.**

Table 8. Distribution of number of farms by type, 1985 and 1986

Farm type	Mean	Std Error	T-statistic
Cash grain	80092	34.80	2301 **
Field crops	38006	16.51	2302 **
Vegs & fruits	11136	4.67	2386 **
Nursery	8538	5.36	1591 **
Beef, hog & sheep	181983	38.98	4668 **
Dairy	14692	22.19	662 **
Poultry	11805	23.97	492 **

**** Represents significance at the 1 percent level, for two tailed test.**

The inventory turnover of farm products for 1985 and 1986 of 3.99 and 3.29 (Table 9), fell below the industry norm of 6.4. The return on equity in 1985 was 3 percent and 2 percent in 1986(Table 9). These were below the industry standard of 5.0 for return on equity. Likewise, proprietors' equity declined in 1986 to 534 billion (Table 10), a decrease of 8 percent with respect to 1985. However, net farm income increased from 30.5 to 33 billion dollars or about a 10 percent increase (Table 11). This incongruity occurred because from 1985-86 although farm receipts declined by approximately 6.4 percent, total farm expenses declined 8 percent and direct government payments went up by nearly 43 percent. This demonstrates the importance of government subsidies to enhance the farm net income for this period in time. Also, because some non-real estate debt is held against durable assets, which were stabilized in 1986, U.S. net farm income is understated.

Table 9. Financial Ratios of the farming sector, 1985-1986.

Item	1985	1986	Industry
		Percentage	
Current ratio	.50	.50	2.0
Inventory turnover	3.99	3.29	6.4
Return on sales	2.54	2.43	4.4
Return on assets	2.00	2.00	4.7
Debt to equity	26.00	23.00	30.90
Return on equity	3.00	2.00	5.00

Source of industry ratios: Dun & Bradstreet Inc., 1986

Table 10. Balance Sheet of the U.S. Farming Sector. Figures are in billions.

	Calendar year			
	1983	1984	1985	1986
Assets				
Real estate	736.1	639.6	559.6	515
Non-real estate	220.4	216.5	211.9	196
Livestock & poultry	49.7	49.6	45.9	44
Machinery & motor vehicles	100.9	95.0	92.2	88
Crop stored	33.2	33.7	37.1	29
Financial assets	36.5	38.1	36.7	35
Total farm assets	956.5	856.1	771.4	711
Liabilities				
Real estate	103.5	102.9	97.3	90
Non-real estate	98.7	95.8	94.8	87
CCC loans	10.8	8.6	16.9	19
Other non-real estate	87.9	87.1	77.9	68
Tot. farm liability	202.4	198.7	192.7	177
Total farm equity	754.0	657.3	579.3	534
		Percent		
Selected ratios				
Debt to assets	21.2	23.2	24.9	24.9
Debt to equity	26.8	30.2	33.2	33.1

Source: Agriculture Outlook, June 1987

Table 11. Farm Income Statistics. Figures are in billions.

Item	Calendar years			
	1983	1984	1985	1986
1. Farm receipts	140.9	146.4	148.5	139
Crops	67.0	69.2	72.7	63
Livestock	69.5	72.9	69.4	71
Farm related	4.4	4.3	6.4	5
2. Direct Gov. Payments	9.3	8.4	7.7	12
Cash payments	4.1	4.0	7.6	8
Value of PIK Commod.	5.2	4.5	0.1	4
3. Total gross farm inc.	152.4	174.4	166.6	158
4. Gross cash income	150.2	154.9	156.2	151
5. Nonmoney income	13.2	13.3	11.5	10
6. Value of inv. change	-10.9	6.3	-1.1	-3
7. Cash expense	113.0	115.6	112.1	102
8. Total expenses	139.5	141.7	136.1	125
9. Net cash income	37.1	30.3	44.0	49
10. Net farm income	13.0	32.7	30.5	33
11. Off-farm income	37.0	37.9	40.8	43
12. Loan changes				
Real estate	2.5	-0.8	-5.6	-8
13. Non real estate	1.0	-0.8	-9.2	-10
14. Rental income	5.7	7.8	8.0	7
15. Capital expenditures	13.0	12.5	10.1	8
16. Net cash flow	33.3	33.0	27.1	30

Source: Agricultural Outlook. June 1987

A comparison of the financial ratios of the farm sector with those of the industry (Table 12) indicates that there was a significant difference, at the 1-percent level, in the current and inventory turnover ratios. Also, there was a significant difference on return on equity ratio at the 5 percent level.

The degree of operating leverage is the increase or decrease in earnings from the use of borrowed funds. It exists as long as it is greater than 1. Even though the farming sector in 1985-1986 had operating leverage of 1.42 (Table 13), the effect of changes in sales on earnings was nearly balanced. The t-test analysis of the leverage ratios (Table 14), indicates that there was no significant difference between those leverage ratios.

Table 12. Financial ratios of the farming sector, 1985-1986, attest.

Item	Mean	Std error	T-statistic
Current ratio	1.8	2.75	2345 **
Invent. turnover	2.2	1.56	1345 **
Return on sales	1.2	2.56	2356
Return on asset	2.0	1.34	1467
Debt to equity	24.0	3.67	2345
Return on equity	2.5	2.45	1987 *

**** Represents Significance at the 1 percent level, for two tailed test.**
*** Represents significance at the 3 percent level, for two tailed test.**

Table 13. Leverage ratios of the farming sector, 1985-1986

Item	1985	1986
Degree of operating leverage	1.42	1.42
Degree of financial leverage	1.48	1.50
Degree of total leverage	2.10	2.13

Table 14. Leverage ratios of the farming sector, a t-test.

Item	Mean	Std Error	T-statistic
Degree of operator leverage	30054	1.78	3592
Degree of financial leverage	76893	3.25	5784
Degree of total leverage	13478	1.47	4873

SUMMARY

During 1986 U.S. farmers were affected by several adverse factors: lower product prices, farm exports and land values, among others. Despite those negative conditions most of the farms were financially sound. However, approximately 228,000 farmers, or 10 percent of the total, experienced financial stress. This financial stress is caused by a high debt load (a debt/asset ratio of 40 percent or more) and insufficient cash to pay their bills.

The degree of financial stress, which is based on two measures (the farm's debt/asset ratio and its cash flow), varied with size and the type of the farm. The debt/asset ratio was 0.10 for the smallest farmers to .30 for farms with annual sales of $100,000 to $499,000. It went from 0.16 for nursery/greenhouse, and beef/hog/sheep farms to 0.31 for cash grain farms.

Farmers' cash flow improved in 1986 by 10 percent with respect to 1985, due to an increase in direct government payments and in Commodity Credit Corporation loans. Net farm income also increased in 1986, by 10 percent over the 1985 value, while net cash income rose from 44 to 49 billion during the same period.

Analysis of the farm balance sheet of 1986 shows that assets and debts were lower causing a reduction in owner equity. The drop in equity by 8 percent indicates a decline in the wealth position of farmers.

Also, the return on investment of the farming sector in 1985-1986 was below the industry standard and most of the financial ratios calculated for that period were short of the industry norm.

Although there was an increase in the amount of sales, crop inventories also increased. This was the result of a greater production in 1986, compared to 1985. As a consequence, the operating leverage did not contribute to net farm income.

LITERATURE CITED

Brooks, Nora L., 1985. "Minifarms. Farm Business or Rural Residence?". USDA, Economic Research Service. Bulletin Number 480.

Devino, Garay T. 1981. Agribusiness Finance, Danville, Illinois: The Interstate Printers & Publishers Inc. pp. 4-6.

Edwards, Clark, Mathew Smith, and Neal Perterson. 1985. "The Changing Distribution of Farms by Sales: A Market Analysis." Agricultural Economic Research. Vol. 37, No. 4, Fall 1985.

Johnson, Jim. 1986. "Financial characteristics of U.S. Farms." USDA. Agricultural Information Bulletin. No. 500.

Johnson, Thomas A., and Donn Reimund. 1987. "Large Scale Farms in Perspective." USDA. Agricultural Information Bulletin. No. 505.

Lee, Warren F., Michael D. Boehlje, Aaron G. Nelson, and William G. Murray. 1984. Agricultural Finance, Ames: The Iowa State University Press. pp. 83-87

Lee, Warren F., Nichael D. Boehlje, Aaron G. Nelson and William G. Murray. 1988. Agricultural Finance, Ames: The Iowa University Press. pp 164

Reimund, Donn A., and Somwaru Agapi. 1985. "Farm Income by Type of Farm, 1984 and 1985." USDA, Economic Research Service. Report Number 531.

Tomek, William G., and Kenneth L. Robinson. 1982. Agricultural Product Prices, Cornell: Cornell University Press. pp. 124-134.

U.S. Department of Agriculture . 1985 and 1986. Agricultural Statistics.

U.S. Department of Agriculture. 1986 and 1987. Economic Research Service. Agricultural Outlook.

SIZE, DISTRIBUTION AND ORIENTATION PATTERN OF PLAYA LAKES IN NORTHWESTERN CASTRO COUNTY, TEXAS

Richard E Zartman and Ernest B. Fish[1]

ABSTRACT

Playa basins and their associated ephemeral lakes are the most significant expression of surface hydrology on the Southern High Plains of Texas. A better understanding of the spatial characteristics of these lakes is critical for land use management planning. In Northwest Castro County, Texas playa lakes display a bidirectional linear orientation. Playa lake size was not a function of the east-west and north-south orientation. The bidirectional orientation pattern indicates a potential hazard for large area contamination from waste storage or disposal activities in the playa lake complex.

Key Words: Playa lakes, spatial characteristics

INTRODUCTION

Playa basins of the Southern High Plains are the most significant topographic expression on this otherwise featureless eolian plateau of Texas. These "pancake" shaped basins are typically 125 to 2000 acres in size and exhibit a maximum relief of 20 to 30 ft. Each drainage basin supports an ephemeral lake (playa lake) which is typically shallow and may vary in surface area from a fraction of an acre to more than 200 acres. The playa lakes are underlain by heavy textured soils. Within the Southern High Plains, the frequency of large playa lakes increases from south to north (Grubb and Parks, 1968) and the average size of the playa lakes increases from southwest to northeast (Allen, et al., 1972). This combination accounts for a larger per unit surface area in the northeast portion of the Southern High Plains. Estimates of the number of playa lakes on the Texas High Plains vary from 17,000 (Lehman, 1972) to 19,000 (Schwiesow, 1965) with totals ranging from 30,000 (Wood and Osterkamp, 1984) to 37,000 (Reddell, 1965) on the entire Southern High Plains region.

The origin of playa lakes has not been adequately explained. Reeves (1966) reviewed five theories on the origin of these lake basins and concluded that most were probably eolian in origin. Supporting this theory is the work of Price (1972), who characterized the playa lakes of the Llano Estacado in eolian developmental terms as mature, oval, and oriented. The term "mature" refers to playa lakes that are neither expanding nor being filled by sedimentation. "Oval" refers to the shape of playa lakes and their average axis ratio of 1.0:1.3 (Price, 1972). The longer axis is normally oriented from NW to SE. Recently, Osterkamp and Wood (1987) proposed that playa lakes in the Southern High plains originate wherever water collects in a "surficial depression." They present evidence for this mode of occurrence from hydrologic, geomorphic, and geological perspectives. In a subsequent publication, Wood and Osterkamp (1987) used mass balance arguments to document their theory of playa lake origin. Finley and Gustavson (1981) described lineament orientation of playa lakes and report a preferred orientation of 300 to 320 degrees (360 degrees = N). They attribute this geomorphic orientation to control exerted by geologic structure. The geologic joints provide paths of weakness which may encourage increased surface drainage. This increased surface drainage model agrees with the theory and models of Osterkamp and Wood (1987) and Wood and Osterkamp (1987). Osterkamp and Wood (1987) present diagrams with playa lake orientations of 75 degrees west [comparable to 285 degrees of Finley and Gustavson], 45 degrees, and 40 degrees west [comparable to 315 and 320 degrees of Finley and Gustavson].

RATIONALE

Playa lakes represent the hydrologic storage basin for most surface runoff in the region. Aronovici, et al., (1971) report that playa lakes impound 2 to 3 million acre-feet of water annually. Until recently, it was believed that playa lakes held surface water until it evaporated. Reddell (1965) reported that 90% of the accumulated water was lost to evaporation. Based on this assumption, playa lakes have been used as impoundment reservoirs for feedlot runoff (Lehman, 1972). However, the current thinking is that playa lakes and the area immediately surrounding them are major recharge zones for the Ogallala aquifer (Zartman, 1987; Wood and Osterkamp, 1984). This interpretation of the fate of playa lake water is significant because it not only may provide a way to add to the life of the Ogallala aquifer; but, may also contribute to its contamination. Estimates of the volume of water accumulated annualy in playa lakes in the Texas and New Mexico portion of Southern High Plains range from 1.8 to 5.7 million-acre feet (Clyma and Lotspeich,1966). This is equivalent to 4 to 11.5 inches of recharge over the irrigated portion of the Texas High Plains. Recharge of the Ogallala through the playa lake model may necessitate alteration of some current utilization methods (feedlot waste impoundment) and influence other development decisions (DOE, 1986). Since playas contribute to the recharge of the aquifer, what enters the playa influences the groundwater.

This project was initiated to evaluate the spatial relationships of playa lakes in northwestern Castro County, Texas. The specific interest in this study was generated by the possible development of a high-level nuclear waste repository site. Potential concerns were for the quantity, quality and direction of excavated salt movement during site development and radioactive nuclide movement following site activation. Average size of playa lake, distribution, and orientation of closest playa were evaluated. In order to obtain a better understanding of the spatial relationships and the potential utilization of playa lakes, this study proposes to determine the possibility for contamination of the aquifer from feedlot wastes or pesticides. A single axis, linear orientation would indicate the predominate surface drainage direction. Secondary orientations may reflect the impacts of subsurface geological connections.

MATERIALS AND METHODS

The study area encompasses 279 square miles primarily covering northwestern Castro County, Texas. For purposes of this study, playa lakes were defined in terms of the fine textured soils (Randall clay) which typically occupy the lowest elevational positon in a playa basin and upon which these ephemeral water bodies develop following a precipitation event. The criteria for designation was the location and area of soil mapped as a Randall clay (fine, montmorillonitic, thermic Udic Pellustert) in the Soil Conservation Service county Soil Survey Reports for Castro, Deaf Smith and Parmer counties (Burns, 1974; Geiger, et al., 1968; Burns, 1978).

Playa lake location was expressed in Universal Transverse Mercator (UTM) grid coordinates to the nearest 164 feet for the "center of mass" of each Randall clay mapping unit shown on 1:20,000 scale photomaps. Designated playa lakes were classified into one of five

[1]Associate Professor, Department of Agronomy, Horticulture and Entomology; and Professor, Department of Park Administration and Landscape Architecture, College of Agricultural Sciences, Texas Tech University. Lubbock, TX 79409. College of Agricultural Sciences Publication T-4-268

size classes based on the area of the Randall clay mapping unit. The classes were: #1 = less than 8 acres; #2 = 8 to 31 acres; #3 = 31 to 70 acres; #4 = 70 to 124 acres; #5 = greater than 124 acres. Location distribution by size class was examined through analysis of average size class within subsections of the study area. The area was divided into three north-south zones and three east-west zones. Each subsection encompassed approximately 31 square miles.

The distribution and orientation relationships of the designated playa lakes were evaluated using Fisher and geostatistical models. Geostatistical models used were similar to those presented by Vieira, et al. (1983:51-54). Spatial orientations of the playa lakes were modeled using linear, power, logarithmic and exponential equations. The spatial orientations were analyzed in five degree increments with tolerances of one degree from 270 degrees (west) through zero-degrees (north) to 90 degrees (east).

RESULTS AND DISCUSSIONS

Table 1 indicates the overall size class frequency distribution of the 188 playa lakes encountered on the study area. The spatial orientations of the playa lakes were best fit by non-linear models rather than linear ones, $r^2 = 0.9$ vs 0.8. However, most previous research has considered determination of the lineament (topographic features) rather than "best fit" of the data. The angle of orientation and linear equations modeling the playa lakes spatial orientation are presented in Table 2. Those angles with high r^2 values (r^2>O.8) are 270, 275, 350, 0, and 25. These indicate that the playa lakes are oriented; predominatly on an east-west (270, 275) and/or north-south direction (350, 0). The other direction having a high r^2 was 25 degrees, which would be a north-northeast to south-southwest orientation. These data are in apparent disagreement with the published information of Finley and Gustavson (1981). However, a closer examination of Plate 1 of their article, indicated that within the particular area of our study there are lineament orientations similar to those found using our geostatistical techniques and the area differs from the remainder of the Texas Panhandle as a whole.

Table 1. Playa lake size class distribution

Size Class	Number of Lakes	Percent
#1 = less than 8 acres	26	13.8
#2 = 8 to 31 acres	95	50.5
#3 = 31 to 70 acres	61	32.5
#4 = 70 to 124 acres	5	2.7
#5 = greater than 124 acres	1	0.5
Total	188	100.0

Linear equations such as those presented in Table 2 do not lend themselves to determination of lineament length. However, the length to the maximum number of pairs for each equation would be a realistic indication of the maximum length to which the equation could be extrapolated. For all of the preferred angles of orientation listed above, the lineament length was 15,000 to 20,000 yards. This indicates that the equation would be useful for predicting frequency of playa lakes for approximately an 8 to 11 mile distance in that direction. The values are similar to those presented by Finely and Gustavson (1981).

Table 2. Playa lake angle of orientation, linear model for orientation with r^2, maximum number of pairs, and lag distance for maximum number of playa pairs.

Angle, deg	Linear Equation	r^2	Maximum # of pairs	Lag Distance x 103 yd
270	$0.339+0.940X10^{-5}h$	0.89	59	15
275	$0.196+0.222X10^{-4}h$	0.91	69	20
280	$0.450-0.600X10^{-7}h$	0.14	60	20
285	$0.556+0.457X10^{-5}h$	0.16	65	20
290	$0.945+0.455X10^{-4}h$	0.66	60	20
295	$0.251+0.175X10^{-4}h$	0.65	57	22.5
300	$0.352+0.164X10^{-4}h$	0.61	55	20
305	$0.365+0.120X10^{-4}h$	0.60	47	20
310	$0.850-0.158X10^{-4}h$	0.16	53	20
315	$0.378+0.133X10^{-4}h$	0.49	69	15
320	$0.285+0.171X10^{-4}h$	0.67	41	20
325	$0.752-0.846X10^{-6}h$	0.10	54	15
330	$0.333+0.359X10^{-4}h$	0.57	45	20
335	$-0.900+0.681X10^{-4}h$	0.65	46	15
340	$0.203+0.374X10^{-4}h$	0.45	43	15
345	$0.468+0.165X10^{-4}h$	0.19	45	15
350	$0.287+0.264X10^{-4}h$	0.97	51	15
355	$0.449+0.134X10^{-4}h$	0.13	41	20
360/0	$0.145+0.332X10^{-4}h$	0.81	51	20
5	$0.822-0.151X10^{-4}h$	0.37	43	15
10	$0.195+0.269X10^{-4}h$	0.66	53	15
15	$0.518+0.205X10^{-5}h$	0.04	56	15
20	$0.596-0.847X10^{-5}h$	0.15	51	15
25	$0.308+0.276X10^{-4}h$	0.81	41	12
30	$0.263+0.158X10^{-4}h$	0.47	45	15
35	$0.940-0.299X10^{-4}h$	0.78	47	15
40	$0.442+0.172X10^{-5}h$	0.01	59	20
45	$0.519-0.113X10^{-5}h$	0.00	51	20
50	$0.467-0.519X10^{-5}h$	0.13	45	20
55	$0.602-0.651X10^{-5}h$	0.20	69	20
60	$0.411+0.479X10^{-5}h$	0.53	58	20
65	$0.420+0.301X10^{-5}h$	0.06	43	15
70	$0.462+0.119X10^{-4}h$	0.19	61	20
75	$0.627-0.237X10^{-5}h$	0.03	67	15
80	$0.267+0.118X10^{-4}h$	0.29	54	25
85	$0.462+0.214X10^{-5}h$	0.02	67	25
90	$0.339+0.940X10^{-5}h$	0.89	59	15

Playa lake size as a function of the east-west and north- south orientation is presented in Table 3. The playa lake sizes were not consistently significantly different with respect to direction. However, the only class 5 playa lake (>124A) occurred in the most northeastern section of the area. This would be as expected from the data of Grubb and Parks (1968) and Allen, et al. (1972).

Table 3. Playa lake size class distribution as a function of location.

	Mean size class with standard error		
	West	Central	East
North	2.00+/-0.11 (n=19) Ba*	2.04+/-0.12 (n=25) Ba	2.20+/-0.19 (n=20) Aa
Central	2.21+/-0.14 (n=29) Ba	2.27+/-0.16 (n=22) ABa	2.25+/-0.19 (n=20) Aa
South	2.71+/-0.19 (n=14) Aa	2.50+/-0.17 (n=22) Aa	2.29+/-0.17 (n=17) Aa

*Means with the same capital letter within a column are not significantly different at the 5% level using Duncan's Multiple Range Test. Means with the same lower case letter within a row are not significantly different at the 5% level using Duncan's Multiple Range Test.

CONCLUSION

The playa lakes of northwest Castro County, Texas are generally atypically oriented compared to other areas of the Southern High Plains. They have an average size of approximately 27 acres. The primary orientations of these playa lakes are east-west (275 degrees) and north-south (350 degrees). This criss-crossing orientation (275 and 350 degrees) pattern signifies a potential for contamination of the whole area if surface contaminants were to enter the playa lake complex. Land use planners and managers should be encouraged to exercise extreme caution concerning future decisions involving waste storage or disposal activities in this part of the Southern High Plains.

LITERATURE CITED

Allen, B.L., B. L. Harris, K.R. Davis, and G.B. Miller. 1972. The mineralogy and chemistry of High Plains playa lake soils and sediments. Texas Tech Univ. Water Resources Center WRC-72-4

Aronovici, V.S., A.D. Schneider, and O.R. Jones. 1971. Basin recharging the Ogallala aquifer through Pleistocene sediments. Proc. Ogallala Aquifer Symp. Lubbock, Texas.

Burns, H.E. 1974. Soil Survey of Castro County, Texas. U.S. Govt. Printing Off., Washington D.C.

Burns, H.E. 1978. Soil survey of Parmer County, Texas. U.S. Govt. Printing Off., Washington D.C.

Clyma, W. and F.B. Lotspeich. 1966. Water Resources in High Plains of Texas and New Mexico, Agricultural Research Service, Bulletins 41-114, Department of Agriculture.

Department of Energy. 1986. Enviromental Assessment of Deaf Smith County Site, Texas. Vol. 1. cpt 3.

Finley, R.J. and T.C. Gustavson. 1981. Lineament analysis based on Landsat imagery, Texas panhandle. Tx. Bur. of Econ. Geol. Circular 81-5, 37p.

Geiger, L.C., H.E. Burns, and B.R. Chance. 1968. Soil Survey of Deaf Smith County, Texas. U.S. Govt. Printing Off., Washington, D.C.

Grubb, H.W. and D.L. Parks. 1968. Multipurpose benefits and costs of modifying playa lakes of the Texas High Plains: Special Rept. #6. ICASALS Texas Tech Univ.

Lehman, O.R. 1972. Playa water quality for groundwater recharge and use of playas for impoundment of feed yard runoff. In Reeves, C. C. (Ed.) Playa Lake Symposium. ICASALS Publication #4, Texas Tech Univ. 25-30.

Osterkamp, W.R. and W.W. Wood. 1987. Playa-lake basins on the Southern High Plains of Texas and New Mexico: Part 1. Hydrologic, geomorphic and geologic evidence for their development. Geol. Soc. Am. Bul. 99:215-223

Price, W.A. 1972. Oriented lakes: Orgin, classification, and developmental histories. In Reeves, C.C. (Ed.) Playa Lake Symposium. ICASALS Publication #4, Texas Tech Univ. 305-334.

Reddell, D.L. 1965. Water Resources of playa lakes, Cross Section 12(3):1.

Reeves, C.C., Jr. 1966. Pluvial lake basins of West Texas. Geol. 74(3): 269-291.

Schwiesow, W.F. 1965. Playa lake use and modification in the High Plains. In Texas Water Dev. Bd, Rept. 10.

Vieira, S.R., J.L. Hatfield, D.R. Neilsen, and J.W. Biggar. 1983. Geostatistical theory and application to variability of some agronomical properties. Hilgardia. 51(3):1-75.

Wood, W. W. and W.R. Osterkamp. 1987. Playa lake basins on the Southern High plains of Texas and New Mexico: Part II. A hydrologic model and mass-balance arguments for their development. Geol. Soc. Am. Bul. 99:224-230.

Wood, W. W., and W.R. Osterkamp. 1984. Recharge to the Ogallala Aquifer from playa lake basins on the Llano Estacado (an outrageous proposal?): Proceedings of the Ogallala Aquifer. Symposium II, George Whetstone, ed., Texas Tech Univ. Water Resources Center. p. 337-349.

Zartman, R.E. 1987. Playa lakes recharge aquifers. Crops Soils 39(5):20.

AN INVESTIGATION OF VITIS ARIZONICA (THE CANYON GRAPE) AS A POTENTIAL ROOTSTOCK IN WEST TEXAS[2]

Patrick J. Johnson and Richard A. Hilsenbeck[1]

ABSTRACT

The Canyon Grape, Vitis arizonica, a species native to far west Texas, is evaluated for its use as a rootstock using six recently developed criteria. The study seeks to determine the suitability of V. arizonica as a rootstock for the purpose of grafting scions of Vitis vinifera (various varieties), the European wine grape, in an effort to enhance wine grape production in Texas. Propagation methods of V.arizonica from dormant, woody cuttings are assessed, as is the efficacy of grafting trials using both rooted and unrooted stock material. Field observations concerning the ecological requirements of V. arizonica are presented including the first report of a leaf-galling form of the grape phylloxera parasiting this species in its native habitat. The necessity of evaluating the performance of V. arizonica as a suitable stock under actual vineyard conditions is discussed, including trails being conducted at the Sul Ross State University experimental vineyard.

Key words: Vitis arizonica, V. vinifera, rootstock, scion, propagation, disease-resistance.

INTRODUCTION

Vitis arizonica Engelm. (the Canyon Grape), one of the 14 species of grapes native to Texas, occurs in the montane regions of far west Texas. It is the only species of grape documented as occurring in this area of Texas known as the Trans-Pecos (Powell, 1988). The species has been little studied with virtually no research concerning its use as a rootstock nor is it currently employed as a rootstock in viticulture. Possibly, its remote range in the southwestern United States and adjacent Mexico made it difficult to collect in the early years of rootstock research. Its western distribution may have seemed beyond the range of the pathogenic phylloxera and hence not worthy of consideration as a rootstock.

The purpose of this study is to investigate V. arizonica as a potential rootstock (stock), particularly for use in the Trans- Pecos Region of Texas in an effort to enhance production of V. vinifera wine grapes. The Trans-Pecos Region, which encompasses the high altitude Davis Mountain area, is new to viticulture. The Davis Mountains area has been cited as the most outstanding region of Texas to grow the high acid cultivars of V. vinifera (Perry & Bowen, 1974; McEachern, 1986). No stocks are employed in this region now. Should the need for a suitable rootstock arise, V. arizonica should be well adapted to serve as a stock in the Trans-Pecos.

Soil conditions vary greatly in the range of V. arizonica. Populations found in the Davis Mountains are rooted in non- calcareous acidic podzols (USDA, 1977). Some populations such as those in Black Gap Wildlife Management Area (BGWMA) are found in alkaline soils along the Rio Grande River. Although not collected for this study, populations are known from the highly alkaline soils of the Glass and Guadalupe Mountains. The range of the canyon grape is so great that it can probably be found in most soil types, with perhaps, the exception of saline soils.

Climatic conditions in the range of V. arizonica also vary considerably. Along the Rio Grande, the climate is very hot with mild winters and little freezing weather. In the upper reaches of the Davis Mountains, summers are mild but winters have prolonged periods of subfreezing temperatures (Perry and Bowen, 1974). One of the most adverse factors to viticulture in Texas, and in the Trans-Pecos particularly, is freezing weather in late spring that damages fruit set. A stock that would inhibit bud break by even a few days would be of great economic value. Bud break of V. arizonica is relatively late and so might serve well in this respect. The populations of V. arizonica occurring in the Trans-Pecos Region are genetically adapted to survive in the environment in which they naturally occur. It is this fact that makes this species worthy of consideration for use as stock in this region. Morton and Jackson (1988) have stressed the importance of considering the ecological conditions of rootstocks or stock progenitors when considering their potential as stocks.

Husmann (1930) stated that a good rootstock is resistant to soil borne diseases and injury, adapted to the soil type, and is compatible with the scion resulting in abundant fruit yields. Nesbitt (1974) amplified Husmann's criteria listing six general characteristics that make an ideal rootstock: (1) adapted to soil and climatic conditions of the geographic area of intended use, (2) easily propagated and grafted to the scion, (3) compatible with the scion cultivar forming a strong graft union, (4) has the correct vigor that induces good fruit set and maturation, (5) has practical immunity or resistance to pathological or entomological organisms found in the area of intended use, and (6) virus free. Because V. arizonica naturally occurs in the Davis Mountains Region, it obviously meets criterion one above. This study seeks to provide data concerning Nesbitt's criteria two and three, with additional observations and comments on the remaining criteria.

MATERIALS AND METHODS

Specimens of V. arizonica were collected in the Davis Mountains of Jeff Davis County, in the Del Norte Mountains in Brewster County, and along the Rio Grande River in the BGWMA also in Brewster County. Cuttings of dormant woody stems were taken in February of 1987 and 1988 and propagated in the greenhouse at Sul Ross State University. The basal ends of all cuttings were dipped in Hormodin 3 (0.8% indole-butyric acid [IBA] equivalent to 8000 ppm) to stimulate root initiation. Cuttings were placed vertically in containers of perlite/vermiculite to root. A misting chamber was employed for some cuttings. After ca. 90 days, rootings were transplanted into sterile potting media. Eight months after the initial collection, dead rootings were removed. Numbers of cuttings, rootings, and survivors were recorded for each population.

Three grafting trials were conducted using V. arizonica as the stock and various cultivars of V. vinifera as the scion. . Twenty grafts of V. vinifera cv. Cabernet Sauvignon were made to unrooted cuttings of V. arizonica. Grafted cuttings were placed in a misting chamber in order to promote both rooting and graft union formation simultaneously. In a second trial, 20 grafts of several V. vinifera cultivars were made to specimens of V. arizonica rooted in pots. In a third grafting trial 15 grafts of V. vinifera (various cultivars) were made on V. arizonica stocks also rooted in pots. In all three trials, grafts were kept in temperature controlled greenhouses. After ca. two months grafts were analysed for successful graft unions. Numbers of attempted and successful grafts were noted and recorded. In addition to the experimental trials described above, a descriptive analysis of V. arizonica was performed based on the literature and extensive field observations of this grape in its natural habitat.

RESULTS

As revealed in Table 1, V. arizonica propagates well from dormant, woody cuttings. When treated with IBA in the form of Hormodin 3,

[1]Department of Biology, Sul Ross State University, Alpine, Texas 79832.

[2]The authors wish to thank Dr. A. M. Powell and D. Gantt for their advice and assistance. This work was supported by a research grant from the Texas Higher Education Coordinating Board's Advance Technology Program awarded to R. A. H. and A. M. P., and funds from the General Land Office of the State of Texas.

76% of all cuttings produced roots. Survival was also high. Cuttings collected from BGWMA rooted at an 80% success rate with all rootings surviving. The results of the grafting trials are presented in Table 2. In the first trial, conducted in March, only three out of 15 successfully rooted and formed graft unions. In the second trial, conducted in August, no successful unions formed. In the last trial, three out of 15 formed graft unions.

Table 1. Propagation of V. arizonica

Population & Treatment	No. cuttings	No. rootings	% rooted	No. survivors	% survivors
Davis H3*	57	39	68	38	66
Del Norte H3*	38	32	84	28	73
Black Gap H3M**	20	16	80	16	80
All	115	87	76	82	71

*H3 Application of Hormodin 3
**H3M Application of Hormodin 3 with misting

Table 2. Grafting trials of V. arizonica (stock) and V. vinifera (scion).

Date [2]	Scion Cultivar(s)	No. Attempted	No. Successful
March 1988	All Cabernet	20	03
August 1988	Various Cultivars	20	00
October 1988	Various Cultivars	15	03

[2]The March 1988 trial was made on unrooted stocks. The August 1988 and October 1988 trials were made on rooted potted stocks.

The first report of Daktulosphaira vitifoliae (the grape phylloxera) parasitizing V. arizonica was also documented. A leaf-galling form of the insect was found on some individuals in the Limpia Canyon area of the high Davis Mountains. No root infesting forms of the aphid were found.

DISCUSSION

Ease of propagation is an economically important trait for grape rootstocks. Because grapes are traditionally propagated vegetatively, an important consideration of rootstock selection is the capacity of a stock to be grown from cuttings or canes. Vitis arizonica can be propagated with good success. Thus, the ability of this species to root from cuttings enhances its attractiveness for use as a stock.

The ability of V. arizonica to form successful graft unions with scions of V. vinifera was not adequately documented by the study. Only six successful grafts were formed in 55 attempts. It may be noteworthy that five of the six successful unions were made to specimens of the BGWMA population of V. arizonica, indicating that this population may possess genetically controlled characteristics making it more compatible with V. vinifera scions.

Although the grafting trials produced a low rate of success, the results must be viewed with caution. The grafting was performed by a person without a great deal of experience in performing grafts. Furthermore, in the first trial some graft unions seemed to be forming well, but without simultaneous root formation by the stock. It has also been noted that the presence of viruses or mycoplasmas in the stock or scion can inhibit or even prevent callus formation and thus stock-scion union (Hartman and Kester, 1983). Stocks collected from the field were not treated to cleanse them of microbes and probably did contain viruses. At this time, it can only be stated that scions of V. vinifera cultivars can successfully be grafted to specimens of V. arizonica. Further trials should be conducted. The propagation and grafting trials only address Nesbitt's second and third criteria listed above. The remainder of this article will address the remaining criteria.

Even though most specimens of this grape are not large and vigorous, they attain considerable size in areas particularly well watered. Individuals with trunk diameters of ca. 4 inches, and greater, exist in the Davis Mountains (unpubl. data). The extent of the root systems of such large plants, although not recorded, must be extensive. The large size of some specimens indicate that, within a well watered vineyard, the Canyon Grape should support ample scion growth and fruit production, thus meeting Nesbitt's fourth criterion. Only field trials can indicate whether or not stock support might be overly ample.

Regarding Nesbitt's fifth criterion, that the stock should have practical immunity or resistance to pathogenic organisms found in the area of intended use, we note that although the resistance of V. arizonica to various soil pathogens is not well documented, the tolerance of this species to the grape phylloxera, Daktulosphaira vitifoliae, has been reported several times. Munson (1909) found that the species was moderately resistant to the grape phylloxera while testing specimens from Arizona. Hussman (1910), in his seminal rootstock research in California, stated that the species was not resistant to the grape phylloxera and so did not conduct field tests with it. Of the specimens treated by Boubals (1966), all were susceptible to the phylloxera biotype found in Europe. More recent work (Granett et al., 1985; Williams and Shambaugh, 1988) indicates that the insect is of several biotypes and forms varying symbioses with different species of grape. Additional field and greenhouse testing is needed to answer questions of tolerance of V. arizonica to the grape phylloxera. Nevertheless, our report of a leaf-galling form of this aphid on V. arizonica in the Davis Mountains calls for reanalysis of the published data. Renewed testing should consider populational differences of both the phylloxera and its host.

Mortensen (1938) found that cotton root rot, Phymatotrichum omnivorum, was one of the most significant limiting factors in growing Vitis species in Texas. Taubenhaus and Ezekiel (1936) reported that V. arizonica was moderately susceptible to the fungus. Significantly, however, Mortensen (1952) noted that one of three V. arizonica plants remained alive after 15 years in soil bearing cotton root rot. Therefore, the full relationship of V. arizonica to this fungus has not been well documented.

Nesbitt's final criterion holds that a good stock is free of viruses. The risk of transmitting viral infection from the stock to scion is an important consideration. There are, however, established procedures for "cleaning" plant material of viruses. They involve sterile micropropagation and/or thermal therapy (Hartmann and Kester, 1983; Barlass, 1987; Monette, 1986). Virus indexing is not within the scope of this study. Vitis arizonica, however, can undoubtedly be purged of viruses as has been demonstrated with other plant material.

CONCLUSIONS

Preliminary analysis of V. arizonica indicates that it may be suitable for use as a stock in the Davis and Del Norte Mountain region of Trans-Pecos Texas. Following Nesbitt's criteria V. arizonica merits further consideration and research. Experimental field trails under actual vineyard conditions should be conducted as soon as is practicable using this species of native grape. Sul Ross State University is currently completing the construction and planting of a 3.2 acre experimental vineyard on campus in which these tests will be carried out in West Texas under a working vineyard setting.

Being a native species, V. arizonica is adapted to the area of proposed use. It might serve well as a stock in alleviating the most critical problem of grape growing in the Trans-Pecos: late freeze damage to buds and inflorescences. Field trials can reveal, within a relatively short period of time, if V. arizonica stocks will delay bud break. It is suggested that this factor may be the most important in proposing this species for additional study.

LITERATURE CITED

Barlass, M. 1987. Elimination of stem pitting and corky bark diseases from grapevine by fragmented shoot apex culture. Ann. Appl. Biol. 110:653-656.

Boubals, D. 1966. Etude de la distribution et des causes de la resistance au phylloxera radicoles chez les Vitacees. Ann. Amelior Plantes 16:145-184.

Hartmann, H. T. and D. E. Kester. 1983. Plant propagation: principles and practices. 4th ed. Prentice-Hall, Inc., Englewood Cliffs, N.J.

Husmann, G. C. 1910. Grape investigations in the vinifera regions of the United States with reference to resistant stocks, direct producers and viniferas. U.S. Dept. Ag. Bureau of Plant Industry Technical Bull. 172.

Husmann, G. C. 1930. Testing phylloxera-resistant grapestocks in the vinifera regions of the United States. U.S. Dept. of Agriculture Tech. Bull. 146.

McEachern, G. R., ed. 1986. The 1987 Texas Vineyard Management Handbook. Texas Ag. Extension Service. The Texas A&M Univeristy System, College Station, Texas.

Monette, P. L. 1986. Elimination in vitro of two grapevine nepoviruses by alternating temperature regime. J. Phytopathology 116:88-91.

Mortensen, E. 1938. Nursery tests with grape rootstocks. Proc. Am. Soc. Hort. Science 36:153-157.

Mortensen, E. 1952. Grape rootstocks for southwest Texas. Texas Ag. Exp. Sta. Progress Report 1475.

Morton, L. T. and L. E. Jackson. 1988. Myth of the universal rootstock: the fads and facts of rootstock selection. Proceedings of the Second International Cool Climate Viticulture and Oenology Symposium. Auckland, New Zealand.

Munson, T. V. 1909. Foundations of American grape culture. T. V. Munson and Son. Denison, TX.

Nesbitt, W. B. 1974. Breeding resistant grape rootstocks. Hortscience 9:359-361.

Perry, R. L. and H. H. Bowen. 1974. A feasibility study for grape production in Texas. Texas Ag. Exp. Sta. Technical Report 74-43.

Powell, A. M. 1988. Trees and shrubs of Trans-Pecos Texas. Big Bend Natural History Assoc., Big Bend National Park, Texas.

Taubenhaus, J. J. and W. N. Ezekiel. 1936. A rating of plants with reference to their relative resistance or susceptibility to Phymatotrichum root rot. Texas Ag. Ext. Service Bull. No. 527.

United States Dept. Agriculture Soil Conservation Service 1977. Soil Survey of Jeff Davis County, Texas.

RESOURCE UTILIZATION AND NESTING ECOLOGY OF THE WHITE-WINGED DOVE (ZENAIDA ASIATICA) IN CENTRAL TRANS-PECOS, TEXAS[2]

Michael F. Small, Richard A. Hilsenbeck, and James F. Scudday[1]

ABSTRACT

The White-winged Dove (Zenaida asiatica), a native of the Chihuahuan Desert Region, is a recent immigrant to the central Trans-Pecos of Texas. Because its range is documented as recently expanding northward into and beyond this area, data pertaining to its nesting ecology and habitat preferences are of considerable importance in assessing its reproductive biology and management. Fifty active or recent nests of White-winged Doves in and around Alpine, Texas, were located and studied. Tree species in which the nests were constructed were identified, as were tree height, and mean nest height; nest contents were also documented. Eighty percent of the nests were located in Cupressus arizonica Greene (Arizona Cypress) which appears to provide the most suitable nesting requirements for these economically important game birds.

Key words: White-winged Dove, nesting ecology, resource management, Arizona Cypress, habitat utilization

INTRODUCTION

The White-winged Dove, Zenaida asiatica L., is the only North American dove that is extensively marked with white on the upper wing surface (Johnsgard, 1975). It occurs throughout the southwestern United States into southern Texas, southward through Mexico and Central America, to Costa Rica and western Panama (Johnsgard, 1975). Populations of White-winged Doves of Trans- Pecos Texas, until recently, were confined to a narrow corrider paralleling the course of the Rio Grande River (Scudday et al., 1980). The presence of whitewings in this region in increasing numbers and population densities is believed, partially, to be the result of recent, massive influxes of several species of Salt Cedar (Tamarix) along the Rio Grande and its drainages (Powell, 1988; Scudday et al., 1980). At least six species of Tamarix, an old world genus, were introduced into Texas by early Anglo settlers (Cottam and Trefethen, 1968). Engel-Wilson and Ohmart (1978) and Gallucci (1978) observed a near exclusive nesting preference by these doves for species of Tamarix.

The nesting requirements of White-winged Doves have been of interest to wildlife and natural resource biologists for some 50 years. The first record of White-winged Doves within the city of Alpine was in 1966, with initial nesting confirmed in 1975 (Scudday et al., 1980). Since that time, the dove population in the Alpine area has grown significantly, due in part to the presence of suitable nesting sites, adequate water, and the availability of food. The primary nesting season of the White-winged Dove in the Alpine area begins in the late winter and continues into the summer. Two to several clutches are not unusual, and a successful brood has been recorded as late as September (Scudday, unpubl. data). Nests are usually located in large shrubs or trees and constructed almost entirely of twigs with no apparent design (Goodwin, 1983). The characteristic "bowl" shape associated with most bird nests is scarcely apparent, and eggs are sometime visible from below. White-winged Dove nests are distinguished from Mourning Dove (Zenaida macroura L.) nests in that the latter have a more circular appearance, a shallow "bowl", and a greater variety of construction materials. Clutches generally consist of two buff, cream, or white eggs with incubation lasting approximately two weeks (Goodwin, 1983). After hatching, it takes approximately two additional weeks before the young are capable of flight.

The White-winged Dove is an economically valuable natural resource in that it generates revenue through the purchase of hunting licenses and stamps, and land leases for hunting rights. Throughout the United States, the highest population densities of the bird occur in association with towns and riparian or lake habitats (Brown, 1977). In addition to their native food sources, White-winged Doves consume agricultural grains in riparian areas, while desert-nesting birds primarily feed on fruits and seeds of native perennial plants (Haughey, 1986). Habitat destruction and hunting pressures in Arizona and the Lower Rio Grande Valley of Texas have caused significant declines in White-winged Dove population numbers (Galluci, 1978). Suitable habitat for reproduction is now considered the major factor limiting the species distribution in the U.S. and resource management must include the acquisition of suitable habitat as well as resource inventory (Brown, 1977). The objectives of this study were to determine some of the habitat components affecting nesting and reproductive success of these birds in an effort to establish stable nesting populations of White-winged Doves in the central Trans-Pecos region.

METHODS

The study was conducted during the summer of 1987. Emphasis was placed on locating and identifying species of trees in which the doves nested. Hundreds of trees in and around Alpine were visually scanned from beneath. Trees with a potential nest were viewed with 8x40 binoculars to determine the presence or absence of a nest. Once a nest was located, the tree was climbed to ensure positive identification of the species of bird which constructed the nest. The nest was then assigned a number. The date the nest was sighted, the species of tree in which it was located, and the location of the tree were recorded. The exact height of the nest was determined using a 100 ft. tape measure. The location of the nest in the tree, its proximity to the trunk and distal branches, as well as the total height of the nesting- site tree (determined with a clinometer) were likewise recorded.

Nest contents were then examined. On four occasions, pairs of young birds approximately two-weeks-old or less were found occupying a nest. As part of a separate study, these young birds were carefully removed from the nest, banded with USFWS aluminum bands, and returned to the nest. After the nest contents were determined, a piece of orange flagging tape with the assigned nest number was tied to the branch as close as possible to the nest. Other miscellaneous information, such as nest condition and the presence of fledglings nearby, was also recorded.

RESULTS

Fifty White-winged Dove nests were located in 45 trees during the study. The nests examined were located in nine different species of trees (Table 1). Cupressus arizonica, an evergreen gymnosperm, was the tree choice for nesting whitewings. This species held 80% of the nests (40 total nests) in the Alpine area. One Cupressus contained three nests, while three others contained two nests each. Only one other species, Cedrus deodora, (also an evergreen gymnosperm) contained more than one nest, with two trees containing a single nest each. All other tree species contained just one nest each. Of the trees in which nests were located, 67% were gymnosperms while 33% were angiosperms. All of the gynmosperms are evergreen, while two of the three angiosperms species are deciduous with sympodial, widely spreading branching habits. These deciduous species are still

[1]Department of Biology, Sul Ross State University, Alpine, Texas 79832

The authors wish to thank F. Chavez-Ramirez for his help in collecting data for this study. This work was supported in part by a Chihuahuan Desert Studies grant from the Texas State Legislature awarded to J. F. S.

nearly devoid of leaves when nest building by the birds begins in late winter.

Table 1. Tree species (n=45) with number and percentage of nests located in each.

Species	Number of Nests	Percentage of Total
Cupressus arizonica	40	80
Cedrus deodora	3	6
Juniperus erythrocarpa	1	2
Juniperus flaccida	1	2
Pinus cembroides	1	2
Ligustrum japonicum	1	2
Morus rubra	1	2
Thuja orientalis	1	2
Ulmus chinensis	1	2

Mean tree height of the trees containing nests was 45.9 feet. The mean nest height was 21.7 feet. The mean nest height for all nests in this study, expressed as a percent of tree height, was 47.2%, indicating that the nests were predominantly located at or near the mid-point of the tree. Examination of the nests showed 40% (20) to be empty. Of the remaining 60% (30), either close examination was not possible or one or more of the following were found: feces, down feathers, adult White-winged Doves, fledglings, hatchlings, dead hatchlings, an egg, or egg fragments.

DISCUSSION

Eighty percent (80%) of the White-winged Dove nests located in the immediate vicinity of Alpine were found in Cupressus arizonica. This figure indicates that of the available nesting habitats (i.e., tree resources) in this area, that Cupressus appears to best provide the requisite nesting requirements of this bird species. These trees are relatively abundant in the area and have a monopodial growth habit containing horizontal, forking branches. This species is evergreen, provides year-round cover, and possesses protective, water-shedding properties. In light of Haughey's (1986) findings concerning the diet of desert White-winged Dove populations, it appears that these doves could also derive a portion of their diet from eating the abundant seeds produced by this species. The occurrence of nests approximately 50% of the way up the trees, on average, may be due to the relative stability of these mid-point areas during times of high wind in the late spring when eggs or young are most often found in the nests. These areas also contain the greatest cover to conceal the nests from predators and provide shade for the fledglings during the hottest times of the year. These areas of the trees may also contain branches that are most desirable in size for nest building and perching, while still being high enough to afford protection from climbing predators (i.e., domestic cats).

The results of this study differ from earlier studies along the Rio Grande by Engel-Wilson and Ohmart (1978) and Scudday et al. (1980), where nests occurred almost exclusively in Tamarix sp. There is a virtual absence of Tamarix sp. in the immediate vicinity of Alpine. Tamarix, a weedy, exotic species in the region, grows primarily along the water courses of the Rio Grande and Pecos River drainage systems, and near surface tanks. Cupressus arizonica, a native species, occurs as isolated stands in the Chisos Mountains of Big Bend National Park disjunct from the main distribution center in Arizona and northwestern Mexico (Powell, 1988). Because Cupressus is easily propagated from seed and widely cultivated in the region, we suggest its use as an important tool for recruiting, establishing, and managing stable nesting populations in the central Trans-Pecos area. The widespread planting of this species in suitable habitats in the region should provide a way of increasing this valuable game bird and economic resource throughout West Texas. The use of Cupressus in this way is paramount to using one kind of renewable natural resource to increase the population base of another renewable resource.

CONCLUSION

As demonstrated, Cupressus arizonica can provide important cover, nesting habitat, and possibly forage for White-winged Doves, and the presence of these trees should increase the successful reproduction of the birds, resulting in greater population densities of this game species in the Trans-Pecos region.

LITERATURE CITED

Brown, D.E., Chairman. 1977. White-winged dove (Zenaida asiatica). Pages 247-272 in Management of migratory shore and upland game birds in North America. G.C. Sanderson, ed. Intl. Assn. of Fish and Wildl. Agencies, Washington D.C. 358 pp.

Cottam, C. and J.B. Trefethen, eds. 1968. Whitewings. D. Van Nostrand Co., Princeton, N.J. 348 pp.

Engel-Wilson R.W. and R.D. Ohmart. 1978. Assessment of vegetation and terrestrial vertebrates along the Rio Grande between Fort Quitman, Texas and Haciendadita, Texas. Final unpublished report submitted to International Boundary and Water Commission, El Paso, Texas.

Gallucci, T. 1978. The Biological and Taxonomic Status of the White-Winged Doves of the Big Bend of Texas. M.S. Thesis, Sul Ross State University, Alpine, Texas.

Goodwin, D. 1983. Pigeons and Doves of the World, 3rd ed. Cornell University Press, Ithaca. 363 pp.

Haughey, R.A. 1986. Diet of desert-nesting western white-winged doves (Zenaida asiatica mearnsi). M.S. Thesis, Arizona State University, Tempe.

Johnsgard, P. 1975. North American Game Birds of Upland and Shoreline. University of Nebraska Press, Lincoln and London. 183 pp.

Powell, A.M. 1988. Tress and Shrubs of Trans-Pecos Texas. Big Bend Natural History Association, Inc., Big Bend National Park, Texas. 536 pp.

Scudday, J.F., T.L. Gallucci, and P.S. West. 1980. The status and ecology of the white-winged dove of Trans-Pecos, Texas. Contract Report for USFWS Contract No. 14-16-0008-2096, U.S.F.W.S.

SUPPLEMENTAL FEEDING OF FREE-RANGING DEER IN SOUTH TEXAS

Robert E. Zaiglin and Charles A. DeYoung[1]

ABSTRACT

Free-ranging white-tailed deer (Odocoileus virginianus) near Laredo, Texas were fed a pelleted supplement from February 1976 to August 1977. Adult deer consumed the supplement readily but did not appear to travel far to obtain it. Fawns were never observed utilizing the supplement. Deer use of some feeder sites was curtailed because collared peccary (Tayassu tajacu) chased deer away. Consumption of supplement was inversely related to average crude protein content of selected forage plants except during winter. Helicopter counts in October showed significantly higher fawn/doe ratios in the supplemented pastures.

Key words: Deer, Odocoileus virginianus, supplemental feed, Texas, white-tailed deer

INTRODUCTION

Supplemental feed is widely used in Texas, where white-tailed deer are important economically (Ramsey, 1965; Teer and Forest, 1968). Feed is distributed legally during the hunting season as bait to attract deer. Some landowners supplementally feed deer year-round in anticipation of increased income or recreation from more quality animals. There is additional interest in using supplemental feed to deliver medication, such as anthrax vaccine, to free-ranging population (Davis, 1981). The present study was conducted with objectives of documenting the behavior of free-ranging deer in response to supplemental feed and determining the effects of supplemental feed on fawn/doe ratios.

MATERIALS AND METHODS

The study was conducted on 2,740 acres of the Zachry Blanco Ranch 12 miles southwest of Laredo, Texas. The study area was surrounded by 8 foot high fencing that limited deer movement. This area is within the South Texas Plains ecological region (Gould, 1975) and receives an average of 17.7 inches of precipitation annually. Vegetation of the study area is dominated by coldenia (Coldenia canescens), blackbrush (Acacia rigidula), tasajillo (Opuntia leptocaulis), shrubby sage (Salvia ballotaeflora), brasil (Condalia hookeri), and honey mesquite (Prosopis grandulosa) (Sanders, 1963). About 800 acres within the study area had been rootplowed in strips and seeded to buffelgrass (Cenchrus cilaris).

A barbed wire crossfence that divided the study area approximately in half was used as the boundary between a supplemented and a control pasture. The crossfence was not a significant barrier to deer. Trough-type feeders were located at four sites in the eastern pasture from February 1976 to January 1977 while the western pasture served as a control. The treatment in each pasture was then switched. Three feeding sites were established in the western pasture from February through August, 1977, while eastern pasture served as a control. Three or four feeders were spaced about three yards apart at each site to help curb aggression that can occur when only one feeder is present (Espmark, 1971). Feeding sites were fenced to exclude cattle by an 8 by 12 yard rectangular enclosure of four strands of barbed wire.

The supplement was a commmercially produced, pelleted mixture of 12.8% digestible protein. A complete analysis of the feed was given by Zaiglin (1977). The amount of supplement distributed was dependent upon the weather and deer consumption. Normally, about 100 pounds was placed at each site every 5-6 days. When rain occurred, no feed was distributed until the weather cleared. Wet feed was removed from feeders and discarded off of the study area.

Observations of deer behavior at feeder sites were made with binoculars from elevated blinds. Nocturnal observations were made when moonlight was sufficient. Most observations were made during the first two hours after daylight and the last two hours before dark. Consumption per unit time was estimated by timing individual deer feeding on a pre-weighed amount of supplement and reweighing the supplement after deer departed. Feeding deer were timed with a stopwatch while they had their heads in a trough. Timing was discontinued each time the deer raised its head. Total time individual deer remained at feeding sites was recorded by noting when they entered and departed through the fence surrounding feeder sites. Differences in consumption rate and length of visit were tested between sexes using t-tests.

To estimate the distance deer would travel to obtain the supplement, 12 deer were trapped under baited dropnets (Ramsey, 1968) and individually marked with color-coded collars. Nine deer were marked in the east pasture and three in the west. Marked deer also served to determine if there was an exchange of deer between supplemented and control pastures. Only female deer were marked, at the request of the ranch manager. Sightings of marked deer were recorded on maps of the study area.

In order to compare supplement consumption against status of the natural forage, a crude protein index was determined using four to eight deer forage species biweekly throughout the study. Forage species selected for each sampling were high in occurrence in deer rumens during corresponding months on the Zachry Randado Ranch approximately 33 mile southwest of the study area (Arnold, 1976). What seemed to be the most edible portions of several widely scattered plants of each species were plucked at each collection. Standard micro-Kjeldahl nitrogen analysis was used to estimate crude protein.

The fawn/doe ratio was determined within each pasture by counting and classifying deer from a Bell Model 47 helicopter flown at 35 miles per hour and at about 75 feet elevation during October 1976 and 1977. Each pasture was flown separately using the crossfence as a starting point. The two observers, one counting on each side of the flight line, had previous experience conducting aerial counts, which was important in obtianing reliable results (Le Resche and Rausch, 1974). The pilot had several hundred hours of experience in flying deer counts and was able to fly uniform transects while the observers counted a strip about 200 yards wide. Complete coverage of the study area was attempted by flying adjacent strips.

The fawn/doe ratio was calculated by dividing total number of fawns by total number of does observed in each pasture. Data for the two years were pooled and tested for differences between fed and unfed pastures using a 2 x 2 contingency table.

RESULTS AND DISCUSSION

A total of 257 hours was spent observing feeder sites, primarily during February to August 1976 and June to August 1977. A total of 379 deer visits were recorded, many of which were obviously repeat visits by the same individuals. Length of visits ranged from a few seconds to 37 minutes. Bucks remained at feeder sites for an average of 13.4 minutes, as compared to 11.4 minutes for does. The difference was not significant ($P > 0.05$).

Only four fawns were observed near feeder sites through the study. Fawns were always accompanied by a doe. The does would enter a site and feed, but fawns remained outside of the surrounding fence.

Deer typically were cautious around feeders and seldom ap-

[1]Authors are Wildlife Manager, Harrison Interests, Ltd., Catarina, TX 78836 and Professor, Caesar Kleberg Wildlife Research Institute, Texas A&I University, Kingsville, TX 78363. We thank Al Brothers and H. B. Zachry Ranches for valuable support during this study. The Caesar Kleberg Foundation for Wildlife Conservation provided finanical support.

proached without hesitation. Deer would typically approach within a few yards of the fence surrounding the site, and remain stationary for several minutes before entering. Feeding was generally crepuscular and nocturnal, but by checking for tracks at the sites, some feeding was found to occur at all times. Large bucks commonly entered feeder sites after sundown and remained after dark, often making several visits of short duration. Ozoga (1973) reported that in Michigan nocturnal use of feeders by deer accounted for 75% of the total feeding time in spring. Nocturnal observations in the present study also indicated frequent visits by deer.

There were 48 sightings of marked deer, but only one marked deer was observed outside of the pasture in which it was trapped. This individual was observed once watering at a pond in the west pasture, approximately one mile from its trap site in the east pasture. Seven of the marked deer were observed at feeder sites, but never more than one-fourth mile from their capture site.

Comparison of the two helicopter counts indicated some redistribution of deer from the east pasture into the west pasture in 1977 (Table 1), possibly because of counting variation or different cattle grazing patterns between pastures. Cattle were present in the east pasture for several weeks prior to the 1977 count, while the west pasture was deferred. Adams (1978) reported that in some circumstances, deer will vacate pastures grazed by cattle and move to adjacent areas without cattle.

Aggressive behavior of collared peccary curtailed deer use at some feeder sites. In 12 encounters with peccary inside the fenced rectangle, deer were displaced 11 times. Peccary remained at feeder sites for long periods to feed on spilled supplement and often bedded at the site. Six visits by peccary that were timed averaged 30.1 minutes. Deer approaching within approximately five yards were repelled, usually by a single peccary. The peccary would either walk or run toward the approaching deer. Deer would retreat often to return after departure of the peccary, but they would sometimes leave the vicinity altogether.

Deer were observed utilizing the supplement within two days of its distribution in the eastern pasture versus 7 days in the western pasture. This rapid acceptance may have been attributable to the fact

Table 1. Results of October deer counts conducted from a helicopter in a pasture with supplemental feed available versus a control pasture lacking feed on the Zachry Blanco Ranch near Laredo, Texas.

	1976			1977		
Pasture	Treatment	Does	Fawns/doe	Treatment	Does	Fawns/doe
East	Fed	43	0.39	Control	34	0.08
West	Control	20	0.20	Fed	29	0.24

that deer on the study area were used to feed distributed as bait during the hunting season. Results of 16 timed bouts of deer feeding (head within trough) on pre-weighed amounts of supplement indicated that an average of 0.55 pounds were consumed/minute of feeding. Consumption rate was estimated for an additional 21 buck visits and 20 doe visits by multiplying minutes of feeding time (head within trough) by 0.55 pounds. Bucks fed for an average of 2.4 minutes and consumed 1.3 pounds per visit. Does fed for an average of 2.9 minutes and consumed 1.6 pounds per visit. The difference was not significant ($\underline{P} > 0.05$).

A total of 44,000 pounds of supplement was distributed during the study. The amount that disappeared from feeders was used to approximate the amount consumed by deer. However, supplement was also consumed by 20 exotic large mammals present on the area from February to July 1976, and by racoons (<u>Procyon lotor</u>), rodents, and small birds throughout the study. Liscinsky (1975) estimated that 10% of the supplement fed in his study was consumed by rodents and small birds.

Consumption of supplement was generally inversly related to the average crude protein content of the selected forage plants, except during winter (Figure 1). Previous research has shown that reduced intake by deer during the winter is common, even when high quality food is available (Short et al., 1969; Silver et al., 1969; Ozoga and Verme, 1970; Short, 1975; Holter et al., 1977). Consumption of supplement was particularily high during the late summer both years when crude protein values in the native forage were relatively low. Varner et al. (1977) also found that summer was a critical time in the nutrition of deer in south Texas.

October 1976 and 1977 helicopter counts showed a higher fawn/doe ratio ($\underline{P} < 0.04$) in the supplemented pastures (Table 1). The overall fawn/doe ratio across treatments was low in 1977 due to drought. Based on annual helicopter counts conducted on the ranch since 1969, large fluctions in fawn survival are common. The peak of fawning in this area of Texas usually occurs in July (Leal, 1973). The high nutritional demands on lactating does in late summer, the relatively low nutritional value of forage during this period (Figure 1), and the high late summer consumption of supplement all suggest that the supplement contributed to increased fawn survival through improving the diet of the dam. Coyote predation has been thought to be a major factor depressing fawn survival in south Texas (Cook et al., 1971; Beasom, 1974). However, it appears that summer nutrition also may be critical.

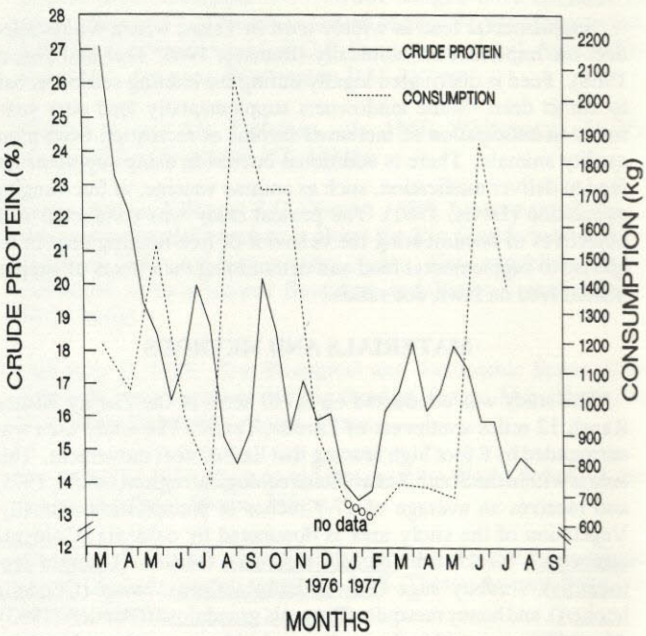


Figure 1. Deer consumption of supplemental feed versus an index of crude protein in the natural forage on the Zachry Blanco Ranch near Laredo, Texas.

Precise estimates of cost were not possible from the data. However, considering the supplement, feeders, fencing, labor, and vehicles, the cost per additional fawn produced was likely several hundred dollars. Thus, year-around feeding for fawn survival alone was probably uneconomical. However, the data indicated consumption was high for a 2- to 3-month period during summer (Fig. 1), which may have influenced fawn survival. Future research should determine if it is feasible to supplement for a short time during the critical summer period and produce the same results as the year-around supplemention practiced in this study.

Landowners that supplement heavily frequently do so with the goal of increasing antler and body weights of males. We were unable to measure antlers and weights in sufficient numbers to determine if there were differences between supplemented and unsupplemented deer. However, we were unable to detect differences from subjective observations.

In conclusion, deer in South Texas will readily accept a pelleted supplement when crude protein values of the natural forage are relatively low. The exception is during winter months when deer curtail intake of all food. Collared peccaries repell deer at feeding sites and this interference should be considered when planning feeding programs. Year-around supplemental feeding will apparently increase fawn survival in south Texas. However, the cost of the practice is high.

LITERATURE CITED

Adams, N. E., Jr. 1978. The effects of cattle on white-tailed deer distribution. M. S. Thesis, Texas A&I University, Kingsville 63pp.

Arnold, L. A. 1976. Seasonal food habits of white-tailed deer on the Zachry Ranch in south Texas. M. S. Thesis, Texas A&I University, Kingsville 59pp.

Beasom, S. L. 1974. Relationships between predator removal and white-tailed deer net productivity. Journal of Wildlife Management 38:845-859.

Cook, R. S., M. White, D. O. Trainer, and W. C. Glazener. 1971. Mortality of young white-tailed deer fawns in south Texas. Journal of Wildlife Management 35:47-56.

Davis, D. S. 1981. Efectiveness of anthrax vaccine. Performance Report, Federal Aid Project No. W-109-R-4, Texas Parks and Wildlife Department 5pp.

Espmark, Y. 1971. Dominance relationships as a possible regulating factor in roe deer and reindeer populations. Pages 787-796 in V. Geist and F. Walter (editors). The behavior of ungulates and its relation to management. International Union for the Conservation of Nature (New Series) No. 24, Volume 2.

Gould, F. W. 1975. Texas plants: a checklist and ecological summary. Texas Agricultural Experiment Station Misc. Publication 585 121pp.

Holter, J. D., W. E. Urban, and H. H. Hayes. 1977. Nutrition of northern white-tailed deer throughout the year. Journal of Animal Science 45:365-376.

Leal, R. A. 1973. Female reproductive potentials and productivity of the Randado Ranch herd of white-tailed deer (Odocoileus virginianus Mearns). M. S. Thesis, Texas A&I University, Kingsville 62pp.

Le Resche, R. E., and R. A. Rausch. 1974. Accuracy and precision of aerial moosing censusing. Journal of Wildlife Management 38:175-182.

Liscinsky, S. 1975. Diet effects on deer. Pennsylvania Game News 46:29-31.

Ozoga, J. J. 1973. Field trial of maintaining deer under artifical conditions. Michigan Department of Natural Resources Pittman Robertson Progress Report for Project W- 117-R-5. 10pp.

Ozoga, J. J. and L. J. Verme. 1970. Winter feeding patterns of penned white-tailed deer. Journal of Wildlife Management 34:431-439.

Ramsey, C. W. 1965. Potential economic returns from deer as compared with livestock in the Edwards Plateau region of Texas. Journal of Range Management 18:247-250.

Ramsey, C. W. 1968. A drop-net deer trap. Journal of Wildlife Management 32:187-190.

Sanders, C. L., Jr. 1963. Habitat preference of the white- tailed deer and several exotic ungulates in south Texas. Ecology 44:803-806.

Short, H. L. 1975. Nutrition of southern deer in different seasons. Journal of Wildlife Management 39:321-329.

Short, H. L., J. D. Newson, G. L. McCoy, and J. F. Fowler. 1969. Effects of nutrition and climate on southern deer. Transactions of the North American Wildlife and Natural Resources Conference 34:137-145.

Silver, H., N. F. Colovos, J. B. Holter, and H. H. Hayes. 1969. Fasting metablolism of white-tailed deer. Journal of Wildlife Management 33:490-498.

Teer, J. G. and N. K. Forrest. 1968. Bionomic and ethical implications of commerical game harvest programs. Transactions of the North American Wildlife and Natural Resources Conference 33:192-204.

Varner, L. W., L. H. Blankenship, and G. W. Lynch. 1977. Seasonal changes in nutritive value of deer food plants in south Texas. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 31:99-106.

Zaiglin, R. E. 1977. The effect of a supplemental feed on free-ranging white-tailed deer. M. S. Thesis, Texas A&I University, Kingsville 52pp.

RESPONSE OF HERBACEOUS VEGETATION TO PRESCRIBED BURNING IN THE HILL COUNTRY OF TEXAS

Ann-Marie Hutcheson, John T. Baccus, Terry M. McClean and Paul J. Fonteyn[1]

ABSTRACT

The use of prescribed burning to control shrub growth in range and grassland areas has increased in recent years. A study was conducted in an oak savanna to determine maximum temperatures reached during burning, the effect of fuel moisture and fuel on these temperatures, and the response of forbs and grasses. Maximum temperatures varied from 104°F and 388°F at the base of live and post oaks, respectively, to 412°F in the grasslands surrounding the trees. Forb biomass increased dramatically in burn areas, whereas grass biomass decreased slightly in live oak areas and increased slightly in post oak areas. Standing dead biomass was 3-4 times greater in control plots than in burn plots.

Keywords: Prescribed burning, hill country, temperature, live oak **(Quercus fusiformis)**, post oak **(Quercus stellata)**, forbs, and grass.

INTRODUCITON

The use of prescribed burning to control shrub growth on rangeland has increased in recent years because of the acceptance of fire as a low cost management tool to control shrubs (Wink and Wright 1973, Hamilton and Scifres 1980, Ueckert 1980). Many investigators have studied the effects of prescribed burning on grass production because it directly affects cattle production. An important income supplement to cattle production in the Hill Country of Texas is deer production. Because deer prefer both forbs and succulent new grass growth (Cross 1984), forb production should also be considered when the effects of fire are assessed; very few studies, however, have considered this effect.

This study was conducted in an oak savanna. The specific objectives of the study were to determine: 1) maximum temperatures achieved during a burn, 2) the effect of fuel moisture and fuel load on fire temperature, and 3)the response of forbs and grasses to prescribed burning.

MATERIALS AND METHODS

Study Site and Sampling Positions

The study was conducted in Love Pasture at the Kerr Wildlife Management Area in Kerr County,Texas. The pasture is an oak savanna dominated by two oak species—live oak(**Quercus fusiformis**) and post oak (**Q. stellata**). (Nomenclature follows Correll and Johnston, 1970). Four pairs of trees of each species and the grassland surrounding them were selected. One vegetational unit of each pair was designated a control unit, the other a burn unit. Both vegetational units of every pair had similar micro-habitats. Five sampling positons were chosen along four transects that began at the base of each tree and radiated along each of the cardinal compass directions. Specifically, these were located at the base of the tree, and at 0.5 canopy radius, 1 canopy radius, 1.5 radii,(half-grassland), and 2 radii (grassland) from the base (Figure 1).

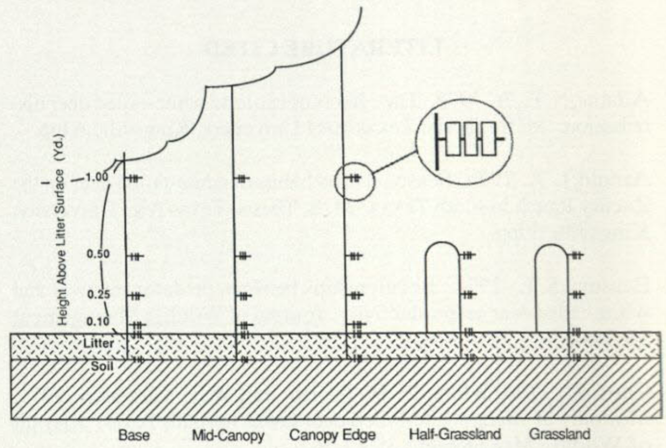


Figure 1. Vertically-stratified levels. Positions beneath tree canopies are at soil surface, litter surface, and 0.10, 0.25, 0.50 and 1.0 yds. above litter surface. Grassland positions are at soil surface, litter surface, 0.25 and 0.50 yds. above litter surface.

Temperature Measurement

Maximum temperatures reached during the burn were measured with the use of temperature recording slides. Frosted glass slides (1 in.x 3in.) were marked with 28 heat-sensitive crayons with melting points ranging from 100 to 550°F (Figure 2). These slides were then wrapped in aluminum foil to protect the marks from becoming obscured by ash; yet permitted rapid transfer of heat. At the base, mid-canopy and canopy positions, a set of three slides were placed at six vertically stratified levels. These levels were: soil surface, litter surface, and 0.1,0.25,0.5, and 1.0 yds. above the litter surface (Figure 1). Slides above the litter surface were hung on 0.2-in. diameter wire suspended from the tree canopy. Temperature slides were insulated from possible heat conduction through suspension wires by 0.01-in. thick glass slides and were oriented with marked surfaces directed toward the litter surface. In the two grassland sampling positions, temperatures at only four vertically stratified levels (soil surface, litter surface, and 0.25 and 0.50-yd. above the litter surface) were measured (Figure 1). These slides were connected to 0.2-in. diameter wire wickets.

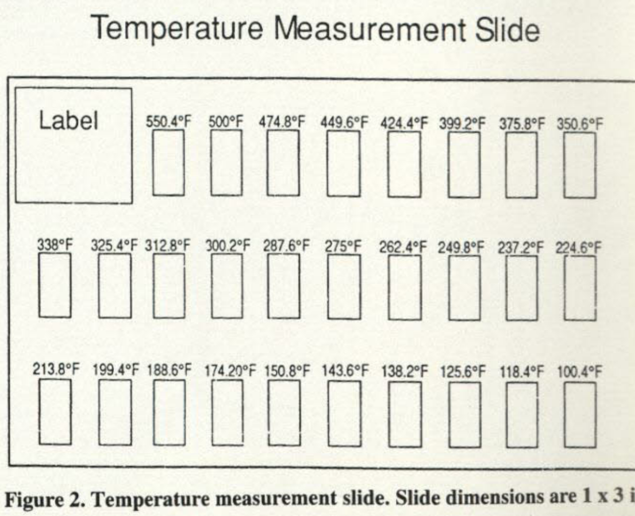


Figure 2. Temperature measurement slide. Slide dimensions are 1 x 3 in.

[1]Former graduate student, Biology Department, Southwest Texas State University; Professor, Biology Department, Southwest Texas State University; graduate student, Botany Department, University of Wyoming; Professor, Biology Department, Southwest Texas State University. The authors wish to thank Donnie Harmel and Bill Armstrong of the Texas Department of Parks and Wildlife for their assistance in this project. This investigation was carried out under Pittman-Robertson Projects (Fedral Aid) W-56-D, Kerr Wildlife Management Area (KWMA) Development; W-62-R, Edwards Plateau Game Management Survey; W-76-R KWMA Research and W-109-R, Big Game Investigations.

The Burn

The pasture was burned in a striphead fire pattern between 12:30 and 1:15 p.m. on 1 February 1982 (Wright 1974). Controls were protected by a bulldozed 15 yd. fire lane. At the time of ignition, air temperature was 55°F, relative humidity was 42-48%, and wind speed was 10-32 mi./hr. from the SSW(Baccus, 1982).

Fuel Moisture and Fuel Load

On the day of the burn, fuel moisture samples were collected between 9:00 and 10:00 a.m. from each of five positions located diagonally between two vegetational transects from both burn and control units. Immediately prior to the fire, fuel moisture samples were again collected from controls. Samples consisted of a representative sampling of fuels present at each position collected in moisture-proof, heat-tolerent bags. To determine percent dry weight, samples were weighed, dried at 212°F for 24 hours and reweighed.

Pre- and postburn samples of fuel load were collected from burn units within five O.3 yd.^{2} frames located diagonally between two vegetational transects. These samples were sorted into four fine-fuel classes (grass, forbs, twigs, and leaves), and dried at 212°F to constant weight to determine fuel present at ignition and percent fuel oxidized by the fire (Table 1).

Vegetation

At mid-growing season following the burn (Jul. and early Aug. 1982), all standing biomass was collected from within a 0.3- yd.^{2} frame at each sampling position in both control and burn units. The material was sorted initially into live (green) and standing dead biomass. The live biomass was then hand-sorted into individual species by gross morphology and surface characteristics. Some specimens could only be classified to genus(e.g.**Aristida** spp). All specimens were oven-dried to constant weight at 176°F. Data collected were divided into two classes: forbs and grasses. An importance value (IV) for each species was determined from relative dominance and relative frequency within classes (Tables 2-5). Any forb of grass species with an IV ≥ 2% was reported individually; others were combined into the categories 'other forbs' and 'other grasses'.

Statistical Methods

Analysis of variance (ANOVA) was performed on standing-dead biomass data collected from control and burn units for both species. Two-way ANOVA (Sokal and Rohlf, 1981) was performed on fuel moisture, total live biomass, and forb and grass biomass (see Tables,Hutcheson, 1986). Rows for two-way ANOVA were the control and burn; columns were the four pairs of vegetation units. All sample positions were pooled for analysis.

RESULTS

Temperature

Mean temperatures at each vertical stratified level were plotted for each position for both species (Figure 3). Temperatures were highest at the litter surface varied from a low of 138°F at the base sampling postion to 300°F at the half- grassland postion. For post oak burn units, temperatures at the litter surface varied from a low of 388° at the base sampling postion to 412°F at the half-grassland position. Mean temperature at the soil surface was considerably lower than that at the litter surface. For live oak burn units, temperatures at the soil surface varied from a low of 104°F at the base sampling position to 194°F at the grassland position, For post oak burn units, temperatures at the litter surface varied from a low of 266°F at the canopy edge to 316°F at the base sampling position. Mean temperatures above the litter surface dropped off dramatically.

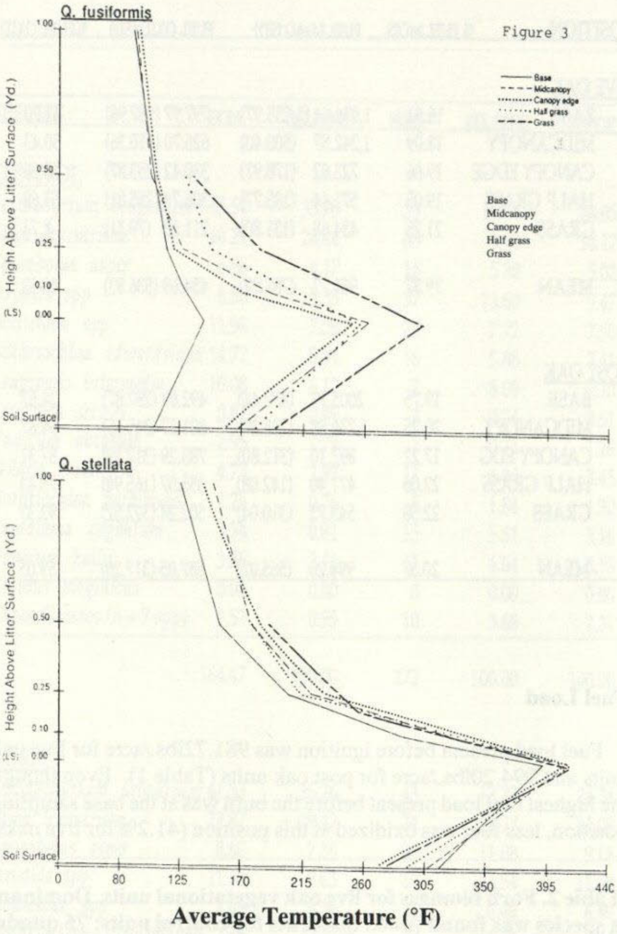


Figure 3. Temperature profiles. Average temperatures represent the mean of 48 readings (three slides in each of four directions from four different trees) at each vertically stratified level above litter surface (LS) for each position.

Fuel Moisture

A two-way ANOVA (Sokal and Rohlf, 1981) on initial fuel moisture readings indicated that there was no significant difference in fuel moisture between tree pairs or between treatments. A separate two-way ANOVA without Replication on each treatment also indicated no difference in fuel moisture readings between unit pairs or between positions. Fuel moisture samples obtained from control units immediately prior to the fire were therefore assumed to be indicative of fuel moisture conditions in vegetational burn units at time of ignition. Resampling was conducted only in controls just prior to ignition to minimize disturbance. Average fuel moisture was 20.4 and 19.4% in live oak and post oak vegetational units, respectively (Table 1).

Table 1. Fuel variables for live oak and post oak vegetational units. Fuel moisture reported as percent dry weight; fuel load and fuel oxidized reported in lbs./acre. SD stands for ± 1 standard deviation.

POSITION	% FUEL MOIS	FUEL LOAD (SD)	FUEL OXID (SD)	%FUEL OXID
LIVE OAK				
BASE	18.81	1,936.64 (1,255.97)	797.97 (987.96)	41.20
MIDCANOPY	18.09	1,242.57 (500.40)	626.70 (610.36)	50.43
CANOPY EDGE	19.66	723.62 (178.97)	330.42 (253.87)	45.66
HALF GRASS	19.05	571.44 (185.77)	306.74 (285.81)	53.68
GRASS	21.25	434.68 (131.80)	211.83 (79.11)	8.73
MEAN	19.37	981.72 (787.87)	454.69 (536.93)	46.32
POST OAK				
BASE	19.75	2005.11 (437.44)	492.69 (282.87)	24.57
MIDCANOPY	20.25	1,236.88 (238.27)	801.27 (345.65)	64.87
CANOPY EDG	17.22	897.10 (312.80)	783.29 (317.39)	87.31
HALF GRASS	22.06	471.40 (142.08)	355.57 (165.94)	75.43
GRASS	22.58	543.72 (310.04)	502.24 (322.52)	92.37
MEAN	20.37	994.20 (565.02)	587.05 (317.20)	59.05

Fuel Load

Fuel load present before ignition was 981.72lbs./acre for live oak units and 994.20lbs./acre for post oak units (Table 1). Even though the highest fuel load present before the burn was at the base sampling position, less fuel was oxidized at this position (41.2% for live oaks, 24.6% for post oaks) than any other position. This was caused by the splitting of the fire front at the base of these trees resulting in small unburned areas on the opposite sides of their trunks (Fonteyn et al. 1984). Only half of the fuel was oxidized (46.3% for live oaks, 59.1% for post oaks). Actual weights of fuel oxidized were greater under tree canopies than in grassland positions (Table 1).

Forbs and Grasses

There was a larger increase (63.7%) in mean forb biomass collected from burn units than from control units. A two-way ANOVA on forb biomass collected from live oak units indicated that burning caused a notable ($p=0.07$) change in forb biomass, whereas pair number and interaction were both insignificant ($p>0.10$). A two-way ANOVA on forb biomass from post oak units indicated that burning caused a significant ($p=0.01$) change in forb biomass; pair number was also significant ($p=0.02$), whereas interaction was insignificant ($p > 0.10$).

The increase in forb biomass (48.1) in live oak burn units was due primarily to **Desmanthus velutinus** and **Smila bonanox.** Although two other major species, **Tragia neptaefolia** and **Carex** spp., showed a change in relative dominance, there was little change in biomass (Table 2). The increase in forb biomass in post oak burn units (78.4%) was also primarily due to **D. velutinus** and **S. bonanox**. The biomass of T. neptaefolia increased slightly rather than decreased; **Carex** spp. decreased (Table 3).

Burn units showed a decrease in species richness of forbs. In live oak units, 22 forb species occurred in the control units and 17 in burn units. Three important species, **Rhynchosia texana, Abutilon icanum** and **Lespedeza procumbens,** did not occur in burn units (Table 2). There was also a decrease in species richness in forbs in post oak burn units: 25 species occurred in control units and 21 burn units (Table 3).

Mean grass biomass from live oak burn units decreased 28%. Even though a two-way ANOVA showed treatment effects to be significant, so also were pair number and interaction. Any clear difference due to treatment alone was obscured because of the large

Table 2. Forb biomass for live oak vegetational units. Dominance in lbs./acre. Frequency represents the number of quadrats in which a species was found (n=65 quadrats for control units; 75 quadrats for burn units). Importance is the mean of relative dominance and relative frequency.

SPECIES	DOM	REL DOM	FREQ	REL FREQ	IMPORT
CONTROL					
Desmanthus velutinus	4.12	31.81	14	10.22	21.01
Tragia neptaefolia	2.19	16.91	55	40.15	28.53
Carex sp.	3.32	25.63	25	18.25	21.94
Smilax Bonanox	0.71	5.48	5	3.65	4.56
Rhynchosia texana	0.20	1.54	2	1.46	1.50
Torilis arvensis	0.01	0.07	2	1.46	0.76
Abutilon icanum	0.06	0.46	1	0.73	0.59
Phyllanthus polygonoides	0.69	5.32	7	5.11	5.21
Oxalis dillenii	0.08	0.61	5	3.65	2.13
Lespedeza procumbens	0.54	4.16	6	4.38	4.27
Other Forbs (12 spp)	0.97	7.49	15	10.95	9.22
	12.95	100.00	137	100.00	100.00
BURN					
Desmanthus velutinus	9.50	49.63	29	16.02	32.82
Tragia neptaefolia	1.80	9.40	67	37.02	23.21
Carex sp.	3.01	15.73	41	22.65	19.19
Smilax Bonanox	2.85	14.89	7	3.87	9.37
Rhynchosia texana	0.00	0.00	0	0.00	0.00
Torilis arvensis	0.05	0.26	1	0.55	0.40
Abutilon icanum	0.00	0.00	0	0.00	0.00
Phyllanthus polygonoides	0.22	1.15	10	5.52	3.33
Oxalis dillenii	0.03	0.16	5	2.76	1.45
Lespedeza procumbens	0.00	0.00	0	0.00	0.00
Other Forbs (n = 10spp)	1.68	8.78	21	11.60	10.19
	19.14	100.00	181	100.00	100.00

Table 3. Forb biomass for post oak vegetational units. Dominance in lbs./acre. Frequency represents the number of quadrats in which a species was found (n=76 quadrats for control units; 79 quadrats for burn units). Importance is the mean of relative dominance and relative frequency.

SPECIES	DOM	REL DOM	FREQ	REL FREQ	IMPORT
CONTROL					
Desmanthus velutinus	5.45	39.66	27	17.20	28.43
Tragia neptaefolia	1.16	8.44	47	29.94	19.19
Carex sp.	4.33	31.51	34	21.66	26.58
Smilax Bonanox	0.07	0.50	5	3.18	1.84
Rhynchosia texana	0.68	4.94	4	2.55	3.74
Torilis arvensis	0.00	0.00	0	0.00	0.00
Abutilon icanum	0.57	4.14	2	1.27	2.70
Phyllanthus polygonoides	0.15	1.09	4	2.55	1.82
Oxalis dillenii	0.07	0.50	4	2.55	1.52
Lespedeza procumbens	0.50	3.63	3	1.91	2.77
Other Forbs (n = 16 spp)	0.72	5.24	27	17.20	11.22
	13.74	100.00	157	100.00	100.00
BURN					
Desmanthus velutinus	9.05	36.92	37	16.67	26.79
Tragia neptaefolia	1.21	4.93	53	23.87	14.40
Carex sp.	3.68	15.01	6	16.22	15.61
Smilax Bonanox	3.19	13.01	11	4.95	8.98
Rhynchosia texana	3.54	14.44	18	8.11	11.27
Torilis arvensis	1.35	5.50	15	6.76	6.13
Abutilon icanum	1.18	4.81	10	4.50	4.65
Phyllanthus polygonoides	0.00	0.00	0	0.00	0.00
Oxalis dillenii	0.04	0.16	5	2.25	1.20
Lespedeza procumbens	0.00	0.00	1	0.45	0.22
Other Forbs (n = 12 spp)	1.22	4.97	36	16.22	10.59
	24.51	100.00	222	100.00	100.00

interaction term. This apparent decrease was due primarily to the two major species **Schizachorium scoparium** and **Stipa leucotricha.** Four other important species, **Sporobolus asper, Aristida** spp., **Panicum obtusum** and **Bothriochloa barbinodis**, increased; the latter two more than doubling their dominance in control units (Table 4). There was no significant difference in grass biomass between post oak control and burn units.

Table 4. Grass biomass for live oak vegetational units. Dominance in lbs./acre. Frequency represents the number of quadrats in which a species was found (n=65 quadrats for control units; 75 quadrats for burn units). Importance is the mean of relative dominance and relative frequency.

SPECIES	DOM	REL DOM	FREQ	REL FREQ	IMPORT
CONTROL					
Scizachyrium scoparium	55.54	33.76	39	14.34	24.05
Stipa leucotricha	40.21	24.44	65	3.90	14.17
Sporobolus asper	6.86	4.17	16	5.88	5.02
Aristida spp	8.80	5.35	37	13.60	9.47
Bouteloua spp	11.98	7.28	21	7.72	7.50
Bothriochloa edwardsiana	14.72	8.94	16	5.88	7.41
Eragrostis intermedia	10.08	6.12	2	8.09	7.10
Eriochloa sericea	0.81	0.49	2	0.74	0.61
Panicum obtusum	2.95	1.79	2	0.74	1.26
Hilaria berlangeri	4.73	2.87	11	4.04	3.45
Bothriochloa barbinodis	1.25	0.76	5	1.84	1.30
Leptoloma cognatum	1.34	0.81	15	5.51	3.16
Panicum hallii	3.56	2.16	11	4.04	3.10
Elymus virginicus	0.00	0.00	0	0.00	0.00
Other Grasses (n = 7 spp)	1.57	0.95	10	3.68	2.31
	164.47	100.00	272	100.00	100.00
BURN					
Schizachyrium scoparium	41.53	35.26	43	13.23	24.24
Stipa leucotricha	22.87	19.42	74	22.77	21.09
Sporobolus asper	8.60	7.30	36	11.08	9.18
Aristida spp	11.34	9.63	44	13.54	11.59
Bouteloua spp	7.49	6.36	21	6.46	6.40
Bothriochloa edwardsiana	2.55	2.16	5	1.54	1.84
Eragrostis intermedia	3.97	3.37	25	7.69	5.53
Eriochloa sericea	0.63	0.53	2	0.62	0.57
Panicum obtusum	6.85	5.81	4	1.23	3.51
Hilaria berlanger	1.69	1.43	18	5.54	3.48
Bothriochloa barbinodis	7.60	6.45	30	9.23	7.83
Leptoloma cognatum	0.58	0.49	11	3.38	1.93
Panicum hallii	0.46	0.39	4	1.23	0.82
Elymus virginicus	0.00	0.00	0	0.00	0.00
Other Grasses (n = 4 spp)	1.51	1.28	8	2.46	1.87
	117.75	100.00	325	100.00	100.00

Table 5. Grass biomass for post oak vegetational units. Dominance in lbs./acre. Frequency represents the number of quadrats in a which species was found (n=76 quadrats for control units; 79 quadrats for burn units). Importance is the mean of relative dominance and relative frequency.

SPECIES	DOM	REL DOM	FREQ	REL FREQ	IMPORT
CONTROL					
Schizachyrium scoparium	62.90	35.22	43	11.68	23.45
Stipa leucotricha	25.80	14.44	73	19.84	17.13
Sporobolus asper	28.54	15.98	32	8.70	12.33
Aristida spp	7.86	4.40	33	8.97	6.68
Bouteloua spp	7.86	4.40	26	7.07	5.73
Bothriochloa edwardsiana	9.36	5.24	39	10.60	7.92
Eragrostis intermedia	5.95	3.33	32	8.70	6.01
Eriochloa sericea	16.48	9.22	24	6.52	7.87
Panicum obtusum	6.76	3.78	53	3.66	3.72
Hilaria berlangeri	0.60	0.33	14	3.80	2.06
Bothriochloa barbinodis	1.51	0.84	3	0.82	0.82
Leptoloma cognatum	0.31	0.17	8	2.17	1.18
Panicum hallii	1.20	0.67	6	1.63	1.14
Elymus virginicus	2.14	1.19	3	0.82	1.00
Other Grasses (n = 7 spp)	1.19	0.66	19	5.16	2.91
	178.57	100.00	368	100.00	100.00
BURN					
Schizachyrium scoparium	46.71	25.56	35	8.93	17.25
Stipa leucotricha	31.18	17.06	79	20.15	18.60
Sporobolus asper	29.34	16.05	37	9.44	12.74
Aristida spp	4.57	2.50	36	9.18	5.84
Bouteloua spp	16.74	9.16	37	9.44	9.29
Bothriochloa edwardsiana	9.49	5.19	37	9.44	7.32
Eragrostis intermedia	5.43	2.97	27	6.89	4.92
Eriochloa sericea	19.89	10.88	22	5.61	8.24
Panicum obtusum	7.31	4.00	12	3.06	3.53
Hilaria berlangeri	0.42	0.22	5	1.28	0.74
Bothriochloa barbinodis	1.26	0.68	4	1.02	0.85
Leptoloma cognatum	0.15	0.08	8	2.04	1.05
Panicum hallii	0.43	0.23	7	1.79	1.00
Elymus virginicus	4.77	2.61	20	5.10	3.86
Other Grasses (n = 6 spp)	4.96	2.71	26	6.63	4.66
	182.74	100.00	392	100.00	100.00

Even though burn vegetational units showed a decrease in species richness of grasses, the change occurred in the relatively unimportant group 'other grasses'. Twenty grass species occurred in live oak control units, 17 in burn units. Twenty-two grass species occurred in post oak control units, 20 in burn units.

Standing Dead Biomass

Standing dead biomass for both groups was 3-4 times greater in control units than burn units. In live oak units, standing dead biomass was 61.12lbs/acre for burn units (31% of total standing crop) and 225.60 lbs/acre for control units (56% of total standing crop). In post oak units, standing dead biomass was 43.68lbs/acre for burn units (17% of total standing crop) and 145.38lbs/acre for control units (43% of total standing crop).

DISCUSSION

Temperature

Daubenmire (1968) noted considerable time has been spent developing techniques and instrumentation to record fire temperatures. Many of the recorded temperatures are not comparable, however, and are at best, relative temperatures that usually have not been positively related to the organisms in question (Vogl 1974). Vogl (1979) stated that highest temperatures are usually well above the ground at the apex of flames and are rapidly dissipated by winds. Davis and Martin (1960) found higher temperatures are usually produced at ground level by slower moving fires. This study indicated that the highest temperatures at all postions (under the canopy of trees and in the grassland) occurred at the litter surface where fuel was oxidized. Temperatures above and below this level showed a substantial decrease.

Fuel

Response of minor vegetation following fire is influenced by added nutrients. Van Wagner and Methven in 1978 found nutrient effects are probably best gaged by the quantity of organic matter ashed. Quanitity of fuel oxidized is a clearer indicator of added nutrients than fuel load or percent fuel oxidized because the quantity of fuel oxidized is directly related to the amount of nutrients added to the soil, whereas the percent of fuel load that is oxidized varies with the fuel load present. In the present study, for example, even though percent fuel oxidized varied from mid-canopy to canopy edge under post oaks, the amount of fuel oxidized was approximately the same.

Vegetation

Vegetative growth of perennial species on most postburn sites occurs more rapidly and vigorously than growth on unburned sites (Duval 1962). In the present study, all important species except **Torilis arvenis** were perennials, and prescribed burning enhanced some species and decreased others.

Forbs: Late-spring burning significantly reduces the biomass of perennial forbs, whereas burning in winter and early spring favored them (Towne and Owensby 1984). Garza and Blackburn (1985) found that forb basal cover was low and similar for burned and unburned plots. They also reported early winter burning favored the growth of forbs, whereas spring burning favored the production of grasses. The present study indicated winter burning increased forb biomass and did not adversely affect grass production.

Grasses: Whisenant, et al. (1984) determined Texas wintergrass (**Stipa leucotricha**) increased more after fall burning than after spring burning and speculated that the increase was due to a reduction in competition from annual forbs and grasses. They found that spring burning, however, generally favored perennial grasses. Significantly higher production of sideoats grama (**Bouteloua curtipendula**)was found on burned than unburned plots (Schacht and Stubbendieck 1985). The present study determined that **Stipa leucotricha** and **Bouteloua** spp. biomass decreased in live oak vegetational units and increased in post oak units after winter burning. However, winter burning seemed to decrease total grass biomass in live oak vegetational units, but not in post oak vegetational units.

Standing dead biomass: Trilica and Schuster (1969) noted burning reduced forage yields for two years. Other determined that any differences in total foliar cover were due to standing dead materials (Garza and Blackburn 1985). Differences in total biomass in the present study may also be attributable to standing dead materials, because total standing crop decreased 65%, whereas total live vegetation decreased only 7% in control and burn units. Cox (1985) determined that even though standing dead biomass was the predominant vegetational component for most of the year in a **Sporobolus wrightii** grassland in Arizona, it desappeared following precipatation. In the present study, the decrease in standing dead biomass by burning may have contributed to the increase in forb biomass by reducing cover, and thus increasing insolation, and by the addition of available nutrients to the soil.

LITERATURE CITED

Baccus, J.T. 1982. Performance Report: Effects of prescribed burning upon white-tailed deer habitat. Federal Aid in Wildlife Restoration Act Project No. W-109-R-4.

Correll, D.S. &M.C. Johnston. 1970. Manual of the vascular plants of Texas. Texas Research Foundation, Renner. 1881 pp.

Cox, J.R. 1985. Above ground biomass and nitrogen quantities in a big sacation [Sporobolus wrightii] grassland. Journal of Range Management, 38:272-276.

Cross, D. 1984. The food habitats of white-tailed deer on the Kerr Wildlife Management Area in conjuction with prescribed burning and rotational livestock grazing systems. Unpublished Master's Thesis, Southwest Texas State University, San Marcos, Texas.

Daubenmire, R. 1961. Ecology of fire in grasslands. Advances in Ecological Research. 5:209-273.

Davis, L.S. & R.E. Martin. 1960. Time-temperature relationships of test headfires and backfires. U.S. Forest Service, Southeast Forest Experimental Station Research Notes 148:2

Duvall, V.L. 1962. Burning and grazing increases herbage on slender bluestem range. Journal of Range Management, 15:14-16.

Fonteyn, P.J., M.W. Stone, M.A.Yancy,&J.T. Baccus. 1984. Interspecific and intraspecific microhabitat temperature variations during a fire. American Midland Naturalist, 112:246-250.

Garza, N.E.Jr. & W.H. Blackburn. 1985. The effect of early winter or spring burning on runoff, sediment, and vegetation in the post oak savannah of Texas. Journal of Range Management, 38:283-287.

Hamilton, W.T. & C.J. Scifres. 1980. Prescribed burning for maintenance of seeded rangeland and pasture. p.37, In Range land Resources Research. Tecas Agr, Exp. Sta, Consol. PR.-3665.

Hutcheson, A-M, P. 1986. Response of herbaceous vegetation to prescribed burning in the hill country of Texas. Unpub lished Master's Thesis, Soutwest Texas State University, San Marcos, Texas.

Schacht, W.&J. Stubbendieck. 1985. Prescribed burning in the Loess Hill mixed prairie of southern Nebraska. Journal of Range Management, 38:47-51.

Sokal, R.R. & Rohlf. 1981. Biometry. W.H. Freeman, San Francisco.

Towne, G.& C. Owensby. 1984. Long-term effects of annual burning at different dates in ungrazed Kansas tallgrass prairie. Journal of Range Management, 37:392-397.

Trilica, M.J. Jr. & J.L. Schuster. 1969. Effects of fire on grasses of the Texas high plains. Journal of Range Manage ment, 22:329-333.

Ueckert,D.N. 1980. Manipulating range vegetation with prescribed fire. Prescribed Burning in the Edwards Plateau of Texas. Texas Agricultural Service.

Van Wagner, C.E. & I.R. Methven. 1978. Discussion: two recent articles on fire ecology. Canadian Journal of Forestry Research. 8:491-492.

Vogl, R.J. 1974. Effects of fire on grasslands. p. 139. In Physio logical Ecology: a series of monographs, texts, and treatises. Academic Press, New York, New York. 542pp.

Vogl, R.J. 1979. Some basic principles of grassland fire management. Environmental Management, 3:51-59.

Whisenant,S.G., D.N.Ueckert,& C.J.Scifres. 1984. Effects of fire on Texas wintergrass communities.Journal of Range Manage ment,37:387-391.

Wink,R.L. & H.A.Wright. 1973. Effects of fire on an Ashe juniper community.Journal of Range Management.

Wright,H.A.1974. Range burning. Journal of Range Management, 27:5- 11.

DAIRY HERD SIZE AND INCOME OVER FEED COST

M.J. Ellerbrock, J.S. Norwood and J. D. Roach[1]

ABSTRACT

Dairy herd size was examined for possible direct or indirect influence on Income Over Feed Cost per cow. Monthly Dairy Herd Improvement Association records were used to predict daily Income Over Feed Cost by herd size categories. The monetary impact of 146 factors recorded monthly per herd are examined by multiple regression and the findings are presented for the 19 most significant factors. The most important positive contributors to Income Over Feed Cost are the percent of cows in milk, energy value of concentrates fed, mean cow weight, days in milk, and Persistency Index. The most significant negative factors are the days open, percent of herd milking over 305 days, somatic cell count, and mixed herds. Herd size, age, first breeding conception rate, and the percent of possible breedings actually serviced were not significant predictors.

Keywords: Income over feed cost, profitability, herd size, determinants, regression, management, dairy herd, improvements association records.

INTRODUCTION

Does dairy herd size influence income over feed cost (IOFC) per cow? If so, is the relationship direct or indirect? Classical microeconomic theory suggests an indirect relationship. Any economies of scale to be received from increasing herd size will not be directly reflected in IOFC per cow because feed requirements per cow are insensitive to herd size. Economies of scale occur when some or all of the "fixed" costs of farming can be spread over an increasing quantity of ouput (hundredweights of milk), thereby lowering the average cost of producing a unit of output. Typical fixed costs include depreciation, interest, taxes and insurance. Total feed costs for the herd are considered "variable" costs because they are correlated with total herd milk production, whereas total fixed costs do not change with an increase or decrease in total milk yield. Thus, since each new cow must eat like the remainder of the herd, increasing the herd size will increase the farmer's profits only by enlarging the differences between income and fixed costs. However, herd size may indirectly influence IOFC by dictating which management factors are most important for dairy farmers with differing herd sizes.

This study examines the key determinants of IOFC by herd size category for dairy farms in Northeast Texas enrolled in the Dairy Herd Improvement Association (DHIA) record keeping system. It offers theoretically consistent answers to the questions of whether herd size has direct and/or indirect effects on IOFC per dairy cow.

Though the DHIA was established to develop a data base on individual farms to promote productivity (Voelker 1981), little work has enhanced the usefulness of the information for the farmer. The member-farmer receives a great deal of data, but must conduct further analysis if he/she wants to know the precise relationships between many of the variables. This analysis is an attempt to ascertain the quantitative relationships between many of the variables, with emphasis on their impact on IOFC. The purposes of this study are to: 1) enable the dairy farmer to predict changes in IOFC resulting from change in some of the routine management variables, solely using information in the DHIA report, and 2) determine the influence of herd size on IOFC. The goals are to enhance short term decision making and examine the viability of small dairy farms.

In addition to monitoring and considering the latest technological developments and capital investments available to dairies, farmers need to manage their current assets as efficiently as possible. Though much recent concern in agriculture has focussed on optimal farm size and making a transition to permanent sustainability (Richardson 1984, Schwart 1985), a need remains to help managers make better short term decisions; otherwise, adoption of expensive technologies and sophisticated management practices may not be possible

LITERATURE

Several linear programming models have been developed to maximize IOFC via nutrient and price data for various feed ration formulations, but with only a few cow and herd specifications (Bath and Bennett 1980, Bath et al. 1972, Dean et al. 1969, Jones et al. 1980, Reyes et al. 1980). Dairy profit functions have been developed, but their meaning and purpose, i.e. to include fixed costs and enhance genetic evaluation, are different from predicting IOFC (Andrus and McGilliard 1975, Balaine et al. 1981, p. 96, Norman et al. 1981, Pearson and Miller 1981, Tigges et al. 1984). Two studies reported simple correlation, but not multiple regression, analysis of IOFC (Grisley 1985, Williams 1985).

Several studies have estimated the impact on IOFC of a few of the factors examined in this analysis. Increasing herd life from 2.8 to 3.3 lactations was found to increase annual income by $30/cow (Congleton and King 1984). Each additional day open from 40 to 140 reduced daily IOFC by $0.71 and $1.18 for 1st and later lactation cows, respectively (Olds et al. 1979). Three studies indicated that extending the calving interval for high-producing cows from 13-15 months did not hurt IOFC (Reyes et al. 1981, Reyes et al. 1980, Shumway et al. 1982), but two other studies found a negative impact of approximately $7/cow/year for every three days beyond 13 months (Gibson 1984, Holmann et al. 1984). Bakker et al. (1980) argued that assessment of sire profitability requires information beyond the impact on first lactation.

METHODOLOGY

From the approximately 250 variables on the monthly DHI-202 Herd Summary Form, the authors selected the 146 variables related most theoretically to IOFC. Stepwise regression at the 0.05 level was conducted to search for the best set of independent variables in predicting IOFC. The procedure used was the SPSS-X forward stepwise regression with entry based on strength of correlation for the first entry and partial correlation for subsequent entries. Multiple linear regression equations were then estimated on IOFC, with and without use of milk and fat production per cow and feed costs per 45.4 kgs. (CWT) of milk produced, i.e., the "Big Three" predictors of IOFC, as one would expect. The Big Three were dropped in order to search for less obvious determinants of IOFC.

The actual size of the herd (1.#COWSMTLHDTD) was examined as one of the 146 independent variables. Additionally, the effect of herd size was investigated from another perspective: to see if it dictated the determinants of IOFC. This was done by rerunning the model without the Big Three (milk, fat, feed costs) on various size farms after partitioning the data into three herd size groups and then into five herd size groups.

[1] Associate Professor of Agricultural Economics and Professor of Dairy Science, East Texas State University, Commerce, TX 75428; and Franklin County Extension Agent, Texas Agricultural Extension Service, respectively. Funded in part by the Office of Graduate Studies and Research, East Texas State University and the Houston Livestock Show and Rodeo.

DATA

Data were collected through the DHIA on 126 farms in a 19-county area (including Hopkins County, one of the major dairy counties in the nation) of Northeast Texas for the two most recent years available, 1982-83. For some of the farms, less than 24 months of data were available. A total of 749 monthly observations were obtained. In essence, the data provide a static picture of the farm by

Table 1. Variables Selected in Economic Models of Income Over Feed Cost (IOFC)

Dependent:		
Y1.	$IOFCACTI	= Mean daily IOFC per cow, all cows (milking and dry)
Independent:		
	Test Day Data	
3.	%COWSNMKTD	= % of cows in milk
19.	KGSCNTACTD	= Kgs. of concentrates consumed per cow per day
20.	CNTENGVALTD	= Net energy value of the concentrates
21.	CNTCSTPCTD	= Cost of concentrates per cow per day
27.	DYSFSTBDGBRHD	= Mean # of days to first breeding, breeding herd
53.	DYSOPLSTCLVDT	= Mean # of days open per cow since last calving date
55.	#COWSCDRILHD	= # of cows in total herd with complete dry periods
56.	#DYSDRYCLP	= Mean # of days dry per cow in 55.
66.	%MKG>305MKHD	= % of milking herd currently milking> 305 days
67.	AVGWGTKGSTLHD	= Mean body weight of cows, total herd, Kgs.
68.	#HRSBTWNMKGSAM-PM	= # of hours between milkings, a.m. to p.m.
	Rolling Annual Average Data	
109.	$PDSVCSRSTLHD	= Mean $ PD of current and former sires, all lactations
110.	#COWSLFTHDLST12MOS	= # of cows that left herd in last year
118.	#DYSNMKLST12TSTSMC	= Mean # days in milk, last 12 test days, milking cows
120.	PRSTCYNDXLST12TSTS	= Mean test period Persistency Index, last 12 test days
128.	AVGSCCLST12TSTS	= Mean weighted average SCC, nearest 1,000, entire herd, last 12 test days
	Dummy Variables(1 = true, o = false)	
134.	MXHD	: Mixed breeds herd
138.	APR	: Apr. test month
142.	AUG	: Aug. test month

month. Table 1 presents the 19 independent variables found to be most significantly correlated with IOFC when the dairies are partitioned into herd size categories.

Though Texas dairies produce only about 2.8 percent of total U.S. milk (ERS, 1985), Texas ranks ninth among the states in quantity produced (Knutson et al. 1981). Whereas approximately 30 percent of the total U.S. dairy herd is enrolled in the DHIA, 23 percent of Texas dairies are enrolled. The study area has approximately 114,000 head of dairy cows wich produce around 590 million kilograms of milk annually, both of which represent approximately 34 percent of their respective state total (Texas Crop & Livestock Reporting Service, 1982).

Sample farms ranged in size from 18 to 384 head, with a mean of 127. The highest daily average milk production per milking cow was 29.9 kgs. Daily IOFC per cow (milking and dry) ranged from $0.08 to $6.21, with a mean of $2.70. The minimum projected calving interval was 11.8 months, with a mean of 13.7 months. Average days open ranged from 80 to 275, with a mean of 137 days. Average days

Table 2. Multiple Linear Regression Models of Y1. $IOFCACTD by Three Farm Sizes*

Independent Variable	Beta Coefficient	Standard Error	T Value
(Model A: Farms with <85 cows)			
Intercept	-3.470	0.530	-6.57 [b]
3. %COWSNMKTD	0.040	<0.005	9.55 [b]
20. CNTENGVALTD	0.020	<0.005	7.86 [b]
66. %MKG>305MKHD	-0.020	<0.005	-4.65 [b]
109. $PDSVCSRSTLHD	-0.850	0.230	-3.74 [b]
118. #DYSNMKLST12TSTSMC	0.010	<0.005	3.69 [b]
128. AVGSCCLST12TSTS	>-0.005	<0.005	-3.38 [b]
R^2 = 0.52	Sig. F<0.00005		No. of Obs. = 245
(Model B: Farms with 85-132 cows)			
Intercept	-13.380	2.460	-5.45 [b]
3. %COWSNMKTD	0.040	<0.005	8.66 [b]
20. CNTENGVALTD	0.030	0.010	3.50 [b]
21. CNTCSTPCTD	-0.430	0.120	-3.47 [b]
66. %MKG>305MKHD	-0.030	0.010	-4.56 [b]
67. AYGWGTKGSTLHD	<0.005	<0.005	2.17 [a]
118. #DYSNMKLST12TSTSMC	0.010	<0.005	4.66 [b]
120. PRSTCYNDXLST12TSTS	0.090	0.020	3.79 [b]
138. APR	0.430	0.140	2.97 [b]
R^2 = 0.39	Sig. F<0.00005		No. of Obs. = 252
(Model C: Farms with >132 cows)			
Intercept	-8.560	2.450	-3.50 [b]
3. %COWSNMKTD	0.050	0.010	8.68 [b]
19. KGSCNTACTD	-0.040	0.010	-2.88 [b]
53. #DYSOPLSTCLVDT	>-0.005	<0.005	-2.12 [a]
68. #HRSBTWNMKGSAM-PM	0.060	0.030	1.88
110. #COWSLFTHDLST12MOS	>-0.005	<0.005	-2.39 [a]
120. PRSTCYNDXLST12TSTS	0.080	0.030	3.17 [b]
128. AVGSCCLST12TSTS	>-0.005	<0.005	-2.49 [a]
134. MXHD	-1.660	0.430	-3.82 [b]
142. AUG	-0.320	0.160	-2.04 [a]
R^2 = 0.38	Sig. F<0.00005		No. of Obs. = 249

Without the "Big 3" Predictors: milk and fat production, feed cost.
[a]Denotes significance at 0.05 level.
[b]Denotges significance at 0.01 level.

dry ranged from 45 to 124, with a mean of 74 days. The average first breeding conception rate was 59.8 percent. Eighty-nine percent of the herds were Holstein, 5 percent were Jersey, 5 percent were mixed herds, and one percent were Guernsey or Brown Swiss. The mean number of hours between milkings was 11.4 from am to pm. Average somatic cell count (SCC) ranged from 7,000 to 984,000, with a mean of 334,335. Two weaknesses in the data were not addressed: the questionable accuracy of DHIA- calculated feed costs and the possible effect of time in the two- year data; both aspects were beyond the scope of the study.

FINDINGS

The influence of herd size on the determinants of IOFC is reflected in Tables 2 and 3. Partitioning the farms into three group sizes (models A-C) yielded less accurate results than by dividing the data into five group sizes (Models 1-5). With one exception (Model 4:

Farms with 122-171 cows), the ability to predict IOFC rose considerably with the additional delineation of herd size. The latter models are discussed next in further detail.

Table 3. Multiple Linear Regression Models of Y1. $IOFCACTD by Five Farm Sizes*

Independent Variable	Beta Coefficient	Standard Error	T Value
(Model 1: Farms with < 71 cows)			
Intercept	-8.880	2.600	-3.41 b
3. %COWSNMKTD	0.050	0.010	7.89 b
19. KGSCNTACTD	-0.110	0.020	-4.79 b
20. CNTENGVALTD	0.030	<0.005	7.69 b
67. AVGWGTKGSTLHD	0.010	<0.005	6.18 b
68. #HRSBTWNMKGSAM-PM	-0.320	0.070	-4.47 b
110. #COWSLFTHDLST12MOS	0.020	<0.005	6.64 b
120. PRSTCYNDXLST12TSTS	0.060	0.020	2.53 a
128. AVGSCCLST12TSTS	>-0.005	<0.005	-3.44 b
R^2 = 0.60	Sig. F<0.00005		No. of Obs. = 136
(Model 2: Farms With 71-93 cows)			
Intercept	-3.640	0.730	-4.98 b
3. %COWSNMKTD	0.050	0.010	8.28 b
20. CNTENGVALTD	0.020	< 0.005	5.52 b
27. DYSFSTBDGBRHD	< 0.005	< 0.005	2.18 a
66. %MKG-305MKHD	-0.030	0.010	-4.26 b
118. #DYSNMKLST12TSTSMC	0.010	<0.005	2.62 b
128. AVGSCCLST12TSTS	>-0.005	< 0.005	-4.64 b
134. MXHD	-0.660	0.290	-2.27 a
R^2 = 0.57	Sig. F<0.00005		No. of Obs. = 154
(Model 3: Farms with 94-121 cows)			
Intercept	-13.490	3.160	-4.27 b
3. #COWSNMKTD	0.040	0.010	7.11 b
20. CNTENGVALTD	0.030	0.010	3.78 b
21. CNTCSTPCTD	-0.530	0.160	-3.41 b
66. %MKG-305MKHD	-0.030	0.010	-3.47 b
67. AVGWGTKGSTLHD	< 0.005	<0.005	2.66 b
118. #DYSNMKLST12TSTSMC	0.010	<0.005	2.84 b
120. PRSTCYNDXLST12TSTS	0.080	0.030	2.81 b
138. APR	0.380	0.160	2.34 a
R^2 = 0.45	Sig. F<0.00005		No. of Obs. = 157
(Model 4: Farms with 122-171 cows)			
Intercept	0.530	0.640	0.83
3. %COWSNMKTD	0.040	0.010	5.15 b
21. CNTCSTPCTD	-0.370	0.140	-2.72 b
53. #DYSOPLSTCLVDT	>-0.005	<0.005	-2.51 a
110. #COWSLFTHDLST12MOS	0.010	<0.005	2.24 a
R^2 = 0.20	Sig. F<0.00005		No. of Obs. = 148
(Model 5: Farms with > 171 cows)			
Intercept	-15.190	3.010	-5.04 b
3. %COWSNMKTD	0.060	0.010	10.18 b
53. #DYSOPLSTCLVDT	-0.010	< 0.005	-3.51 b
56. #DYSDRYCDP	-0.010	< 0.005	-2.49 a
120. PRSTCYNDXLST12TSTS	0.150	0.003	5.18 b
128. AVGSCCLST12TSTS	> -0.005	< 0.005	-2.82 b
134. MXHD	-1.970	0.450	-4.42 b
R^2 = 0.57	Sig. F<0.00005		No. of Obs. = 151

The percent of herd in milk is a good predictor across all herd sizes, increasing IOFC $0.04-0.06 per cow per day for each percentage increase; as is the mean test period persistency index over the last 12 tests, whose influence becomes more pronounced as herd size increases. For smaller herds (Models 1 and 2), the number of hours from am to pm between milkings tended to hurt IOFC, as did the amount of concentrates used. The energy value of concentrates was correlated significantly with an increase in daily IOFC of $0.02-0.03 per cow on small to moderate size dairies. For farms with 94-121 cows (Model 3), the percent of milking herd currently milking over 305 days and the cost of concentrates had negative effects, whereas the month of April was associated with a marked increase of $0.37-0.53. Larger herds (Models 4 and 5) were more sensitive to the mean number of days open since the last calving date, the mean number of days dry for cows with at least one complete dry period, and mixed herds, each of which had a negative impact on IOFC, as did the cost of concentrates. For the largest dairy operations, having a mixed herd was associated with a drop in IOFC of $1.97 per cow per day.

It may be of interest to note that the age of the herd, first breeding conception rate and percent of possible breedings that were actually serviced are generally considered key dairy management variables, yet did not enter any of the models. Also, actual size of the herd was not found to be a statistically significant predictor of IOFC.

CONCLUSION

Assuming that dairy farmers and DHIA field inspectors record accurate information, it is possible to accurately anticipate the direction and magnitude of change in IOFC from change in many of the feeding, breeding, genetic, health and management factors reported on the monthly DHI-202 Herd Summary Form. The size of herd appears to have more of an impact on which factors determine IOFC than it does on the actual level of IOFC, implying that a positive flow of IOFC can be achieved at any herd size, though not neccessarily portending positive profits, which depend further on fixed costs and debt load. The finding reflects the fact that operators of different size farms have different managerial concerns. The beta coefficients presented in this report (most of which are statistically significant at the one percent level and almost all of which are significant at the five percent level) are offered in the hope of helping producers improve short run financial decisions during periods of uncertainty and transition.

REFERENCES

Andrus, D,F., and McGilliard, 1975. "Selection of Dairy Cattle for Overall Excellence. " Journal of Dairy Science. 58(12) :1876.

Bakker, J.J., R.W. Everett and L.D. Van Vleck. 1980. "Profitability Index for Sires, " Journal of Dairy Science. 63(8):1334.

Balaine, D.S., R.E. Pearson and R. H. Miller. 1981. "Profit Functions in Dairy Cattle and Effect of Measures of Efficiency and Prices. " Journal of Dairy Science. 64(1):87

Balaine, D.S., R.E. Pearson and R.H. Miller. 1981. "Repeatability of Net Economic Efficiency in Dairy Cattle and Role of Some Economic Variables and Its Predictors. " Journal of Dairy Science. 64(1):96

Bath, D. L. and L. F. Bennett. 1980. "Development of a Dairy Feeding Model for Maximizing Income Above Feed Cost for Dairy Cattle." Journal of Dairy Science. 63(8):1379

Bath, D.L., G.A. Hutton, Jr. and E.H. Olson. 1972. "Evaluation of Computer Program for Maximizing Income Above Feed Cost From Dairy Cattle." Journal of Dairy Science. 67(3):661

Congleton, W.R., Jr. and L.W. King. 1984. "Profitability of Dairy Cow Herd Life." Journal of Dairy Science. 67(3):661

Dean, G.W., D.L. Bath and S. Olayide. 1969. "Computer Program for Maximizing Income Above Feed Cost from Dairy Cattle." Journal of Dairy Science. 52(7):1008.

Economic Research Service. 1985. Dairy: Outlook and Situation Report. Washington: vs. Department of Agriculture (US-400):9.

Gibson, S. 1984. "Should You Change Your Strategy for Today's Situation?" Hoard's Dairyman. 129(13):807.

Grisley, W. 1985. Dairy Management Practices and Pennsylvania Dairy Farm Incomes, 1983. University Park, The Pennsylvania State University (AE + RS # 179):1-2,30-32.

Holmann, F.J., C.R. Shumway, R.W. Blake, R.B. Schwart and E.M. Sudweeks. 1984. "Economic Value of Days Open for Holstein Cows of Alternative Milk Yields with Varying Calving Intervals." Journal of Dairy Science. 67(3):636.

Jones, G.M., W.R. Murley and S.B. Carr. 1980. "Computerized Feeding Management Systems for Economic Decision-Making." Journal of Dairy Science. 63(3): 495.

Knutson, R.D., C.A, Hunter, Jr. and R. B. Schwart, Jr. 1981. The Texas Dairy Industry: Trends and Issues. (College Station : Texas Agricultural Experiment Station B-1362): 4, 20.

Norman, H. D., B. G. Cassell, R. E. Pearson and G. R. Wiggans. 1981. "Relation of First Lactation Production and Conformation to Lifetime Performance and Profitability in Jerseys." Journal of Dairy Science. 64(1):104.

Olds, D., T. Cooper and F. A. Thrift. 1979. "Effect of Days Open on Economic Aspects of Current Lactation." Journal of Dairy Science. 62(7):1167.

Pearson, R.E. and R. H. Miller. 1981. "Economic Definition of Total Performance, Breeding Goals, and Breeding Values for Dairy Cattle," Journal of Dairy Science. 64(5):857.

Reyes, A.A., R. W. Blake, C.R. Shumway and J.T. Long. 1981. "Multistage Optimization Model for Dairy Production. " Journal of Dairy Science. 64(10):2003.

Reyes, A.A., C.R. Shumway, R.W. Blake and J.T. Long. 1980. "Profit Potential and Risk from Alternative Dairy Feeding Practices. " Dairy Research in Texas - 1980. College Station, Texas Agricultural Experiment Station (PR 3733-3651):64.

Richardson, J.W. 1984. "Description and Application of a Dairy Simulation Model." Dairy Short Course : 1984 Proceedings. College Station : Texas Agricultural Extension Service, 24.

Schwart, R.B., Jr. 1985. "The Economic Environment of the Dairy Industry." Dairy Policy Options for 1985. College Station: Texas Agricultural Extension Service, 24.

Shumway, C.R., A.A. Reyes and R.W. Blake. 1982. "Profitability and Risks in Dairy Feeding Programs : A Multiperiod Optimization." Southern Journal of Agricultural Economics. 14(2):77.

Texas Crop and Livestock Reporting Service. 1982. 1982 Texas Livestock, Dairy and Poultry Statistics. Austin : Texas Department of Agriculture, 16-18, 21-22.

Tigges, R. J., R.E. Pearson and W.E. Vinson, 1984. "Use of Dairy Herd Improvement Variables to Predict Lifetime Profitability." Journal of Dairy Science. 67(1):180.

Voelker, D.E. 1981. "Dairy Herd Improvement Associations." Journal of Dairy Science. 64(6):1269.

Williams, E.B. 1985. Correlation Analysis of Dairy Practices and Management Factors on New York Dairy Farms, 1982. Ithaca : Cornell University (A.E. Res. 85-3):46,52-55.

ANDROSTENONE AEROSOL AND AZAPERONE INJECTION INFLUENCE ON PIG AGGRESSIVE AND SUBMISSIVE BEHAVIORS

Robert J. Hurst and John J. McGlone[1]

ABSTRACT

A total of 80 nursery-age pigs were used to compare the effectiveness of azaperone and androstenone on reducing the aggressive and submissive behavior in freshly mixed pigs. Forty pairs of unfamiliar barrows and gilts were placed in pens for 24 hr. Duration of aggressive and submissive behavior by each pig were recorded and analyzed. Results showed that androstenone reduced the total duration of aggressive and submissive behavior to levels below that of the control pigs ($p = .069$). This effect was eliminated for aggressive behavior when both azaperone and androstenone were applied ($p > .4$). Both azaperone and androstenone reduced submissive behavior below control levels ($p < .05$). In conclusion, androstenone is more effective than azaperone an reducing pig agonistic behaviors, and androstenone's anti-aggressive property was reduced when given in combination with azaperone.

Key Words: Pigs, behavior, aggression.

INTRODUCTION

Often during normal hog farm operations, unfamiliar pigs are brought together and fight to establish a dominance order. This fighting causes decreased productivity and possible injury to the pigs involved (reviewed in McGlone, 1986). Androstenone, a naturally occurring pheromone in pigs, has previously been shown to reduce aggressive behavior in nursery-age pigs (McGlone and Morrow, 1988). Recently, intramuscular injections of azaperone, also was shown to reduce aggressive behavior in pigs and cause mild traquilizing effects (Gonyou et al., 1988). This study was designed to determine the effectiveness of androstenone, azaperone or both drugs in combination in reducing agonistic behavior (aggressive and submissive) in nursery-age pigs.

METHODS

A total of 80 five- to eight-week old pigs were used to determine the effect of azaperone on their agonistic behaviors. Unfamiliar pigs were matched by weight, placed into barrow-gilt pairs and randomly assigned to one of four treatments. Treatments were 1) androstenone only (5 μg/pig, dissolved in isopropyl alcohol, aerosolized and applied to each pigs' snout), 2) azaperone[2] (2.2 mg/kg, im injection), 3) androstenone and azaperone and, 4) no treatment (control).

Two blocks were used with 24 pairs in the first block conducted over six days and 16 pairs in the second block over four days. Each day, four pairs (one pair/treatment) were placed in separate 2 x 2 m pens and administered treatments. Each pen was equipped with a 5-hole feeder along one side from which feed was available ad libitum. A nipple waterer was on the opposite side of the pen.

Pigs were video taped via time-lapse video recorders for 22 h after placement in pens. After testing, pigs were removed to pens away from pigs yet to be tested. Videotapes were later summarized to determine duration of agonistic behavior (aggressive and submissive behavior). Aggressive behavior was defined as alternating pushes and bites. Submissive behavior was registered when one pig turned its body away from the attacking pig. These agonistic behaviors were derived from the ethogram collected by McGlone (1985).

Video records were viewed at three times real-time speed. Filming was at a speed of one frame per 1.2 seconds. Data were registered in an electronic event recorder using validated data collection techniques (Arnold-Meeks and McGlone, 1986).

There were 10 complete blocks in this study. Data were analyzed using analysis of variance as a randomized complete block with a 2 x 2 factorial arrangement of treatments (SAS, 1985). Behavior data were normalized by performing a log transformation. However, for simplicity, data are presented as raw means (p-values represent transformed data). Means were separated by the least-significant difference test.

RESULTS AND DISCUSSION

Results for agonistic behaviors are shown in Table 1. Submissive behavior was reduced in pigs treated with androstenone ($p < .05$), regardless of azaperone treatment. Azaperone had no effect on pig submissive behavior. Aggressive behavior was not significantly affected by treatments. This finding is in contrast to previous studies that showed androstenone and azaperone each reduced pig aggression (Gonyou et al., 1988; McGlone and Morrow, 1988).

An examination of the means in the present study does, however, support the previous work. McGlone and Morrow found androstenone (in the same dose and application scheme as used here) reduced pig aggression by 90% ; in the present work androstenone-treated pigs had a 72% lower mean compared with the control. Gonyou et al., (1988) found azaperone reduced pig aggression by 39%; in the present study azaperone-treated pigs had 36% lower duration of aggression. Thus, experiment-wise replication of each drugs' anti-aggressive property was documented without in-study statistical significance.

The combination of azaperone and androstenone was less effective than androstenone alone in reducing total agonistic behavior (Table 1). This may be due to a sedative effect which appeared to occur in the pigs treated with azaperone — delaying fighting beyond when the androstenone may have worn off. The manufacturer suggests azaperone effects last six to eight hours.

Data in this study showed considerably more variation than previous work. Reasons for this increased variation are unclear. Normally five replicates per treatment are sufficient to detect treatment effects on agonistic behavior (McGlone, 1986). With 10 replications per treatment this study failed to replicate previous findings. Clearly a very poor understanding of mechanisms controlling pig agonistic behavior still exists, and this makes it difficult to consistently reduce this harmful behavior.

[1]Reserch Technician and Associate Professor, respectively, Department of Animal Science, Texas Tech University, Lubbock, Tx 79409-2141. Research supported by state of Texas line item for efficient production of pork. College of Agricultural Sciences publication number T-5-274.

[2]Stresnil, donated by Pitman-Moore, Washington Crossing, N.J. 08560.

Table 1. Effect of androstenone and azaperone on the agonistic behavior of nursey pigs.

		Duration of behavior, min.		
Treatment	N	Aggressive	Submissive	Total Agonistic
Androstenone	10	2.43	.83[b]	3.26[d]
Azaperone	10	5.52	1.21[b,c]	6.73
Androstenone+ azaperone	10	6.42	.89[b]	7.31
Control	10	8.58	1.74[c]	10.32[d]
Standard Error		2.14	.34	2.35
P-values				
Androstenone[a]		.280	.048	.219
Azaperone[a]		.591	.423	.168
Interaction		.192	.234	.168

[a]P-values associated with main effects.

[b,c]Means with common superscripts do not differ, P>.05.

[d]These means differ P= .069, by unprotected least significant difference test.

LITERATURE CITED

Arnold-Meeks, C. and McGlone, J.J. 1986. Validating techniques to sample behavior of confined, young pigs. Appl. Anim. Behav. Sci. 16:149-155.

Gonyou, H.W., K.A. Rohde Parfet, D.B. Anderson and R.D. Olson. 1988. Effects of amperozide and azaperone on aggression and productivity of growing-finishing pigs. J. Anim. Sci. 66:2856-2854

McGlone, J.J. 1985. A quantitative ethogram of aggressive and submissive behaviors in recently regrouped pigs. J. Anim. Sci. 61:559-565.

McGlone, J.J. 1986. Agonistic behavior in food animals review of research and techniques. J. Anim. Sci. 62:1130-1139.

McGlone, J.J. and J.L. Morrow. 1988. Reduction of pig agonistic behavior by androstenone. J. Anim. Sci. 66:880-884.

SAS, 1985. SAS User's Guide. SAS Institute , Cary NC.

GENETIC VARIABILITY IN MEASURES OF BEEF CATTLE IMMUNE RESPONSE

Janeen L. Salak, John J. McGlone, Julie L. Morrow, Robert J. Hurst and Ronnie D. Green[1]

ABSTRACT

The objective of this study was to determine if a relationship could be found between dam and offspring immune measures. A secondary objective was to determine the relationship between dam's performance (expected progeny difference, EPD) and her immune measures. The regression between dam and offspring was significant for number of white blood cells, indicating selection for this trait would be productive. White blood cell numbers were positively correlated with maternal EPD for birth weight (r=.34), weaning weight (r=.36) and yearling weight (r=.38). Number of peripheral lymphocytes was also correlated with maternal EPD for birth weight (r=.40), weaning weight (r=.37) and yearling weight (r=.38). These data indicate that selection for leukocyte numbers would be successful and that these traits are favorably correlated with measures of growth.

Keywords: Beef cattle, Immune response, Genetics.

INTRODUCTION

While much is known about genetic sources of variation in live animal performance, body composition and reproduction, relatively little is known about underlying genetic mechanisms of immune function. If immune function of domestic animals could be improved through selection, there could be substantial economic gains.

Previous studies have concentrated primarily on genetics of immunoglobulin and antibody response (Muggli et al., 1984; Gilbert et al., 1988). These studies have found , generally, that the heritability of immunoglobulin level is low and that progress from selection for this trait might be slow, yet possible. We know of no reports of heritability estimates of numbers of metabolic activity of beef cattle leukocytes. Therefore, the objective of this work was to obtain first approximations of the level of heritability of leukocyte numbers and function and to determine if variation in these traits was correlated with measures of performance. Later studies involving greater munbers would benefit from the hypotheses generated in this study.

METHODS

General: Twenty-eight purebred Angus cows and their calves (20 females, 8 males) were used in this study. Cows were 2 to 10 years old and calves were three to four months old and nursing their dams. Cows were fed during the preceding year to meet or exceed NRC recommended nutrient requirements of beef cattle (NRC, 1984). Cows were grazing wheat pasture of a sudan-sorghum hybrid during most of the year and were fed crop residues and protein supplement during times of the year when no pasture forage was available.

Bleeding and sample preparation: Each cow and her calf were bled on day 0 and day 7 (day 0 blood samples were used only for background antibody titer determinations). Blood samples were obtained via jugular vein using 20 ml syringes containing heparin. On day 0, cow and calf were injected subcutaneously with 1 ml of 40% sheep red blood cells (SRBC).

The blood samples were centrifuged for 20 minutes to separate plasma. Plasma samples were stored frozen in glass vials until assayed.

Immune measures: Blood samples obtained on day 7 were assayed for various immune measures. Blood smears were made using whole blood. The smears were fixed in methanol and stained with LeukoStat Solution I and II for differential counts. Total white blood cells (WBC) were counted using a hemocytometer.

The lymphocyte transformation assay (LTA) was used to determine metabolic activity of the T and B cells. Fifteen ml of blood were centrifuged for 20 minutes at 2000 RPM. Plasma was aspirated and placed in glass vials for later use. The buffy coat (which contains the white blood cells was removed and placed in a 15 ml conical centrifuge tube and mixed with Roswell Park Memorial Institute (RPMI) 1640 medium (with sodium bicarbonate and gentamicin sulfate). Ten ml of the buffy coat-RPMI mixture were layered onto 4 ml of histopaque and centrifuged at 1350 RPM for 40 minutes at 25°C. The opaque interface containing the mononuclear cells was aspirated and transferred to a clean conical centrifuge tube. The opaque interface was washed in RPMI and centrifuged at 2000 RPM for 10 minutes. The supernatant was removed and the cells were resuspended in 1 ml of RPMI. The cells were counted using a hemocytometer. The samples were diluted in RPMI supplemented with 10% fetal bovine serum (FBS) and a cell concentration of $5x10^6$ cells/ml was obtained.

Each sample ($5x10^6$ cells/ml) was added in triplicate to the wells of microtiter plates containing 100μl of the mitogens. Conconavilin A (Con A, 20μg/ml), Phytohemagglutinin (PHA 10μg/ml)), and Pokeweed (PWM 10μg/ml) were used as mitogens to stimulate B and T cell activity . The plates were incubated at 37°C in 5% CO_2 for 66 hours. After 48 hours, 100 μl of RPMI supplemented with 10% FBS. At 66 hours MTT (5 mg MMT/ml PBS) was added to each well and mixed thoroughly by repeated pipetting with the octapipette. Within an hour the plates were read using plate reader with a 600 nm filter.

An enzyme-linked immunosorbent assay was used to determine antibody levels of bovine IgG. The frozen plasma was thawed and used to measure IgG. The plasma samples were diluted (1:3000) in 10% Tween/PBS. The diluted test samples and standards were added in duplicate to the wells of bovine IgG coated microtiter plates. Rabbit anti-bovine IgG was added to each well. The plates were incubated for two hours at room temperature. The wells were emptied and washed three times. The enzyme linked goat anti- rabbit IgG linked to alkaline phosphatase was added to each well and incubated at room temperature for 1 hour. The wells were emptied and washed three times. The substrate solution was added to each well and incubated at room temperature for 30 minutes. The reaction was stopped by adding 2M NaOH to each well. The optical density of the wells was read at 405 nm and the amount of IgG present was determined.

Hemagglutination assay was used to determine dam and calf antibody response to SRBC. The plasma samples were thawed and heat inactivated in a 57°C water bath for 30 minutes. The heat inactivated samples were placed in the first wells of round -bottom plates in duplicate. PBS was added to all wells. The plates were

[1]Graduate student, Associate Professor, former Post-Doctoral Research Associate, Research Technician and Assistant Professor, Department of Animal Science, Texas Tech University, Lubbock, Tx. 79409-2141. This work was funded by a grant from the Houston Livestock Show and Rodeo and by the State of Texas Line Item for Efficient Production of Beef Cattle. Texas Tech College of Agricultural Sciences paper no. T-5-275.

diluted by removing 100µl of each sample with an octapipette and serially diluting each well from left to right, discarding the final 100µl. To each well 1% solution of SRBC was added and the plates were agitated for 1.5 minutes. The plates were covered and incubated at room temperture for 24 hours.

The titers were determined by the sedimented cells forming a distinct pattern on the bottom of the wells. The highest dilution giving a positive reaction determined the titer.

Statistical analyses and genetic parameter estimation: Data were analyzed by analysis of variance and covariance techniques employed on the general linear models procedures of SAS (1985) with effects of sire and sex of calf investigated as potential sources of variation. In order to estimate heritability of various immune meaures, the regression of offspring performance on dam performance was estimated and doubled (Falconer, 1981). In cases involving negative regression coefficient, heritability levels were assumed to be zero. Residual correlations between measures of growth and maternal performance (in the form of expected progeny differences, i.e. breeding values from the American Angus Associations national cattle evaluation program) and those of immune fuction were also estimated using covariance analyses. While the number of observations in this study was certainly limited, the objective was to identify possible trends for future study.

RESULTS

The relationships between cow and calf immune measures are presented in Table 1. A correlation (p<.05) was found between cow and calf total white blood cells and lymphocyte numbers resulting in a high estimate of heritability for these traits. Offspring-dam regression coefficients were low for LTA data, with LTA for pokeweed mitogen exhibiting a trend (p=.069). Thus, resulting heritability estimates for LTA data were all low or zero.

Table 1. Relationship between cow and calf immune measures.

Immune Measures	b^*	SE_b	h^2	r^{**}	P
IgG, mg/ml plasma	-.13	.15	0	-.17	.403
SRBC titer	-.04	.21	0	-.04	.849
Total WBC, no/µl	.60	.28	1.20	.39	.040
Lymphocytes, no/µl	.53	.38	1.06	.27	.171
Neutrophils, no/µl	-.35	.04	0	-.16	.431
Monocytes, no/µl	-.05	.62	0	-.02	.932
Eosinophils, no/µl	-.03	.22	0	-.27	.173
Lymphocyte transformation					
Background	.00	.00	0	.11	.583
PHA mitogen	-.01	.02	0	.13	.530
Pokeweed mitogen	.03	.02	.06	.36	.069
ConA mitogen	.08	.06	.16	.24	.227

*Regression coefficient of offspring on dam.
**Correlation between offspring and dam measures.
P refers to P-value associated with b- and r-values.

Table 2. Correlations between EPD's and cow immune measures.

Immune Measures	EPD Birth Weight	EPD Weaning Weight	EPD Weaning Maternal	EPD Yearling Weight
IgG, mg/ml plasma	-.09	.03	-.05	-.02
SRBC titer	.11	.01	-.17	.20
Total WBC, no/µl	.34$^+$	.36$^+$	-.17	.38$^+$
Lymphocytes, no/µl	.40*	.37$^+$	-.19	.38$^+$
Neutrophils, no/µl	.10	.15	-.02	.18
Monocytes, no/µl	-.01	.04	-.22	.09
Eosinophils, no/µl	-.17	-.02	-.07	-.03
Lymphocyte transformation				
Background	-.25	-.20	.20	-.26
PHA mitogen	-.15	-.06	.27	-.17
Pokeweed mitogen	-.18	-.07	.23	-.17
ConA mitogen	-.12	-.09	-.01	-.06

$^+$ P < .10

* P < .05

EPD = Expected progency difference estimated by National Cattle Evaluation program of American Angus Association, St. Joseph, MO (1988).

Correlations between EPD and cow immune measures are presented in Table 2. Cow's total WBC and number of lymphocytes were favorably correlated with EPD for birth, weaning and yearling weights (p<.10 or p<.05).

Sire effects on calf immune measures are presented in Table 3. Sire had an effect on calves' response to PHA mitogen (p≤.05) in the lymphocyte transformation assay. Sires A, B, and D showed greater LTA under PHA mitogen than sire C.

Table 3. Sire effects on immune measures.

Immune measures	Sire A	Sire B	Sire C	Sire D
IgG, mg/ml plasma	1.20	1.83	1.07	1.21
SRBC titer	3.18	2.71	3.33	3.50
Total WBC, no/µl	12255	14407	11200	12343
Lymphocytes, no/µl	8888	9650	8696	9472
Neutrophils, no/µl	2885	4282	2426	2851
Monocytes, no/µl	166	151	32	429
Eosinophils, no/µl	315	325	46	83
Lymphocyte transformation				
Background	.19	.18	.11	.17
PHA mitogen	.35^a	.38^a	.23^b	.32^a
Pokeweed mitogen	.33	.32	.22	.27
ConA mitogen	.29	.28	.24	.25

a,b Means with same superscript are not significantly different, (P < .05).

Table 4. Sex effects on immune measures.

Immune measures	Male	Female	P*
IgG, mg/ml plasma	.99	1.49	.12
SRBC titer	4.29	2.75	.03
Total WBC, no/μl	11656	13120	.28
Lymphocytes, no/μl	8763	9375	.66
Neutrophils, no/μl	2361	3536	.12
Monocytes, no/μl	368	138	.11
Eosinophils, no/μl	153	271	.55
Lymphocyte transformation			
Background	.18	.17	.69
PHA mitogen	.27	.36	.002
Pokeweed mitogen	.28	.31	.34
ConA mitogen	.21	.29	.02

*Significance level of effect of sex of calf.

Sex effect on immune measures are presented in Table 4. SRBC titers were effected by sex of the calf. Male calves had higher titers ($p<.05$) than the heifer calves. Heifer calves had a higher lymphocyte response to PHA ($p<.01$) and ConA ($p<.05$) than bull calves.

DISCUSSION

These data represent a first attempt at understanding genetic variability in leukocyte numbers and function in beef cattle. The primary objective was to generate hypotheses to be tested in later studies with larger numbers. Immune measures which appear to offer the greatest genetic variability are numbers of WBC and lymphocytes. On the other hand, lymphoyte metabolic function (LTA in particular) seems to have a lower degree of heritability in these cattle.

It is not possible to say, at this point, which direction would be desirable (selecting for a greater or lower number of cells). Given a positive correlation between leukocytes numbers and EPD values, the authors predict that more leukocyte are preferred. However, a large-scale selection study should be addressed to this question.

A negative, but non-significant, correlation existed for WBC and lymphocyte numbers with EPD weaning weight maternal. This potential negative relationship between general maternal ability (primarily milk production) and leukocyte numbers should be viewed with caution at this stage, due to marginal significance and low numbers.

General lack of significant differences among sires may simply be a reflection of this particular sample of sires. A larger sample of sires would be desirable before firm conclusions should be drawn.

Sex effects in immune measures were not consistent. In absence of other evidence, differences due to sex were probably random and not biologically meaningful.

LITERATURE CITED

Gilbert, R.P., C.T. Gaskins, J.K. Hillers, J.S. Brinks and A.H. Denham. 1988 Inbreeding and immunoglobulin G_1 concentrations in cattle. J. Anim. Sci. 66:2490-2497.

Falconer, D.S. 1981. Introduction to quantitative genetics. Longman, New York. 339pp.

Muggli, N.E., W.D. Hohenboken, L.V. Cundiff and K.W, Kelley. 1984. Inheritance of maternal immunoglobulin G_1 concentration by the bovine neonate. J. Anim. Sci. 59:39-48.

NRC, 1984. Nutrient requirements of beef cattle. National Academy Press. Washigton, D.C.

SAS, 1985. SAS user's guide. SAS Institute. Cary, NC

ADDITIONAL REFEREED AGRICULTURAL/NATURAL RESOURCE RESEARCH PUBLICATIONS FROM THE ACT UNIVERSITIES (1987-1989)

Stephen F. Austin University

Cripps, R.W., Young, J.L., Bell T.L., Leonard, A.T. 1988. Effects of lime and potassium application on arrowleaf clover, crimson clover, and coastal bermudagrass yields, Journal of Production Agriculture. V.1, no. 4, Oct-Nov.

Cripps, R.W., Young, J.L., and Leonard, A.T. 1989. Effects of potassium and lime applied for costal bermudagrass production on sandy soil. Soil Science Society of Am.Jour. V.53, n.1. Jan-Feb.

Long, Rill R. and Cannon, Jeff. 1988. A comparison of foreign and domestic S.A.E. grade five metal fasteners. The Journal of Agricultural Mechanizaion. V. 3n. 2, Spring 19-25.

Tatum, Chris and Perritt, Dale. 1987. Perceptions of job readiness as measured by the Texas essential element competency profile scale. The Journal of Agricultural Mechanization. V.3 n.1 Fall, 23-30.

Stanly, T.J. 1988. NACTA annual meeting for the record. Journal of National Association of Colleges and Teachers of Agriculture. V. XXXII, N.3 September.

Texas A&I University

Baker, D.L., and F.S. Guthery. 1990. Effects of continuous grazing on habitat and density of ground-foraging birds in south Texas. J. Range Manage. 43:In press.

Boydstun, C.B. and C. A. DeYoung. 1987. Nesting success of white-tipped doves in south Texas. J. Wildl. Manage. 51:791-793.

Boydstyn, C.P., and C.A. DeYoung. 1988. Movements of white-tipped doves in southern Texas. Southwest. Naturalist. 33:365-367.

Cain, J. R., R. J. Lien and S. L. Beasom. 1987. Phytoestrogen effects on reproductive performance of scaled quail. J. Wildl. Manage. 51:198-201.

DeYoung, C.A., and J.C. Priebe. 1987. Comparison of methods for inventorying wild turkeys in south Texas. Proc. Annu. Cont. Southwest. Assoc, Fish and Wildl. Agencies. 41:294-248.

DeYoung, C.A. and S.L. Beasom. 1987. Improving Economic returns from hunting. Beef Cattle Sci. Handb. 21:690-695.

DeYoung, C. A. 1988. Comparison of net-gun and drive-net capture for white-tailed deer. Wildl. Soc. Bull. 16:318-320.

DeYoung, C.A., J.R. Heffelfinger, S.P. Coughlin, and S.L. Beasom. 1988. Accuracy of track courts as an estimator of white-tailed deer abundance. Proc. Annu. Cont. Southeast. Assoc. Fish and Wildl. Agencies. 42:in press.

DeYoung, C.A. 1989. Aging live white-tailed deer on southern ranges. J. Wildl. Manage. 53:in press.

DeYoung. C.A. 1989. Mortality of adult male white-tailed deer in south Texas J. Wildl. Manage. 53:in press.

Eastland, W.G. and S.L. Beasom. 1988. Acute toxicity of sodium monofluoreacetate to the striped skunk. Bull Environ. Contam. and Toxicol. 38:934-936.

Flenniken, K.S. and T.E. Fulbright. 1987. Effects of temperature, light, and scarification on germination of brownseed paspalum seeds. J. Range Manage. 40:175-179.

Fulbright, T.E., and K.S Flenniken. 1987. Temperature and scarification treatment effects on germination of prostrate bundleflower seeds. J. Range Manage. 40:170-173.

Fulbright, T.E., and S.L. Beason. 1987. Long-term effects of mechanical treatments on white-tailed deer browse. Wildl. Soc. Bull. 15:560-654.

Fulbright, T.E. 1988. Effects of temperature, water potential, and sodium chloride on germination of Indiangrass. J. Range Manage. 41:207-210.

Fulbright, T.E., and K.S. Flenniken. 1988. Causes of dormancy in Paspalum plicatulum (Poaceae) seeds. Southwestern Naturalist. 33:35-39.

Garza, A., and T.E. Fulbright. 1988. Comparative chemical composition of armed saltbush and fourwing saltbush. J. Range Mange. 41:401-403.

Guthery, F.S. 1987. Guidelines for preparing and reviewing manuscripts based on field experiments with unreplicated treatments. Wildl. Soc. Bull. 15:306.

Guthery, F.S., T.E. Shupe, L.J. Bareiss, and C.E. Russell. 1987. Responses of selected plants to herbicide treatment of disturbed soil. Wildl. Soc. Bull. 15:247-251.

Guthery, F.S., D.E. Capen, and N.E. Koerth. 1988. Guidelines for authors and reviewers of Wildife Society Bulletin manuscripts. Wildl. Soc. Bull. 16(1,Suppl.). 23pp.

Guthery,F.S. 1988. Line transect sampling of bobwhite density on rangeland: evaluation and recommendations. Wildl. Soc. Bull. 16:226-227.

Guthery, E.S. 1988. Perspectives on peer review. Wildl. Soc. Bull. 16:226-227.

Guthery, F.S. 1988.Review of Inventory and Monitoring of Wildlife Habitat. J. Wildl. Manage. 52:568.

Hellgren, E.C., D.W. Carney, N.P. Garner, and M.R. Vaughan. 1988. Use of breakaway cotton spacers on radiocollars. Wildl. Soc. Bull. 16:216-218.

Hellgren, E.C., R.L. Lochmiller, M.S. Amoss, Jr., S.W.J. Seager, S.J. Magyar, L.P. Coscarelli, and W.E. Grant. 1989. Seasonal variation in serum testosterone. testicular measurements, and semen characteristics in the collared peccary (Tayassu tauacu). J. Reprod. Fert. 85:677-686.

Hellgren E.C. and M.R. Vaughan. 1987. Home range and movements of winter-active black bears in Great Dismal Swamp of Virginia and North Carolina. Proc. Int. Conf. Bear Res. and Manage. 7:227-234.

Hellgren, W.C., and M.R. Vaughan. 1988. Seasonal food habits of black bears in Great Dismal Swamp, Virginia-North Carolina. Proc. Annu. Meet. Southeastern Fish and Wildl. Agencies. 42:in press.

Hellgren, W.C., M.R. Vaughan, and R.L. Kirkpatrick. 1989. Seasonal patterns in nutrition and physiology of the black bear in Great Dismal Swamp, Virginia-North Carolina. Can. J. Zool. In Press.

Hellgren, E.C., and M.R. Vaughan. 1989. Denning ecology of Black bears in a southeastern wetland. J. Wildl. Manage. 53:347-353.

Hellgren W.C., and M.R. Vaughan. 1989. Rectal temperatures of immobilized, snare-trapped black bears in Great Dismal Swamp. J. Wildl. Dis. In press.

Hyde, K.J., C.A. DeYoung, and A. Garza, Jr. 1987. Bed sites of white-tailed deer fawns in south Texas. Proc Annu Conf. Southwest. Assoc, Fish and Wildl. Agencies. 41:288-292.

Johnson, D.B., and F.S. Guthery. 1988. Loading converts used by northern bobwhites in subtropical enviroments J. Wildl. Manage. 52:464-469.

Johnson, D.B., and F.S. Guthery and N.E. Koerth. 1989. Grackle damage to grapefruit in the Lower Rio Grande Valley. Wildl. Soc. Bull. 27:46-50.

Johnson, D.B., F.S. Guthery, and A.H. Kane. 1990. Attributes of whistling posts used by northern bobwhites (Colinus virginianus). Southwestern Nat. In press.

Kelley, J.K., R.L. Lochmiller, E.C. Hellgren, and W.E. Grant. 1987. Vitamin A levels of Blood in collared peccaries (Tayassu tajacup) from south Texas. Comp. Biochem. Physiol. 86A:751-&53.

Koerth, N.E. and F.S. Guthery. 1987. Body fat levels of northern bobwites in south Texas. J.Wildl. Manage. 50:194-197.

Koerth, N.E., and R.S. Guthery. 1988. Reliability of body fat indices for northern bobwhite populations. J. Wildl. Manage. 52:150-152.

Kohl. T.F., C.A. DeYoung, and A. Garza, Jr. 1987. Effects of short duration grazing on deer home ranges. Proc. Annu. Cont. southeast Assoc. Fish and Wildl. Agencies. 41:299-302.

Kuti, J.O., T.J. Ng and G.A. Bean. 1987. Phytotoxic effects of trichothecene metabolites from pathogenic strains of Myrothecium roridum on muskmelon. Biodeterioration Research 1:213-222.

Kuti, J.O., T.J. Ng and G.A. Bean. 1987. Reactions of muskmelon cultigens to Myrothecium roridum. HortScience 22(4): 635-637.

Kuti, J.O., T.J. Ng and G.A. Bean. 1988. Isolation of cells and protoplasts from muskmelon leaves. Cucurbit Genetics Report 11:35-36.

Kuti, J.O., T.J. Ng and G.A. Bean. 1989. Possbile involvement of a pathogen-produced trichothecene metabolite in Myrothecium leaf spot of muskmelon. Physiol. Molecular Plant Pathology 34(1): 41-45.

Kuti, J.O. and T.J. Ng. 1989. Combining estimates for muskmelon tolerance to Myrothecium roridumps and its toxic metabolite, Roridin E.J. Amer, Soc. Hort. Sci. 114(2):319-321.

Leon, F.G., III, C.A. DeYoung, and S.L. Beasom. 1987. Bias in age and sex composition of white-tailed deer observed from helicopters. Wildl. Soc. Bull. 15:426-429.

Lochmiller, R.L. E.C. Hellgren, and W.E. Grant. 1987. Influences of moderate nutritional stress during gestation on reproduction of collared peccaries. J. Zool. (London). 211:321-328.

Lochmiller, R.L., E.C. Hellgren, and W.E. Grant, 1987. Physical characteristics of neonate, juvenile, and adult collared peccaries (Tayassu tajacu angulatus) from south Texas. J. Mammal. 68:188-194.

Lochmiller, R.L., E.C. Hellgren, W.E. Grant, and L.W. Varner, 1987. Urea concetration in collared peccary mild as an indicator of protein nutritional status. J. Wildl. Dis. 23:518-520.

Lochmiller, R.L., E.C. Hellgren, L.W. Varner, and W.E. Grant. 1988. Indices for Physiological assessment of nutritonal condition in pregnant collared peccaries (Tayassu tajacu) J. Wildl. Dis. 24:496-506.

Lochmiller, R.L., E.C. Hellgren, J.F. Gallagher, L.W. Varner, and W.E. Grant. 1989. Volatile fatty acids in the collared peccary (Tayasu tajacu) gastronintestinal tract. J. Mammal. 70:189-190.

Lochmiller, R.L., E.C. Hellgren, L.W. Varner, K. McBee, and W.E. Grant. 1989. Body condition indices for malnourished collared peccaries. J. Wildl. Manage. 53:205-209.

McCall, T.C., R.D. Brown, and C.A. DeYoung. 1988. Mortality of pen-raised and wild white-tailed deer bucks. Wildl. Soc. Bull. 16:380-384.

Rappole, J. and S.L. Beasom. 1987. Non-consumptive wildlife: an unexploited resource. Beef Cattle Sci. Handb. 21:684-689.

Schulz, P.A., and F.S. Guthery, 1988. Effects of short duration grazing on northern bobwhites: a pilot study. Wildl. Soc. Bull. 16:18-24.

Shupe, T.E., F.S. Guthery, and S.L. Beasom. 1987. Use of helicopter surveys of mammals in brushland. Wildl. Soc. Bull. 15:458-462.

Shupe, T.E. and S.L. Beasom 1987. Speed and altitude influences on helicopter surveys of mammals in brushland . Wildl. Soc. Bull. 15:352-555.

Springer, M.D., T.E., Fulbright, and S.L. Beasom. 1987. Long-term response of live oak thickets to prescribed burning. Tex. J. of Sci. 39:89-96.

Texas Tech University

Alecoazy, A.A., K.W. Selcer, J.R. Clark, J.M. Burns, R.L. Norman, G.D. Niswender and W.E. Leavitt. 1988. Pattern of ovarian progesterone secretion during the luteal phase of the ovine estrous cycle. Biol. Reprod. 39:287-294.

Barbarick, K.A., W.A. Anderson, D. R. Hicks, N. W. Hopper, G. Joliff, T.E. Loynachan and D.F. Post. 1988. Survey results evaluating the Journal of Agronomic Education. J. Agron. Educ. 17:63-68.

Barrigossi, J., L. Chandler and N. Lopes. 1988. Resposta fisiologica do feijoeiro (Phaseolus vulgaris L.) ao forate e suas consequencias entomologicas. III. Efeito sobre aspragas e producao do cultura, no plantio "das aguas". Revista Ceres. 35:355-369.

Barrigossi, J., L. Chandler and N. Lopes. 1988. Resposta fisiologica do feijoeiro (Phaseolus vulgaris L.) ao forate e suas consequencias entomologicas. IV. Efeito sobre as pragas e producao da cultura, no plantio da "seca". Revista Ceres. 35:370-387.

Barrighossi, J., N. Lopes and L. Chandler, 1988. Reposta fisiologica do feijoeiro (Phaseolus vulgaris). ao forate e suas consequencias entomologicas. I. Analise de crescimento e cibversai da ebergua solar. Revista Ceres. 35:327-340.

Barrigossi, J., N. Lopes and L. Chandler. 1988. Reposta fisiologia do feijoeiro (Phaseolus vulgaris L.) ao forate e suas consequencias entomologicas. II. Crescimento, morfologia, particao de assimilados e producao de materia seca das plantas. Revista Ceres. 35:341-354.

Bartle, S.J., S.W. Kock, R.L. Preston, T.L. Wheeler and G.W. Davis. 1987. Confirmation of urea space as a predictor of body compostion in cattle. J. Anim. Sci. 64:1024-1030.

Bartle , S.J., T.P. Eck and R.L. Preston. 1987. Dietary factors affecting feed intake in receiving feedlot cattle. Texas J. Agr. Natural Resources. 1:21-23.

Barlte, S.J., R.L. Preston and J.H. Bailie. 1988. Dose-response relationship of the ionophore tetronasin in growing-finishing cattle. J. Anim. Sci. 66:1502-1507.

Bartle, S.J., O.A. Turgeon, Jr., R.L. Preston and D.P. Brink. 1988. Procedural and Mathematical considerations in urea dilution estimation of body composition in lamb. J. Anim. Sci. 66:1920-1927.

Braulick, L.S., J.C. Cokendolpher and W.P. Morrison. 1988. Effect of acute exposure to relative humidity and temperature on four species of fire ants (Solenpsos, Formicidae, Hymenoptera). Texas J. Sci. 40(3):331-340.

Brinkley, C.K. and R.T. Ervin. 1987. Economic analysis of a feedlot biomass fuel and waste meal system. Biomass. 14:115-127

Bryant, F.C. and L. M. Smith. 1988. The role of wildlife as an ecomomic input into a farming or ranching operation. Pages 95-98 in J. E. Mitchell, ed. Impacts of the Conservation Reserve Program in the Great Plains. USDA Forest Service General Tech. Rep. RM-158.

Bunting, L. S., D. B. Mc Carthy, C.R. Richardson and R.W. Tock. 1987. Pilot plant production of sulfur dioxide treated mesquite wood. II. Digestibility and feedlot performance by lambs. J. Anim. Feed Sci. and Technol. Ainfeed No. 716.

Camilo, G.R. and J.C. Cokendolpher. 1988. Schizomidaw de Puerto Rico (Arachnida: Schizomida). Caribbean J. Sci. 24(1-2)52-59.

Carey, J.A., B.F. Craddock, A.Florez and F.C. Bryant. 1988. Effects of grazing strategy and stocking rates on wool quality and quantity in the Andes of Peru. J. Small Ruminant Res. 1:127-134.

Chandler, L. 1989. The broad-headed bug, megalotomus parvus (Westwiid) (Hemiptera: Alydidae), a dry season pest of beans in Brazil. Annu. Rep. Bean Improv. Coop. 32:84-85.

Claborn, D.M., S.A. Phillps, Jr. and H.G. Thorvilson. 1988. Diel foraging activity of Solemopsis invicta and two native species of ants (Hymenoptera: Formicidae) in Texas. Texas J. of Science. 40(1):93-99.

Cokendolpher, J.C. 1987. A new species of Fossil Pellobunus from Dominican Republic amber (Arachnida: Opiliones: Phalangodidae). Carribbean J. Sci. 22(3-4):205-211.

Cokendolpher, J.C. 1987. Observations on the defensive behaviors of a Neotropical Gonyleptidae (Arachnida: Opiliones). Rev. Arachnol. 7(2):59-63.

Cokendolpher, J.C. 1987. On the identity of the genus Homolophus: A senoir synonym of Euphalangium (Opiliones: Phalangiidae). Acta Arachnol. 35:89-96.

Cokendolpher, J.C. and J.R. Reddell. 1987. Supplementary descriptive notes on Schizomus liberiensis (Cook) (Schizomida, Schizomidae). J. Arachnol. 15(1):138-139.

Cokendolpher,J.C. and R.W. Sites. 1988. A new species of eyed Schizomus (Schizomida: Schizomidae) from Java. Acta Arachnol. 36:79-85.

Cokendolpher, J.C. 1988 Schizomids of Japan and the Republic of China (Arachnida: Schizomida). Bull. Natn. Sci. Mus, Tokyo. Ser. A, 14(4):159-170.

Cokendolpher, J.C. and W.D. Sisom. 1988. New gynandromorphic Opiliones and Scorpiones. Bull. British Arachnol. Soc. 7(9):278-280.

Cokendolpher, J.C., W.D. Sissom and S.B. Bastawade. 1988. A new Schizomus from the Indian state of Maharashtra, with additional comments on eyed schizomids (Arachnida: Schizomidae). Insects Mundi. 2(2):90-96.

Conner, M.C. and C. R. Richardson. 1987. Utilizaion of cotton plant residues by reminants. J.Anim. Sci. 65:1131.

Crocker, R.L., D.L. Morgan and M.T. Longnecker. 1987. Effects of microwave treatment of live oak acorns on germination and on Curculio sp. (Coleoptera: Curculionidae) larvae. J. Econ. Entomol. 80:916-920.

Currah, L.C. and E.B. Peffley. 1988. Chromsomal locations of two enzyme-coding genes in Allium fistulosum. Theoretical and Applied Genetics. 75:945-949.

Dawson, P.L., D.M. Janky, M.G, Dukes, L.D. Thompson and S. E. Woodward. 1987. Effect of post-mortem boning time during simulated commercial processing on the tenderness of broiler breast meat. Poultry Sci. 6:1331-1333.

Dawson, P.L., D.M. Janky, M.G. Dukes, L.D. Thompson and S.A. Woodward. 1988 Interaction of cooking method and chilling media on the tenderness and physical characteristics of broiler breast fillets. Poultry Sci. 67:715.

Dawson, P.L., D.M. Janky, M.G. Dukes, L.D. Thompson and S. A. Woodward. 1988. Tenderness of hot-bones broiler breast fillets chilled in either water or brine using two different chilling regimens. Poultry Sci. 67:1545.

Deliberto, T.J., J.A. Pfister, S. Demarais and J.S. Seel. 1988. Urea nitrogen in serum and vitreous humor of white-tailed deer. J. Wildl. Manage. 52:599-601.

Demarais, S., D.D. Everett and M.L. Pons. 1987. Seasonal comparison of endoparasites of nothern bobwhites from two habitat types in southern Texas. J.Wildl. Dis. 23:256-260.

Demarais, S., H.A. Jacobson and D.C. Guynn, Jr. 1987. Effects of season and area on ectoparasites of white-tailed deer in Mississippi. J. Wildl. Dis. 23:261-266.

Dermarais, S. and R.E. Zaiglin. 1988. Doe harvest effects Rangelands. 10:220-223.

Demarais, S., R.E. Zaiglin and D.A. Barnett. 1988. Effect of orphaning on physical development of white-tailed deer fawns. J. Range manage. 51:340-342.

Dickerson, R.L., Jr., B.E. Bahl and G. Scott. 1988. Cellulase vs rumen fluid for In Vitro digestibility of mixed diets J. Range manage. 41:337-339.

Eck, T.P., S.J. Bartle, R.L. Preston, R.T. Brandt, Jr. and C. R., Richardson. 1988. Protein source and level for incoming feedlot cattle. J. Anim. Sci. 66:1871-1876.

Elam, E. and B. Dixon. 1988. Examining the validity of a test of futures market efficiency. Journal of Futures Markets 8:365.

Elam, E. 1988. Estimated hedging risk for cash settlement versus delivery feeder cattle futures. Western Journal of Agricultural Economics. 3:45-52.

Elam, E. and D. Vaught. 1988. Risk and return in cattle and hog futures. Journal of Futures Markets. 8:79-87.

Epplin, F.M. and R.T. Ervin. 1988. Evaluating the use of an alternative breed type as a pest management strategy. North Central Journal of Agriclutural Economics. 10:225-232.

Ervin, R.T., F.M. Epplin, R.L. Bydord and J.A. Hair. 1987. Estimation and economic implications of Lone Star Tick (Acari: Ixodidae) infestation of gain response of stocker cattle, Bos taurus and Bos taurus X Bos indicas. Journal of Economic Entomology. 80:443-445.

Ervin, R.T.,D.E. Ethridge and B.G. Freeman. 1988. Economic feasibility of rangeland pest control via microcomputer models. Journal of the American Society of Farm Managers and Rural Appraisers. 52:76-81.

Ervin, R.T., D.E. Ethridge and B.G. Freeman. 1988. Economic evaluation of tobosagrass prescribed burning with the use of a microcomputer. Rangelands. 10:184-186.

Ethridge. D.E., J.D. Nance and B.E. Dahl. 1987. Integration of cattle production and marketing strategies with improved pastures and native range. J.Range Manage. 40(3):199-202.

Ethridge, D.E. and J.T. Neeper. 1987. Producer returns from cotton fiber strength annd uniformity: An hedonic price approach. Southern Journal of Agricultural Econimics. 19(1):91-97.

Fish, E.B. 1987. Water quality trends in Guadalupe Mountains National Park, Texas. Contributed Papers of the Second Symposium on Resources of the Chihuahuan Desert Region: United States and Mexico. Series No. 10. Chihuahuan Desert Research Institute. Alpine, Texas. 16p.

Forwood, J.R., A.G. Matches and C.J. Nelson. 1988. Forage yield, carbohydrate levels and quality trends of caucasian bluestem. Agron. J. 80:135-139.

Gomez, J.G., B.L. McMichael, A.G. Matches and H.M. Taylor. 1987. Impact of variability in forage legumes and development on seedling establishment. Proc. Sym. on: The role of legumes in conservation tillage systems. Univ. of Georgia, April 27-29, 1987. Pp. 20-21/

Habib, A., R.E. Zartman and R.H. Ramsey. 1988. Intrapedal macropore distribution and infiltration rate of three Friona Polypedons. Soil Science 145(4):244-249.

Hansmire, J.A., D.L. Drawe, D.B. Wester and C.M. Britton. 1988. Effect of winter burns of forbs and grasses of the Texas Coastal Prairie. Southwest. Nat. 33(3):333-338.

Hawkins, R.R., G.W. Davis, J.K. Cable, Jr. and C.B. Ramsey. 1987. Fragmentation index as an early postmortem predictor of beef tenderness. J. Anim. Sci. 64:171.

Henke, S.E., S. Demarais and J.A. Pfister. 1988. Digestive capacity and diet selectivity of white-tailed deer and exotic ruminants in Texas. Wildl. Mange. 52:595-598.

Hopper, N.W. and H.R. Hinton. 1987. Electrical conductivity as a measure of cottonseed viability. Agron. Jour. 79:147-152.

Hupp,J.W., J.T. Ratti and L.M. Smith. 1988. Gray partridge food habits in eastern South Dakota. Great Basin Naturalist 48:202-205.

Johnson, R.C., J.Kebede, D.W. Mornhinweg, B.F. Carver, A.L. Rayburn and H.T. Nguyen. 1987. Photosynthetic differences among Triticum accessions at tillering. Crop Sci. 27:1046-1050.

Johnston, L.J., D.E. Orr, Jr., L. F. Tribble and J.R. Clark. 1987. Effect of body condition and floor material on sow performance. J. Anim. Sci. 64:36-42

Jones, S.R. and S.A. Phillips, Jr. 1987. Aggressive and defensive propensities of Solenopis invcta (Hymenoptera: Fomicidae) and three predominant ant species indigenous to Texas. Texas J.Science. 39:107-115.

Krieg, D.R. 1987. Maximum cotton yields in a short growing season enviornment. Proc. Natl. Fluid Fertilizers in Agronomic Production." pp.66-71.

Krieg, D.R. and M.R. Morrow. 1988. Maximum cotton yields in short growing season environment. Proc. Natl. Fluid Fertilizer Foundation Symposium. "Fluid Fertilizer Research as A Basis for Efficient Crop Production." pp. 160-171.

Lloyd, R.W. and D.R. Krieg. 1987. Cotton development and yield as affected by insecticides. J.Econ. Ento. 80:854-858.

Masters, R.A. and C.M. Britton. 1988. Response of WW517 old world bluestem to fertilization , watering, and clipping Texas J. Agr. Nat. Resour. 2:48-53.

Masters, R.A., K.L. Marietta and C.M. Britton. 1988. Response of yucca (Yucca glauca) to fire, herbicides, and mechanical treatments. Texas J.Agr. and Nat. Res. 2:4-7.

Matches, A.G. 1987. Proper techniques in grazing trails. Abst. No. 94, Southern Sect. Amer, Soc, Anim, Sci. p.41.

Matches, A.G. 1987. Technical considerations in grazing management research. Proc. 43rd. Southern Pasture and Forage Crop Improvement Conference. Clemson, NC. pp. 49-50.

Matches, A.G. 1987. Steer gains on embark treated forage-sorghum pastures. Agron. Abst. p. 144.

Mathis, W.K. 1988. Economic dimensions of changes in U.S. agriculture. J. Amer. Studies Assoc. Texas. 19:83-90.

Meng, T.P., H.M. Taylor, D.W. Fryrear and J.F. Gomez. 1987. Models to predict water retention in Sandy soils. Soil Science Society of America 51:1563-1565.

Mertes, J.D., Clarke, M.L. and Grist, R. 1987. County nature conservancy: A joint use venture. Parks and Recreation. 22(8):42-48.

Mertes, J.D. and Kaiser, R.A. 1987. Drafting defensible park exaction ordinances for your community. California Parks and recreation. California Park and Recreation Society, Inc. 43(3):26-33.

Mertes, J.D. and Kaiser, R.A. Permissible parameters of park exactions. University of Detroit Law Review. 65(1):1-32.

Mertes, J.D. and Hirner, D.K. 1988. Greenlining: Countryside parks come of age in the United States. Renewable Resources Journal. 6(1):17-20.

Miller, M.F., G.W. Davis, A.C. Williams, Jr., C.B. Ramsey and R.D. Galyean. 1987. Acceptability of beef patties extended with pork and/or textured soy protein. J. Food Qual. 10(2):117.

Miller, M.F., G.W. Davis, A.C. Williams, Jr., C.B. Ramsey and R.D. Galyean. 1987. Palatability and appearance traits of beef/pork meat patties. J.Food Sci. 52:886.

Morgan, D.L. 1987. Louisiana iris—a "new" crop for the South. Proc, S.N.A. Res. Conf. 32:328-331.

Mosely, J.C., D.B. Wester and S.C. Bunting. 1987. Estimating herbaceous yield from species frequency. Northwest Sci. 61(1):55-59.

Murphy, B.R., L.M. Smith, D.J. Lee and D.R. Terre. 1988. Forensic discrimination of exotic and native ungulates Wildlife Society Bulletin 16:24-27

McFarlane, J.M., G.L. Morris, S.E. Curtis, J.Simon and J.J. McGlone. 1988. Some indicators of welfare of crated veal calves on three dietary iron regimens. J. Anim. Sci. 66:317-325.

McGlone, J.J., S.E. Curtis and E.M. Banks. 1987. Evidence for aggression-modulating pheromones in prepuberal pigs. Behav. Neural. Biol. 47:27-39.

McGlone, J.J., J.L. Morrow. 1987. Individual differences among mature boars in T-maze preference for estrous of nonestrous sows. Anim. Behav. Sci. 17:77-82.

McGlone, J.J, W.F. Stansbury and L.F. Tribble. 1987. Effects of heat stress, social stress and their interaction on young pig performance and behavior. J. Anim. Sci. 65:456-462.

McGlone, J.J. and F.Blecha. 1987. The welfare of sows and piglets: examination of behavioral immunological and productive traits in four management systems. Appl. Anim. Sci. 18:269-286.

McGlone, J.J. and J.L. Morrow. 1988. Modulation of pig agonstic behavior by androstenone. J. Anim. Sci. 66:880-884.

McGlone, J.J., W.F. Stansbury and L.F. Tribble. 1988. Management of lactating sows during heat stress: effects of water drip, snout coolers, floor type and a high energy-density diet. J. Anim. Sci. 66:885-891.

McGlone, J.J., W.F. Stansbury, L.F. Tribble and J.L. Morrow. 1988. Photoperiod and heat stress effects on sow and litter performance and photoperiod effect on nursery pig performance. J. Anim. Sci. 66:1915-1919.

McGlone, J.J., C.K. Akins and J.L. Morrow. 1988. Preliminary study on sexual behavior of socially dominant and subordinate boars in a seminatural environment. Texas J. Agric. and Nat. Resources 2:7-9.

McGlone, J.J. and J.M. Hellman. 1988. Social and general anesthetic effects on behavior and performance of 2 and 7 week old castrated and non-castrated piglets. J. Anim. Sci. 66:3049-3058.

Paulson, C.E. and M.A. Tucker. 1988. A descriptive study of characteristics, interests and career objectives of agricultural communications students. The AEC Quarterly. 71(3):10-16.

Pederson, R.L. and L.M. Smith. 1988. Policy, planning and science: integrating disciplines for management of wetlands and wildlife. Transactions of the North American Wildlife and natual Resources Conference 53:431-435.

Peffley, E.B. and C. Orozco-Castillo. 1987. Polymorphism of isozymes in plant introductions of Allium cepa L. and A. fistulosum L. HortScience 22:(5):956-957.

Phillips, S.A. Jr., W.M. Rogers, D.B. Wester and L. Chandler. 1987. An ordination analysis of any faunae in definitive habitats along the range expansion front of Solenopsis invicta Buren (Hymenoptera: Formicidae) in south-central Texas. Texas J. Agric. and Nat. Res. 1:11-15.

Pitts, J.S. and F.C. Bryant. 1987. Steer and vegetation response to short duration and continous grazing. J.Range Manage. 40:383-389.

Preston, R.L., S.J. Bartle, T. May and S.R. Goodall. 1987. Influence of sarsaponin on growth, feed and nitrogen utilization in growing male rats fed diets with added urea or protein. J. Anim. Sci. 65:481-487.

Reese, K.P., J.A. Kadlec and L.M. Smith. 1987. Characteristics of islands when selected by nesting Canada geese. Canadian Field-Naturalist. 101:539-542.

Reiner, R.J. and F.C. Bryant. 1987. Forage intake of alpacas grazing Andean rangeland in Peru. J. Anim. Sci. 64:868-871.

Roberts, F.H., C.M. Britton, D.B. Wester and R.G. Clark. 1988. Fire effects on tobosagrass and weeping lovegrass. J. Range Manage. 41(5):407-409.

Robinsion, J.R. and D.E. Ethridge. 1988. Simplified short-run price forecasting models for wheat and corn. Texas Journal of Agriculture and natural Resources. 2:37-40.

Rollins, D., F. C. Bryant, D.D. Waid and L.C. Bradley. 1988. Deer response to several intensities of brush removal in central Texas. Wildl. Soc. Bull. 16:277-284.

Schad, R.T. and R.T. Ervin. 1987. Production of cash market grain sorghum versus contracting hybrid seed. Texas Journal of Agriculture and Natural Resources. 1:8-10.

Schramm, H.L. Jr., P.J. Haydt and K.M. Portier. 1987. Evaluation of pre-release, post-release and total mortality of tournament-caught largemouth bass in two Florida lakes. N. Am. J. Fish. Manage. 7:394-402.

Schramm, H.L., Jr, M.W. Collopy and E.A. Okrah. 1987. Potential problems of bird depredation to fish culture in Florida. Prog. Fish-Cult. 49:44-49.

Schramm, H.L. Jr., K.J. Jirka and M.V. Hoyer. 1987. Epiphytic macroinvertebrates on dominant macrophytes in two central Florida lakes. J. Freshwater Ecol. 4:151-161.

Schramm, H.L. Jr. and K. J. Jirka. 1989. Effects of aquatic macrophytes on benthic macroinvertebrates in two Florida lakes. J. Freshwater Ecol. 5:1-12.

Segarra, E. and D.B. Taylor. 1987. Farm level dynamic analysis of soil conservation: An application to the piedmont area of Virginia. So. J. Agric. Econ. 19:61-73.

Sites, R.W. and H.G. Thorvilson. 1988. The first records of the white fringed beetle, Graphognathus leucoloma (Coleoptera: Curculionidae) in New Mexico and Texas. Fla. Entomol. 71(4):657-659.

Smith, L.M. 1988. Lack of vertebrate herbivory in playa wetlands. Wetlands 8:193-197.

Stansbury, W.F., J.J. McGlone and L.F. Tribble. 1987. Effects of season, floor type, air temperature and snout coolers on sow and litter performance. J. Anim. Sci. 65:1507-1513.

Stoecker, B.J. , Y.C. L, D. B. Wester and S. B. Chan. 1987. Effects of torula and brewer's yeast diets in obese and lean mice. Biol. Trace Element Research 14:249-254.

Taber, S.W., J. C. Cokendolpher and O. F. Francke. 1987. Scanning electron microscopic study of North American Pogonomyrmex (Hymenoptera: Formicidae) from Lubbock, Texas. Entomo. News. 98(4):153-158.

Taber, S.W., J.C. Cokendolpher and O.F. Francke. 1987. Supercooling points of red imported fire ants, Solenopsis invicta (Hymenoptera: Formicidae) from Lubbock, Texas Entomol. News. 98(4):153-158.

Taber, S.W. and J.C. Cokendolpher. 1988. Karyotypes of a dozen ant species from the southwestern U.S.A. (Hymenoptera: Fomicidae). Caryotogia. 41(2):93-102.

Taber, S.W., J.C. Cokendolpher and O.F. Francke. 1988. Karyological Study of North America Pogonomyrmex (Hymenoptera: Formicidae). Insectes Sociaux. 35(1):47-60.

Taylor, H.M. 1987. Soil structure and plant performance. Trasactions of International Society of Soil Science. 5:301-309. Hamburg, Western Germany.

Tereshkovich, G. 1987. Coming out from underneath the bushel Hort. Sci. 22(5):699.

Tereshkovich, G. 1988. Professionalism and ethics needed in Horticulture. Hort. Sci. 23(5):818 Abs.

Thompson, L.D., D.M. Janky and S.A. Woodward. 1987. Tenderness and physical characteristics of broiler breastfillets harvested at various times form post-mortem electrically stimulated carcasses. Poultry Sci. 66:1158-1167.

Thorvilson, H.G., S.A. Phillips, Jr., A.A. Sorenson and M.R. Trostle. 1987. The Straw itch mite, Pyemotes trictici (Acari: Pyemotidae), as a biological control agent of red imported fire ants, Solenopsis invicta (Hymenoptera: Formicidae). Fla. Entomol. 70:439-444.

Thorvilson, H.G., S. A. Phillips, Jr. and A.A. Sorensen. 1989. An innovateve thermo-funigation technique for control of red imported fire ants (Hymenoptera: Formicidae). J. Agr. Entomol. 6(1):31-36.

Tinsley, B.E., E.B. Fish and J.F. Giardino. 1988. An image enlargement technique. Journal of Geography. 87:190-191.

Tock, R.W., R.S. J. Chen and C.R. Richardson. 1987. Snythesis of polymer structures from lignocellulose feedstocks. J. Chem. Engr. Comm. 359-86.

Turner, M.S., D.L. Morgan and D.W. Reed. 1987. The effect of light quality and fertility on long term interior maintenance of selected foliage plants. J. Environ. Hort. 5:76-79.

Turner, M.A., D.W. Reed and D.L. Morgan. 1987. A comparison of light acclimtiztion methods for reduction of interior leaf drop in Ficus spp. J. Environ. Hort. 5:102-104.

Turner, M.A., D.W. Reed and D.L. Morgan. 1987. Ethylene-induced defoliation on Ficus species and thylene depletion by soil bacteria in peat-amended media and In vitro. J. Amer. Soc. Hort. Sci. 113(5):794-796.

Upchurch, D.R., B.L. McMichael and H.M. Taylor. 1988. Use of minirhizotrons to charcterize root system orientation. Soil Sci. Soc. Amer. J. 52:319-323.

Wang, W.C., C.A. Beyl and G.C. Sharma. 1988. Effect of culture media and auxin source on Ward wheat cell suspension containing clumps and single cells. Cereal Research Comm. 16(1-2):69-76.

Wester, D.B. and H.A. Wright. 1987. Ordination of vegetation change in Guadalupe Mountains, New Mexico. Vegetation 72:27-33.

Wheeler, T.L., G.W. Davis, B.J. Stoecker and C.J. Harmon. 1987. Blood serum and tissue cholesterol traits of Chianina and British crossbred beef. J. Anim. Sci. 65:1531.

Wiggins, T.A. 1987. The influence of farm machinery. The Journal of Agricultural Mechaniztion. 2(2):12-18.

Wilcox, B.P. and F.C. Bryant. 1987. An evaluation of range condition on one range site in the Andes of central Peru. J. Range Manage. 40:41-45.

Wilcox, B.P., B.L. Allen and F.C. Bryant. 1988. Selected properties of soils in the high Andean puna of central Peru. Geoderma 42:79-94.

Zack, R.S. and R.W. Sites. 1988. A new species of Donaceus Cresson (Diptera: Ephydridae) from Malaysia. Proc. Entomol Soc, Wash. 90(1):101-105.

Zartman, R.E. and K.S. Hutmacher. 1987. Earth seltered structures: Soil temperature variation and site aesthetics. Tex. J. of Ag. and Nat. Res. 1:29-32.

REVIEWERS FOR VOLUME 3

The editorial board of the Texas Journal of Agriculture and Natural Resources wishes to recognize the revie of the manuscripts for Volume 3 of the Journal and to thank them for their contribution to the Journal.

Dr. John T. Baccus	Southwest Texas State University
Dr. Sam L. Beasom	Texas A&I University
Dr. Robert D. Brown	Texas A&I University
Dr. James E. Casey, Jr.	Sam Houston State University
Dr. W. Arden Colette	West Texas State University
Dr. D. Thomas Duryberry	Southwest Texas State University
Dr. Del Davis	Sul Ross State University
Dr. Mike Ellebrock	East Texas State University
Dr. Gil R. Engdahl	Angelo State University
Dr. R. Terry Ervin	Texas Tech University
Dr. Don Ethridge	Texas Tech University
Dr. Ernest B. Fish	Texas Tech University
Dr. Tim Fulbright	Texas A&I University
Dr. Robert E. Kinucan	Sul Ross State University
Dr. Jimmy T. LaBaume	Sul Ross State University
Dr. Roy V. Miller, Jr.	Southwest Texas State University
Dr. Ted H. Montgomery	West Texas State University
Dr. David G. Moorman	Sam Houston State University
Dr. R.Dale Perritt	Stephen F. Austin University
Dr. Glen M. Rydl	Southwest Texas State University
Dr. Eduardo Segarra	Texas Tech University
Dr. Don L. Shelby	Angelo State University
Dr. Michael E. Tewes	Texas A&I University
Dr. Ronald L. Thomason	West Texas State University
Dr. Donald L. Williams	West Texas State University
Dr. Kenneth O. Wilson	West Texas State University
Dr. Leonard W. Wilson	West Texas State University
Dr. J. Leon Young	Stephen F. Austin State University

MANUSCRIPT INFORMATION

Four copies of the manuscript are to be submitted to the editorial board member representing the ACT institution from which the article originated. Manuscripts submitted by individuals outside ACT Universities may be submitted directly to the Editor-in-Chief or to one of the ACT University editors.

After receipt of the manuscript, the Editor-in-Chief will select two reviewers to serve as referees for the manuscript. One of the referees will be a member of the editorial board and the other an approved faculty member from one of the ACT Universities.

Manuscripts are to be typed on 8 1/2 x 11 inch paper. Text is to be double spaced. The **Publication Manual of the American Psychological Assocation - 3rd Edition** is to be used as the style manual in preparing the paper.

All manuscripts should contain and/or conform to the following items:

1. A descriptive title, with name(s) of author(s). The author's title and affiliation are to be footnoted at the bottom of the first page of the manuscript.

2. An abstract not to exceed 200 words followed by Key words for referencing and cataloging.

3. An introduction including:
   a. A brief review of literature. The author-date system of citing references is to be used in the text of the manuscript.
   b. A statement as to the purpose or need for the study.

4. A materials and methods or a description of the procedures section.

5. A report of the data, observations or results followed by or including discussion, recomendations and/or conclusions.

6. A reference section that lists the literature cited in the paper by alphabetical order of the first author.

7. Tables, if included, should be planned to fit a full page width of 6 1/2". Tables are to be numbered consecutively according to their citation in the text.

8. Figures (photographs, graphs, charts, and diagrams), if included, must be high contrast black and white on heavy white paper. High contrast computer printouts are acceptable. Figures are to be numbered consecutively according to their citationin the text.

9. Tables and figures, are to be noted as to their position in the manuscript .e.g, **Place Table 1 Here.**

10. The English system is the preferred method to be used to express weights and measurements.

ACT MEMBERSHIP