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SUPPLEMENTATION OF A DRY ANNUAL RANGE SIMULATING ROUGHAGE BY USE OF IRRIGATED PASTURE

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Beef production per unit of land, percent calf crop, weaning weight and, in general, thriftiness of animals can be increased on dry, annual-range forage by supplemental feeding of protein (Guilbert *et al.,* 1944; Wagnon *et al.,* 1959). Protein supplementation based on the chemical composition of dry, annual-range forages has been suggested by Wagnon *et al.* (1942) and Weir and Torrell (1959). Hull and Meyer (1962) and Meyer and Hull (1962) have shown that irrigated pasture can supply sufficient protein and other nutrients for reasonable growth and fattening when used as a supplement to a protein-deficient, high-energy ration. Grazed, irrigated forage might, therefore, adequately supplement a low-protein ration such as that from an annual range during the dry season. Comparative average costs (Federal-State Market News Service, 1967) for a protein source (cottonseed meal) and for irrigated pasture production (Raguse *et al.,* 1967) support the approach of using irrigated pasture as an economical protein supplement. Based on these cost data, a unit of protein from cottonseed meal could cost as much as three equivalent units from irrigated pasture. A 2-yr. study to investigate the performance of grazing animals when irrigated pasture is fed with a low-protein high-fiber forage such as dryland annual range to maximize yield of animal products per unit land area is reported in this paper.

Experimental Procedure

For these studies a dry ration to be fed in drylot was formulated to simulate a mid-season, dry, California-type, annual range forage (table 2). A conventional low-protein high-fiber forage such as barley straw was not fed as other workers (Lofgreen *et al.,* 1962) have shown a progressive lowering of voluntary intake for each increment of straw added to a drylot ration. Palatability, therefore, and the levels of crude fiber and protein, based on the reports of Green *et al.* (1958), Wagnon *et al.* (1942) and Weir and Torrell (1959) were the attributes considered in the formulation of a substitute dry range forage. These workers reported that, for annual range during the dry season, crude protein varied between approximately 3% to 7% and crude fiber between 30% to 40%. Vitamin A concentrate, a calcium-phosphorous supplement (oystershell flour), and plain salt were added to the formulated ration or otherwise provided. The formulated ration primarily composed of oat hay, almond shells and almond hulls, was palatable and eaten readily by the animals in all treatments where it was fed. The ration was fed to group lots of steers, as later described, in drylot.

Good to choice yearling beef feeder steers were used. The animals were vaccinated against infectious bovine rhinotracheitis, treated for intestinal parasites, and individually identified (number branded). During the experiment each animal was weighed every 28 days after an overnight stand without feed or water. The steers were randomly allotted to the various treatments (table 1). These were: (1) dry ration only, in drylot, (2) dry ration in drylot plus weekly grazing (9 hr./wk.) on alternate irrigated pasture fields, (3) the dry ration in drylot plus twice weekly grazing (18 hr./wk.) using alternate fields, (4) dry ration in drylot plus daily grazing on irrigated pasture (14 hr./day) with a five-field rotation, (5) irirgated pasture only, using a five-field rotation with a 7-day grazing time per field, resulting in a 28-day recovery interval for the forage between grazings, (6) dry ration in drylot, adjusted with cottonseed meal to meet NRC (1958) protein requirements for growing yearling steers. Treatment 3 was conducted for only 1 yr.; the remainder were conducted for 2 years. The dry ration was fed daily, *ad libitum,* except in treatment 4, where the dry ration intake was limited to approximately one-half that consumed by the animals in treatment 6.

A uniform new seeding of orchardgrass

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TABLE 1. EXPERIMENTAL DESIGN

Dry ration	Daily[a]		Daily[a]		Daily[a]		Daily[a]		None		Daily+CSM	
Irrigated pasture[b]	None		Once weekly		Twice weekly		Daily		Daily		None	
Treatment no.	1		2		3		4		5		6	
Year	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967
No. of animals	8	8	8	8	..	8	8	8	8	8	8	8
No. of days	110	147	110	147	..	147	110	147	110	175	110	147

[a] 5.6% crude protein dry ration.
[b] 24% crude protein.

(*Dactylis glomerata L.*), ryegrass (*Lolium perenne L.*), Ladino clover (*Trifolium repens L.*) and strawberry clover (*Trifolium fragiferum L.*) was used for the irrigated pasture supplement. An adjacent drylot was used for feeding the dry ration. The pastures were irrigated adequately to avoid moisture stress. The first year, 28 days prior to the start of the experiment, the forage was harvested by a field-chopper the prescribed number of days before the start of grazing, to establish the desired recovery interval for rotational grazing (Hull *et al.,* 1960). The second year the desired recovery interval was established by harvesting excess forage with grazing animals. Forage removed was not credited to the experiment.

The trials were started each spring as soon as the rate of forage growth was deemed sufficient to not limit animal gains in the five-field rotational grazing treatments. In all instances the stocking rates (animal grazing days per unit area of pasture) were based on previous work (Hull *et al.,* 1965) and were considered to be of medium intensity.

Protein content of the irrigated pasture forage was determined from forage samples obtained at random prior to entry of the grazing animals. From previous work on this type of irrigated pasture (Hull *et al.,* 1965), this protein content would be expected to be maintained for the experimental grazing season and in any case would be well above the NRC (1958) requirements for growing beef steers.

Specific gravity of a representative group of animals slaughtered before the experiment began, and of all animals at the end of the trial, was determined as described by Garrett *et al.* (1959). Empty bodyweights were estimated by the method proposed by Lofgreen *et al.* (1962). Body composition was estimated by the methods of Garrett and Hinman (1968). Energy gain and composition of the gain made by the animals during the experiment were calculated by subtracting the average initial body energy or composition from final body energy or composition.

TABLE 2. SIMULATED DRY RANGE FORAGE RATION

Ration constitutent[a]	Low protein	Adequate protein
	%	%
Oat hay	40	40
Almond hulls	28	18
Almond shells	30	30
Tallow	2	2
Oystershell flour	0.5	0.5
Cottonseed meal (41.6% CP)	..	10
Chemical analysis		
Crude fiber	30.6	29.9
Crude protein	5.6	10.7
Ether extract	4.2	4.8
Ash	8.7	8.3

[a] 16 gm. vitamin A concentrate (30,000 I.U./gm.) per 100 kg. ration.

Results and Discussion

When analyzed statistically, the data indicated no significant differences for any of the criteria in table 3 between the 2 yr. of the trial. Therefore, for statistical interpretations, the data of the 2 yr. were combined into a simple analysis of variance using unequal subclass numbers and Duncan's (1955) test for differences among means.

Response to the treatments varied with the amount of protein available (table 3). Animals on treatments 5 (pasture only) and 6 (dry ration supplemented with cottonseed meal) responded similarly for the criteria considered. When irrigated pasture was limited (treatment 4) so the animals would consume an amount of dry ration equivalent to approximately one-half the daily dry ration intake of treatment 6, the results were comparable to those with treatments 5 and 6. Daily gains, however, decreased when access to pasture was limited to either twice-weekly (treatment 3), or once-weekly (treatment 2) grazing. This decrease in daily gain was significantly different for each grazing treatment. With treatment 2, once weekly grazing (a stocking rate nine times the normal rate for animals

TABLE 3. ANIMAL RESPONSE TO A LOW PROTEIN RATION SUPPLEMENTED BY IRRIGATED PASTURE GRAZED AT VARYING FREQUENCIES OR BY COTTONSEED MEAL

Dry ration	Daily[a]	Daily[a]	Daily[a, b]	Daily[a]	None	Daily+CSM[c]
Irrigated pasture[d]	None	Once weekly	Twice weekly	Daily	Daily	None
Treatment no.	1	2	3	4	5	6
Animals/treatment	16	16	8	16	18	16
Animal days	1056.0	1028.0	1176.0	1028.0	1156.0	1056.0
Area per treatment, ha.	..	0.15	0.31	0.77	1.50	..
Animals per ha. of pasture	..	53.0	26.0	10.0	6.0	..
Average daily gain, kg.	0.15[h]	0.29[h]	0.47[g]	0.73[f]	0.59[f, g]	0.78[f]
Initial wt. kg.	283.7	287.1	267.0	275.6	272.7	274.2
Dry ration consumed/hd/day, kg. DM	7.35	6.19	6.08	4.33	..	9.70
Carcass data						
U.S.D.A. carcass grade[e]	3.25[h]	3.8[g, h]	5.4[f, g]	5.3[f, g]	5.7[f]	6.5[f]
Backfat, cm.	0.38[i]	0.45[g, h]	0.61[f, g, h]	0.86[f, g]	0.92[f]	0.99[f]
Ribeye area, $cm.^2$	49.3[g]	57.0[f]	56.4[f]	63.0[f]	64.3[f]	60.0[f]
Percent fat	19.3	19.3	19.7	21.1	21.0	22.6
Percent protein	17.5	17.6	17.5	17.1	17.2	16.8

[a] 5.6% crude protein.
[b] One yr. only.
[c] 10.7% crude protein.
[d] 2[illegible]% crude protein.
[e] 2–4 Standard; 5–7 Good.
[f, g, h, i] Means on the same line having the same superscript do not differ significantly ($P<.05$).

entirely on irrigated pasture), plus the dry ration, prevented loss of weight; however, weight gain was reduced markedly. Cattle fed only the low-protein dry ration (treatment 1) were unable to maintain body weight after 90 days (figure 1). Daily gains of animals on treatment 3 (twice-weekly grazing) were intermediate between those having free access to pasture (pasture only group) and those grazed once a week (treatment 2).

As the dry ration was fed to group lots, no statistical analysis of the amount consumed was made. However, the dry feed was weighed to these lots twice daily so some general observations on the daily eating patterns of the steers (treatment 1) can be made. Daily intake varied, as expected, but no long-range patterns of intake were apparent. Dry ration intake by steers with limited access to irrigated pasture (treatments 2 and 3) increased slightly for about 2 days following grazing. It then declined 1 or 2 kg. to a stable intake about the third day following grazing, but increased again after the next grazing. Animals that grazed daily tended to consume larger amounts of dry ration as time progressed toward the seventh day in a rotationally-grazed field, concurrent with an apparent decrease in forage availability. In all cases the dry ration was consumed in amounts comparable to that reported by Van Dyne and Meyer (1964) for a dry annual range.

The NRC (1958) requirement for a 275-kg. yearling steer is 0.68 kg. of crude protein/day. This amount could have been obtained from 2.9 kg. (dry weight) of irrigated pasture forage, as the dried forage contained 24% crude protein. The 2.9 kg. is approximately 50% of what a 275-kg. steer grazing on a medium-stocked, irrigated pasture would consume per day (Hull *et al.*, 1961). Steers would have to consume 12.1 kg. daily of the low protein dry ration (table 2), approximately 5% of their bodyweight, to meet the recommended daily allowance of crude protein from this source.

Carcass data from treatment 1 (low protein, unsupplemented dry ration) were significantly different from the other treatments (table 3) except for carcass grade where treatments 1 and 2 were similar (low protein, unsupplemented dry ration and dry ration supplemented once a week by grazing). Carcass data from treatments 3, 4, 5 and 6 were also similar (dry ration supplemented twice a week by grazing, dry ration with daily grazing, pasture only, and protein-supplemented dry ration lots).

A more complete measure of the response to supplementation must take fill into account. In general, the amount of fill was proportional to the amount of dry ration consumed (table 4). When the data were calculated taking fill into account (on an empty body basis), significant differences occurred among treatment

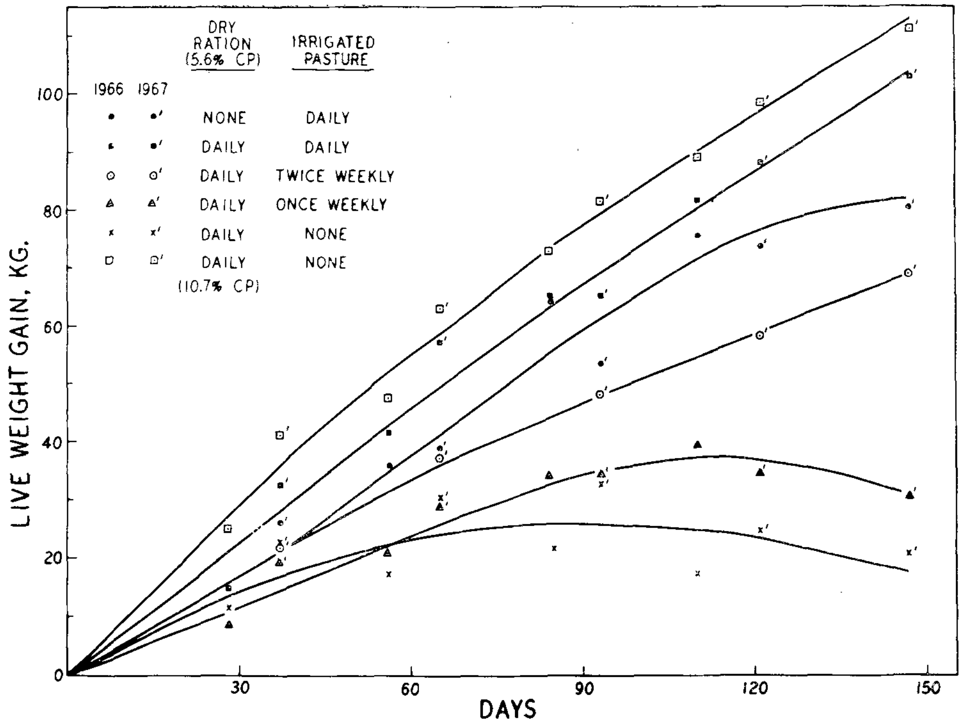

Figure 1. Liveweight gain as influenced by various combinations of irrigated pasture with low- and adequate-protein dry ration.

groups (table 4). These differences were proportional to the amount of protein available.

An approximated maintenance level of production was obtained when the data for the entire experimental period were averaged for treatment 1 (figure 1 and table 4, dry ration only), making it possible to calculate energy for maintenance in the dry ration—1.77 megcal./kg. dry matter. Energy gain per day indicated that the dry ration, when supplemented with cottonseed meal to increase the protein content to 10.7%, was able to supply energy similar to that supplied by the irrigated pasture for production of bodyweight gain—0.76 megcal./kg. dry matter.

Composition of the daily gain of the steers was dependent upon protein content of their diet (figure 2, and table 4). For steers receiving only the low-protein dry ration, there was a net loss of protein and empty body water, while empty body ash remained essentially constant. This loss of empty body protein and

TABLE 4. COMPOSITION OF THE WEIGHT GAIN

Dry ration	Daily[a]	Daily[a]	Daily[a]	Daily[a]	None	Daily+CSM[b]
Irrigated pasture	None	Once weekly	Twice weekly	Daily	Daily	None
Treatment no.	1	2	3	4	5	6
Final liveweight, kg.	302.9	322.9	336.5	368.0	351.2	374.6
Final empty bodyweight, kg.	244.8	272.6	282.8	322.1	314.7	320.2
Final fill, kg.	58.1	50.3	53.7	45.9	36.5	54.4
Empty bodyweight gain/day, kg.	0.02[f]	0.20[e]	0.42[d]	0.62[c]	0.64[c]	0.62[c]
Empty body protein gain/day, kg.	0.029[h]	—.009[g]	0.045[f]	0.085[d]	0.097[c]	0.073[e]
Empty body fat gain/day, kg.	0.091[d]	0.137[c, d]	0.209[c, d]	0.259[c]	0.229[c, d]	0.264[c]
Energy gain/kg. empty body, megcal.	2.63	2.59	2.86	2.73	2.73	2.55
Energy gain/day, megcal.	0.013[f]	0.512[d, e]	1.095[d, e]	1.800[c]	1.612[c, d]	1.822[c]
Total energy gain, megcal.	1.8	65.8	161.0	231.5	235.5	240.5

[a] 5.6% crude protein.
[b] 10.7% crude protein.
[c, d, e, f, g, h] Means on the same line having the same superscript do not differ significantly (P<.01).

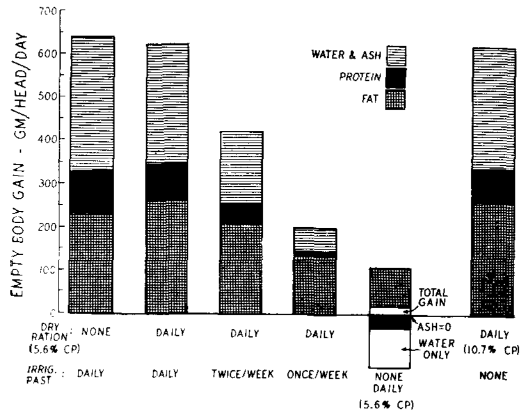

Figure 2. Composition of empty bodyweight gain as influenced by diet.

water was not great enough to offset the greater energy value of fat gained. Therefore, the net result for this treatment was a small, daily empty bodyweight gain consisting of fat. The amount of protein gain per day was related to protein intake, for as protein intake decreased, so did protein in the carcass (figure 2). Differences in body fat gain were not as great as differences in body protein gain, and were positive for all treatments. It might be postulated that some of the fat gain was broken down to meet other needs of the animal body when protein intake is inadequate. This same phenomenon—loss of protein while gaining fat—has been reported by Lofgreen *et al.* (1963) for animals receiving only a maintenance level of alfalfa hay.

Figure 3 gives relationships between gain per animal and gain per unit area as regards liveweight gain and energy gain for the different irrigated pasture grazing treatments. Liveweight gain and energy gain per animal were, in general, inversely related to energy gain per hectare of the grazed irrigated pasture. This emphasizes the need to consider results from any grazing trial on both a per animal and per unit area basis.

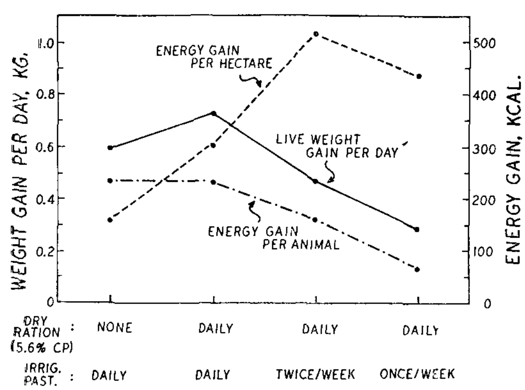

Figure 3. Influence of combinations of irrigated pasture and low-protein ration on per animal and per hectare weight and energy gains.

Based on previously cited cost data (Federal-State Market News Service, 1967 and Raguse *et al.,* 1967) and the experimental results reported herein, it appears that it would be both feasible and economical to use high-quality irrigated pasture as a low-cost protein source. A desired level of production may be obtained by adjusting grazing time on irrigated pasture when an animal's main diet is a low-protein dry ration. The dry rations fed gave results not too dissimilar to those observed by Wagnon *et al.* (1942) and Van Dyne and Meyer (1964) for cattle grazing a dry annual range. The dry ration, therefore, might be used as a tool for preliminary studies on dryland annual-range production problems.

Summary

A 2-yr. study was made of the effects of supplementing a low-protein (5.6%) high-fiber (30.6%) ration with varying amounts of irrigated pasture. A synthetic ration—oat hay, almond shells and almond hulls—was used to simulate a dry, annual-range forage. An orchardgrass-ryegrass-Ladino clover-strawberry clover pasture was used as a supplement daily, twice weekly, or once weekly in some treatments.

Animal response varied with the amount of irrigated pasture (protein) available. Intake of dry ration was inversely related to the amount of irrigated pasture available.

Energy gain per animal varied with the treatments. Animals on a low-protein diet (unsupplemented) had a positive fat gain but negative protein and body water gain. Fat gain per day remained positive regardless of treatment.

Consideration of body fill emphasized differences in response to treatments.

Liveweight and energy gain per animal were inversely related to energy gain per hectare of grazed irrigated pasture.

It is proposed that irrigated pasture could be used as an economical source of supplemental protein for a low-protein high-fiber forage. The dry ration is proposed as a simulated range feed to be used in range research studies.

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