PERFORMANCE OF LACTATING COWS ON DIGITARIA PASTURE UNDER DIFFERENT STOCKING RATES WITH OR WITHOUT ADDED CONCENTRATES

by

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INTRODUCTION

Sown pasture, if well managed by man and efficiently utilized by animals, may be about the cheapest source of livestock feed for economic animal production, (Koch et al. 1971, Appendix Table A).

An increased emphasis on pasture as a complete and cheap source of food for livestock has been one of the recent trends toward efficient and profitable livestock production in tropical countries. Efficient grassland management should ensure an adequate supply of pasture capable of sustaining high-yielding milk cows (Hamilton, 1952, Holmes, 1954, Castle et al. 1960), yet almost all the dairy herds in Nigeria, excluding those of Fulanis, are being fed supplementary concentrates during the wet season when the pastures should be at their best nutritionally. Minimum amounts of concentrates should be fed to milking cows, depending on individual productivity, when there is an ample amount of lush, nutritive grass. Money thus saved on the wet season feeding programme can then be invested in the dry season feeding programme.

Under a system of rotational grazing, on established pasture of good quality, maintenance and the first 5.44 kg of milk production can be obtained off grass alone (Phipps, 1970).

For decades the meagre and seasonal amount of milk supplied to the consumers has been in the hands of the nomadic Fulani cattlemen using their badly managed and low producing local breeds. Because of sociological and cultural characteristics of nomadic Fulani, it has not been possible to settle them in order to improve their animal management and production programmes. However, as a result of importation of exotic breeds and subsequent availability of crossbred cattle which are potentially high producers, it is desirable to improve grazing environment if these animals are to prove their worth under an economic, intensive grazing programme.

McMeekan (1956) found that important aspects of grassland management under the farmer's control which affect the efficiency of

conversion of grass into animal products are, grazing method, kind of animal used and stocking-rate. The yield of animal products from grassland depends upon the efficiency with which herbage is removed from the field and utilized in the animal body. In order that pasture may be fully utilized, attention must be given to the design of grazing management techniques which will be economical, practical and profitable to the progressive mixed dairy farmers in the Guinea Savannah of Nigeria.

Studies reported here were designed to investigate performance of lactating dairy cows on Pangola grass (Digitaria sp.) under a system of rotational grazing using various stocking rates with or without concentrate supplementation.

LITERATURE REVIEW

Pasture establishment

Pangola grass is one of the most recent examples of a plant that has been successfully introduced and well established in the tropics. The genus Digitaria belongs to the family Panicea and has world-wide distribution in tropical areas (Henard, 1950). It is found in areas characterized by fertile soils, seasonal rainfall and generally high temperatures (Osbourn, 1969). It has been introduced into many tropical countries including West Africa since 1953 (Nestel et al. 1962). Successful introduction is due to the fact that it is easily established, it is vigorous and adaptable, it persists under intensive grazing and it is palatable to livestock (Osbourn, 1969). Its stoloniferous habit makes vegetative propagation relatively easy, in that both stolons and mature stems will produce adventitious roots in a humid atmosphere; and the plants can cover the ground within 6 to 8 weeks, even when only 2 or 3 plants take root per square yard (Romney, 1961). In Caribbean areas the actual cost of procuring and planting Pangola grass has been estimated at about 100 shillings per acre (Nestel, 1964); and at Shika (Zaria, Nigeria) the cost of the same operation is 50 shillings per acre (personal communication).

In comparison with Guinea grass, in terms of tolerance to variations in grazing intensity and careful management needed, Pangola grass could be more confidently distributed to livestock farmers who have had relatively little experience or knowledge of grazing management (Osbourn, 1969). Even with low fertilizer application and periodic over-grazing Pangola grass pastures can be maintained without replanting for at least 8 years. At experimental stations in both Florida and Jamaica, stands over 10 years old are to be found (Nestel, 1964). Nevertheless, trials have associated increased milk production on Pangola grass per acre with increased fertilizer use (Clark, 1959; Van Der Molen, 1960).

Herbage sampling

In general, cutting techniques have been recommended to measure the forage available before and after grazing and, by difference, the quantity consumed. These methods are laborious and can introduce very high sampling errors. They can also lead to difficulties in fresh-weight estimations when rain or dew has wetted the grass. Although dry-matter determinations avoid these surface moisture errors, they do introduce additional sampling errors (Joblin, 1962).

Cutting techniques have theoretical as well as practical disadvantages, in that bias is introduced when stock graze above or below the height of the mower (Raymond, 1948) and bias can also arise from allowances made for growth during the grazing period (Raymond, 1957). The highly selective grazing action of the local Zebu cattle increases the chances of grazing intake being different than mown samples would indicate (Joblin, 1962).

Three random one-square-yard unprotected sample plot were cut with sheep-shears before and after grazing by Joblin (1962). As this was laborious, the method was replaced by diagonal cuts made with an Allen motor scythe. Joblin (1962) further reported that the visual method has the outstanding virtue of simplicity, but the bias which could be introduced would depend on the skill and impartiality of the observers and would be very difficult to predict.

Alder et al. (1962) took herbage samples from grazing paddocks immediately before and after grazing to obtain an estimate of herbage offered and herbage consumed. Sample areas 6ft x 3in. (1.5 sq. ft) were cut with a Wolseley sheep shears on each occasion.

Mott (1960) found herbage yield samples, cut at a height of one and a quarter inches, may not give a true indication of herbage availability as steers may graze closer than this to the soil.

Freer (1954) cut ten samples, each from a 0.6 sq. ft area, before grazing on the day before the cows shifted. Each sampling unit was randomly sited within a proportionate area of the paddocks. The herbage within the quadrat was cut as close as possible to ground level, with hand shears. The samples were bulked and sub-sampled and proximate analysis was carried out. The weight of herbage dry matter available in each paddock immediately before grazing was calculated from the results of the dry-matter determinations on the herbage samples. His results indicated that, in the herbage available on the area grazed at the higher stocking rate the percentage of crude protein was higher and of crude fibre lower than in the herbage from the other area.

Castle et al. (1960) took samples of herbage at least twice a week from the sward which the cows were grazing. The samples were cut by shears to a level similar to that left by the animals. The dry-matter content was determined and subsequently samples analysed for crude protein and crude fibre also.

Intake and utilization

Intake, here refers to the amount of grass dry matter consumed by the animals and utilization indicates the conversion of the consumed material into animal products. To date there are no reliable methods for estimating voluntary intake of feeds either under grazing (Milford, 1961) or in the laboratory (Minson, 1971a) and most comparisons of the intake of the tropical pasture species are derived from indoor feeding trials with cattle or sheep.

Insufficient intake of digestible energy is the feed factor primarily responsible for limiting production under practical farming conditions.

The voluntary intake of Pangola grass declines with increasing maturity (decreasing digestibility) in a way similar to that observed with temperate grasses (Osbourn, 1969). In this respect it is unlike tropical forages because Milford and Minson (1966) have shown that the

voluntary intake of many tropical forage is largely unrelated to maturity.

It is a fact that herbage may be wastefully used under grazing conditions owing to excessive consumption leading to only small responses in animal production for a large increase in intake (Holmes et al. 1964).

Greenhalgh et al. (1960) reported in some of their studies that they found intake to be related to weight, milk yield and live-weight gain of the animals. In many instances these three factors account for over 90 per cent of the variability in intake although it is not always so.

Husted-Anderson (1941), Sjollema (1950) found a correlation between feed intake of grazing cattle and milk yield and more recently clipping methods have confirmed this (Cox, 1956). Clipping methods have been superceded by indigestible marker/feacal index methods (Raymond et al. 1955, Smith, et al. 1955, Wallace, 1956). Several studies by these methods agree with the view (Brody, 1945, Kleiber, 1959) that feed intake is largely accounted for by live weight, liveweight gain and milk yield of the cow. (Hancock, 1958, Reid, 1959, Wallace, 1956, Cox, 1956, Corbett, 1961).

Freer (1954) reported that cows at higher stocking rate ate, at each grazing all the herbage that had grown since the previous grazing, whereas the intake of the cows at the lower stocking rate was equivalent to only 80 per cent of this regrowth.

The level of milk yield has been shown to exert an effect on dry-matter intake by Jarl (1952), Cox (1956) McCullough (1956), Holmes (1963) and MacLusky (1955). Body weight remains the dominant factor in the multiple relationships given by these workers. Other workers, Kruger et al. (1955), Legates et al. (1956), Wallace (1956) and Hutton (1962), have shown that cows do not reach maximum dry-matter intake until 6-16 weeks after calving, at which time production is falling. It is, however, now generally agreed that once peak consumption has been reached, the level of milk yield will influence intake for the rest of the lactation (Baker, 1964).

From the findings of Armstrong (1960) and Crampton et al. (1960), it could be suggested that the intake of very young highly digestible herbage is probably not limited by its filling effect in the reticulo-rumen. Wheeler et al. (1963) found no significant correlation between the weight of herbage per acre and the intake of digestible organic matter by sheep.

The direct measurement of feed intake on pasture gives a better understanding of grazing efficiency by measuring the individual feed intakes of cattle by the use of the chromic oxide-faecal nitrogen techniques (Holmes et al. 1964). The problems here are those connected with the efficiency of recovery of chromic oxide and the accuracy of estimation of digestibility.

Hancock (1958) remarked that since the sampling-clipping technique, which he carried out, failed to measure total feed intake accurately, it was not feasible to estimate directly the relative efficiency of production under his feeding systems. It has however, been possible to estimate the nutrient intake of free grazing dairy cows with reasonable accuracy when their milk production, body weights and liveweight increments are known (Wallace, 1957). The total digestible organic matter (D. O. M.) intakes were estimated for the experimental animals using the following equation:

$$Y = 0.3_{x_1} + 2.5_{x_3} + 0.86_{x_1}$$

Where x_1 = F. C. M. lb, x_2 = L. W. O. 73, and

x = lb growth increment.

When feed available per animal is restricted the efficiency of utilization is higher although maximum animal production may not be obtained (Mott, 1961).

Efficiency of pasture use in part depends on the productivity of the animals, but attainment of a stocking rate which ensures a high grazing pressure is essential. Miller (1961) reported that Zebu milking stock did not respond normally to improved nutritional

conditions; and he suggested animal intake as a possible limiting factor. Glover et al. (1961) offered the same explanation for low milk yields in Boran type Zebu cattle.

Leaver et al. (1968) reported a greater response from concentrate for high producing cows. They suggested that one of the reasons for the small response to concentrate feeding was that it reduced the total dry matter intake and only slightly increased the intake of total digestible nutrients.

Grazing management

The objective of grazing management may be defined as an effort to ensure a large supply of nutritious grazing throughout the grazing season at a reasonable cost and to utilize it in such a manner that physical wastage of herbage and inefficient utilization by the animal are minimized while the productive capacity of the grass is maintained. Grazing management is generally a high output of animal products per acre (Holmes, 1962). Except for cows which calve just before the onset of wet season the production curve of grass has no parallel to the nutrient requirement of the grazing animal which fluctuates to a much smaller extent over the season depending on the pattern of production.

Many recent studies have emphasized that grasslands provide the greater part of the feed requirements of ruminant livestock especially in the tropics. A large proportion of this is supplied as grazing (Wright 1940, O. E. E. C., 1954) and in that form it is the cheapest source of feed for ruminants (Currie 1948, H. M. S. O. Lond. 1958, Hamilton 1956).

McMeekan (1952) has shown curves for dairy farming and sheep farming in New Zealand with an excess of pasture growth over requirements in the early wet season and a deficit in the dry season. He stated that any grazing system which ignores these fluctuations is bound to result in uneconomic and in-efficient utilization of herbage.

Mott (1961) expanded on the problems of grazing and its influence of stocking rate in animal production. Other workers (Arnold et al. 1958, Campling et al. 1958, Ivins, 1959, Kennedy et al. 1959, MacLusky, 1959, MacMeekan, 1961 and Voisin, 1959) have indicated their awareness of the influence of stocking rate also.

The increased production associated with heavier stocking (or increased grazing pressure), reported Holmes (1962) may be a result of (a) elimination of waste of herbage because selection is restricted or (b) more efficient utilization, because over feeding is reduced. Holmes (1962) added that it was also possible that over the long term close defoliation induced by the heavier stocking increased pasture density and leaf area index (area of leaf per area of ground surface).

Holmes et al. (1950) and Voisin (1959) carried out studies on grazing management and grazing methods, and classified them according to grazing techniques.

Continous grazing or free grazing is where cattle have unrestricted access to the whole area of the pasture. In temperate conditions from 0.75 to 2.0 acres are available per cow. From 25 to 33 per cent of the area is closed for conservation at the period of peak growth.

Rotational grazing is where cattle have access to only one at a time of a series of paddocks and they progress in a systematic rotation from one to the next. In such cases, 0.5-2 acres per cow may be made available, but subdivided into from 5 to 20 paddocks. Depending on the number of paddocks and system of management, cattle may spend from 1-12 days on each thus leaving little residue before the cattle move to the next paddock. Grazing time may be reduced so that the minimum fouling by dung and wastage by trampling occurs (Holmes, 1962).

Rationed or strip grazing is an extension of the rotational principle in which, generally by means of readily portable electric fences, cattle are restricted to a limited area: ($\frac{1}{20}$ - $\frac{1}{100}$ acre per cow per day), the major proportion of which has to be consumed before

they move to the next strip. From 0.5 to 1.0 acre per cow is commonly allowed and provision is made for conservation of surplus grass. In strip-grazing, cattle may be allowed only limited access to the pasture and spend the remainder of the time on a bare pasture (Flux et al. 1955).

Mechanical- or Zero-grazing or green-chop feeding is a system whereby the herbage is mechanically cut daily or twice daily and transported to feed bunkers in a yard where the cattle are housed. Apart from mechanical inefficiencies this method ensures complete defoliation at any chosen height.

Developmental studies in New Zealand (Riddet, 1951), in the Netherlands (De Geus, 1950) and United Kingdom (Holmes et al. 1950) showed that the use of electric fence to ration grazing facilitated better utilization of grass, and farm studies showed improvements in pasture utilization (De Gues, 1950, Sadar, 1961).

All recent studies have stressed that the attainment of high grazing pressure is the first essential. Reasonable standards for stocking rate for the wet season allowing for efficient and modest use of supplementary concentrates are 1.5 acres per dairy cow, 1.25 acres per beef cow, 1 acre per young cattle beast (Holmes, 1964). McMeekan (1961) and Lambourne (1956) showed that even under experimental conditions, increased performance per acre at high stocking rates results from a rotational system of management.

In Africa, studies have shown that cattle do better if they graze by night as well as by day (Joblin, 1960) and Vik (1956) showed that day grazing reduced intake, This, perhaps, is due to climatic stress on the animals.

Because the yield of animal products from grassland depends upon the efficiency with which herbage is removed from the sward and utilized in the animal body attention has been given to the design of grazing-management techniques which will be practical and profitable to the progressive farmers in Uganda (Stobbs, 1969). Stocking rate

has a pronounced effect upon both animal production and the sward itself (Stobbs, 1966, Stobbs, 1967). Stobbs (1969) reported that heavy stocking with low availability of pasture and less selective grazing gave higher output per acre but lower individual animal production than low stocking rates. But over stocking, which results in low production per animal and per acre, as demonstrated by Harker and McKay (1962), must be avoided.

Joblin (1963) and Stobbs (1967) reported that rotational grazing is desirable to maintain botanical composition and to achieve good liveweight gains. The frequency of rotational grazing has also been shown to affect animal production; rapid frequency produces significantly higher production in the dry season, probably because it allows animal to select their diet over a larger area (Stobbs, 1967).

Stobbs'(1970) findings confirmed his earlier results (1969) that heavy stocking with concurrent low availability of pasture and less opportunity for selective grazing gave a higher output per unit area and lower individual animal production than low stocking rates. This, he indicated was probably due to an accumulation of lignified material which was of low nutritional value.

Conway (1963), working with beef cattle, reported significant responses from rotational grazing only when stocking rate was at a high level. McMeekan (1961) and McMeekan et al. (1963), who worked with dairy cows, obtained similar results. But at low stocking rates rotational grazing gave a lower liveweight gain per animal than uncontrolled or continuous grazing.

Scarisbrick (1971) reported that liveweight gain per unit area at a given stocking rate cannot be used as an assessment of the maximum animal production available from grass unless the defined stocking rate ensures that herbage intake per animal is less than its maximal voluntary intake.

Hodgson et al. (1971) also indicated that the rate of liveweight gain and herbage intake per head declined as stocking rate increased.

Walker and Scott (1968) and Walker (1968a) observed that at light stocking rates continuous grazing was better than rotational grazing. At high stocking rates it was found best to rotationally graze from about five weeks after the start of the wet season up to about the sixth week in the early dry season and to continuously graze for the rest of the year.

Walker et al. (1968) reported that at light stocking rates there was a greater weight gain per steer, than from the heavy stocking rate treatments; but for about eight months of the year, the highest weight gain per acre was from the highest stocking rate. The high stocking pressures used did not adversely affect the botanical composition of the herbage.

Freer (1959) found that the efficiency of year-round pasture utilization by dairy cows on irrigated pasture was no greater with a strip-grazing system than with a rotational grazing technique.

On the other hand, Freer (1960) concluded that the results of experimental comparisons of techniques of grazing management would be valid only if the techniques are compared at the same stocking rate. This is because there is a close relationship between stocking rate and efficiency of milk production.

Kennedy et al. (1959) clearly demonstrated the advantages and necessity of heavy stocking rates if milk production per acre is to be used as a criterion for most efficient pasture management. He states that a valid comparison of production per acre between grazing systems can not be made unless the grazing pressure for all treatments is sufficiently heavy to utilize fully the available forage.

Influence of stocking rate

Stocking rate being a measure of the number of grazing animals per unit area of land, is also a good measure of how efficient pasture grass is utilized in terms of milk or meat production.

Stobbs' (1970) results confirmed earlier findings (Stobbs, 1969) that heavy stocking with concurrent low availability of pasture and less opportunity for selective grazing gave a higher output per unit area and

lower individual animal production than low stocking rates. Production per animal is reported to be constant at low stocking rates (Morley et al. 1968), which results in a linear regression of production per unit area as stocking rate is increased.

Conway (1970) reported that the main factor which can influence production per acre is stocking rate, but to achieve maximum production per acre, liveweight gain per animal is reduced. This has been demonstrated by many workers for both dairy and meat-producing animals (Alder et al. 1967, Freer 1959, Hull et al. 1961, Line, 1961 and Walker 1954). With dairy cattle, the intensity of stocking should be taken to the level where maximum milk production per acre is achieved provided such treatment does not impair subsequent lactations, calf birth-weight and performance. Liveweight gain of the individual animal depends on the amount of feed it consumes. If feed intake is restricted then this will be reflected in liveweight gain (Conway, 1970).

Bone et al. (1963) reported that in both years of his studies, the higher intensity of stocking significantly ($P = 0.001$) reduced herbage offered in all but the first grazing cycle of each season; and that the high stocking rate converted herbage into milk with greater efficiency than the low stocking rates.

This is in agreement with Beynon's (1964) findings that stocking rate is a vital factor affecting the profitability of milk production. This can be explained by considering the pasture - animal relationship. Riewe (1961) has illustrated that as stocking rate is increased gain per animal is constant at a maximum until the rate of stocking is such that the total forage consumed is equal to the total forage available. Beyond this point gain per animal is inversely related to stocking rate. As the rate of stocking continues to increase a point is eventually reached at which the animals neither gain nor lose weight. Further increases in the stocking rate beyond this point result in a loss in weight which is inversely related to stocking rate. Besides, as the rate of stocking is

increased there is a linear increase in gain per acre until a maximum is reached at the point at which the total forage consumed is equal to the total forage available. Beyond this point further increases in the stocking rate result in a linear decreases in gain per acre (Petersen et al. 1965)

All these interrelated factors depend on certain basic assumptions:

i. If the quantity of forage available is not limiting the forage consumption per head is independent of stocking rate;

ii. digestibility of consumed forage is independent of stocking rate;

iii. quantity of forage utilized for maintenance is proportional to metabolic size, and independent of stocking rate;

iv. quantity of forage required, above maintenance, to produce a unit of gain is independent of stocking rate (Petersen et al. 1965).

Kennedy et al. (1959) reported the advantages and the necessity of heavy stocking rates if milk production per acre is to be used as a criterion for most efficient pasture management. A valid comparison between grazing system of production per acre cannot be made unless the grazing pressure for all treatments is sufficiently heavy to utilize fully the available forage (Harkness, 1958).

Smith (1966) found in two out of four years of his studies that the light stocking rate treatment gave significantly higher ($P<0.05$) weight gains than the heavy stocking rate; and the weight gains appeared to be related linearly with stocking rate, but the difference proved non-significant, even when the gains were corrected for initial weights. He also reported a relatively small effect on weight gain per ox by stocking-rate during the rainy season but it had a significant linear effect on weight loss per ox in the dry season. This was explained by the fact that the increase in gain per acre with high stocking-rate is due largely to greater utilization of the veld while relatively nutritious during the rains. On the other hand at a light stocking-rate, the uneaten area

grass matures to a low quality submaintenance feed. At times, it is not always practicable to have long term high stocking rate grazing due to environmental factors. This was confirmed by (Lloyd, 1966) who could only conduct a short-term experiment in two years because the supply of grass could not maintain the high stock numbers after 12 weeks, so that it was necessary to provide additional feed or to reduce the stocking rate.

Stobbs, et al. (1969) realised the importance of high stocking rates to increase animal production per acre. But the individual liveweight gain of stock is of economic importance and affects the readiness with which stock can be sold as fat cattle and the level of stocking adopted in practice must therefore strike a balance between average liveweight-gain and output per acre.

Freer (1960) showed that based on their nutrient requirements, the cows at the higher stocking rate consumed 39 per cent more pasture (in lb S.E.) per acre than the other cows, although their estimated intake of S.E. per cow was depressed by 14 per cent. Because of their lower body-weight gain, these cows used a higher proportion of their estimated intake for both milk production and maintenance (43 and 52 per cent respectively) than did the cows at the lower stocking rate (40 and 48 per cent respectively).

It was shown that a severe restriction of grazing area had a surprisingly small effect on the milk production per cow, and actually resulted in a marked increase in yield per unit area of pasture. The explanation for this is that the restricted cows used available herbage more efficiently (Hancock, 1958). It could be inferred that their greater efficiency was due to the fact that they consumed proportionately more of the herbage alloted to them. This economy of milk production obviously depends on a full utilization of the herbage grown and the importance of stocking rate in governing the efficiency of conversion of pasture to animal products on a per acre basis has been stressed

by McMeekan (1957).

McMeekan listed grazing method, kind of stock, and stocking rate as the three major factors influencing the conversion of pasture to animal products. He rated stocking rate by far the most important.

Influence of supplementary concentrates

It is obvious that concentrate supplementation to grazing milking dairy cows would increase animal production, but whether or not the increases would be economically justifiable is the question when one considers the cost of concentrates fed and revenue accrued from the additional animal production. Supplementing grazing with grain or concentrate feeds may be considered to be a special case to provide minerals, or in drought conditions (Holmes 1962), or of reducing the stocking rate on pasture. However, Huffman (1959), 'tHart (1956) and Castle et al. (1960) have reported many experiments which showed low responses (generally under 0.5 lb milk per lb concentrates). Hancock (1958) showed that concentrates reduced grass consumption by 24 per cent of the weight of concentrates offered.

The net effect of supplementary concentrate feeds on animal production is small (Corbett and Boyne, 1958; Holmes and Sykes, 1961).

With milking cows, experiments at Bridgets (1962) have confirmed that the return from supplementary concentrate feeding is negligible so long as an adequate supply of grazing is available, and Laird and Walker-Love (1962) showed that even careful rationing according to yield did not give a worthwhile response. But where home-grown concentrate feeds are cheap, it may be desirable to practise high stocking rate and supplementation with cheap grain where cereal production is more reliable than grassland production (Holmes, 1964).

Castle et al. (1968) conducted experiments with dairy cows at pasture and showed that the feeding of concentrates increased the yield of milk slightly but decreased the profit per cow (Castle et al. 1960, Castle et al. 1964). Wood (1966) reported similar results. The poor

response in milk yield to the concentrate feeding is possibly due to the relatively small contribution the concentrates make to the total intake where ample herbage is available.

The cost of concentrates and price received for animal products could be functions of its practicability. Castle et al. (1964, 1965) found it not worthwhile feeding supplement of barley, even at the high rate of stocking (0.58 acre/cow). They reported that as a result of feeding supplement, the cows grazed for a shorter time per day and utilized the herbage 8 per cent less than on the unsupplemented treatment.

Conway (1970) reported and referred to many experiments conducted on the supplementation of grazing with concentrates (Alder et al. 1956, Allden et al. 1962, Baird et al. 1954, Castle et al. 1960, Corbett, 1958, Dodsworth et al. 1962, Forbes, et al. 1967, Hancock, 1958, Holder, 1960, Meyer et al. 1953 and Winter et al. 1964). He concluded from the results that the supplementation of a grass diet with meal will not give a satisfactory response in terms of milk production or liveweight gain. In some of these experiments it was reported that the intake of herbage was reduced (Allden et al. 1962, Corbett, 1958, Dodsworth et al. 1962, Holder, 1960 and Meyer et al. 1953) and in others the time spent in grazing was reduced by feeding a supplement (Baird et al. 1954, Hancock, 1958, and Holder, 1960). Conway (1970) however remarked that when the stocking rate is at such a level that liveweight per animal is reduced as a result of inadequate herbage, the feeding of supplements to beef cattle on pasture may give significant responses.

Castle et al. (1964) maintained that the margin between the value of the milk and the cost of the concentrates was reduced significantly per cow for the complete lactation as a result of feeding the supplements.

Since Castle et al. (1960) found no statistical difference in daily milk yield between supplemented and unsupplemented groups of cows on grazing trials, they contended that at the present-day prices of the feeds and with cows on good leafy pasture, it was clearly uneconomic to feed the meal supplements.

Phipps (1970) found in Uganda that at least maintenance and the first gallon of milk production can be obtained from grass alone. While Glover and Dougall (1961) in Kenya and Butterworth, Groom and Wilson (1961) in Trinidad have shown that for most of the year supplementary feeding was only necessary for cows producing more than 2-3 gallons per day.

On the other hand, Hancock (1958) indicated that pasture herbage was not a perfect diet for a dairy cattle, because he obtained a substantial lift in milk yield when concentrate was added to an ad lib. diet of high quality pasture.

Smith (1966) reported affirmatively that supplementary feeding significantly increased the cattle weights in the 1961 rains ($P<0.001$) but stocking-rate effect and the interaction between stocking-rate and supplementary feeding were non significant.

Pauka (1971) suggested that supplementation of pasture should not take place until herbage becomes limiting at the end of growing season, because supplementation of pasture during vigorous growth has little effect.

Lampkin and Lampkin (1960) working with Zebu cattle, and Miller (1961) showed that pasture fed Zebu cattle failed to show any measurable improvement in milk yields following the feeding of concentrates. That was why Joblin (1966) working in Uganda concluded that moderately well managed local pastures are capable of supplying all the necessary nutrients for the local cattle to realize their present genetic milk potential of approximately one gallon a day.

Experimental procedure

Experiment I (1968)

This was an attempt to determine the influence of stocking rates and levels of concentrates on production of lactating White Fulani cows. The experiment took the form of a simple trial.

Six hectares (6.070 hects.) of established Digitaria pasture was dressed with 50.8 kg per 0.40 hectare of sulphate of ammonia and divided into ten unequal plots. These were divided into two blocks consisting of plots (0.51 hectare each) numbers 1-5 which formed one block, and plots (0.71 hectare each) 6-10 which formed the other block.

Twenty-four lactating White Fulani cows were selected from the dairy herd and the cows were divided into two comparable groups of 12 cows each on the basis of age, liveweight, past and present lactations. Each group of 12 was divided into 3 treatment groups of 4 animals: The 4 animals in the first treatment group of block one were grazed at 0.21 hectare per cow plus 0.456 kg concentrates for every 1.13 kg of milk. The 4 in the second treatment group were as the first group minus 0.907 kg concentrates: while the 4 in the third treatment group were as the other two groups but minus 1.814 kg of concentrates. Each corresponding group in block two was similarly treated except that the stocking rate for all the animals in the block was 0.30 hectare per cow.

The treatment groups were rotationally grazed and all the groups were shifted at the same time from their respective paddocks to the next successive paddocks. The daily amount of concentrate for each cow was calculated as follows every fortnight:

Group I: $\frac{\text{total milk production preceeding week}}{7 \times 1.134}$

Group II: $\frac{\text{total milk production preceeding week}}{7 \times 1.134} - 0.907 \text{ kg}$

Group III. $\frac{\text{total milk production preceeding week}}{7 \times 1.134} - 1.814 \text{ kg}$

One half of this amount was offered to each cow at milking time. There was salt mineral mix (4.5 kg per 1021 kg) in the concentrate given and there were always blocks of salt lick in the paddocks. Fresh water was always available.

All cows were milked in a parlour twice daily at 7.00 a.m. and 4.00 p.m. Regular weekly butter-fat content of each cow's milk was determined using the Gerber method. The cows were weighed weekly on three successive mornings after milking and an average of the three weighings was taken as weekly weight.

The response criteria to the treatments were measured in terms of:

i. Milk production per cow per day and,
ii. Weekly liveweight.

Experiment 2 (1969)

This experiment was an attempt to measure the performance of lactating cows at different stocking rates with or without added concentrates between July and October on a 6.1 hectare block of Digitaria pasture. The 6 hectare pasture was divided into 4 grazing treatment strips each of 5 individually fenced paddocks.

Eighteen (9 White Fulani, 9 W.F. x Friesian) lactating cows used were managed uniformly until the experiment started; then they were divided into 4 comparable groups on the basis of weekly milk yield, stage of lactation, age and liveweights.

The cows were subjected to three stocking rates at the following levels:

i. High 4(2 C.B., 2 W.F.) cows per 1.01 hectares i.e. 0.263 hectare/cow.
ii. Medium 4(2 C.B., 2 W.F.) cows per 1.518 hectares i.e. 0.380 hectare/cow.
iii. Low 4(2 C.B., 2 W.F.) cows per 2.023 hectares i.e. 0.506 hectare/cow.
iv. High 6(3 C.B., 3 W.F.) cows per 1.51 hectares i.e. 0.253 hectare/cow plus a concentrate of 22 per cent crude protein according to individual milk production. (Each cow in groups i, ii and iii was offered 0.456 kg of concentrate at milking

There were five plots for each treatment; and all the groups of cows grazed their appropriate plots on the same days in the 4 basic treatments.

Other treatments were exactly as in experiment I.

Before and after grazing, 7 samples of grass were taken using the diagonal cut techniques with sheep-shears. This was to determine herbage intake. Chemical analysis of composite samples was carried out. Regular weekly butter fat content of each cow's milk was determined using the Gerber method.

Experiment 3(1970)

This was exactly the same as experiment 2 (1969).

Grassland management

Grazing was rotational and all the animal groups were shifted at the same time.

Broad-leaved, and grass weeds such as Sporobolus sp. were occasionally hand uprooted.

Each year, all the paddocks were dressed with sulphate of ammonia at the rate of 152.4 kg hectare-hand broadcast - at the beginning of growing season.

Supplementary feeding

The supplement offered to the animals on treatment 4 (high stocking rate plus concentrates) in experiments 2 (1969) and 3(1970) was adjusted fortnightly and individually on the basis of 0.45 kg of concentrate per every 1.134 kg of milk produced during the preceeding week.

Each of the remaining 12 cows in the other 3 treatments (1969 and 1970) which were on grass alone were offered 0.454 kg of concentrates at milking times twice per day to induce milk-let-down.

Herbage sampling

Immediately before and after a group of 4 plots were grazed, 7 samples of herbage were taken at random within each plot. Each sample was cut as close to the soil level as possible on an area 3 ft by 3 ft using a manually operated sheep-shear.

The green weight of each sample was determined separately, but the dry matter and chemical analysis of the herbage (Table 2) were determined on a single sample bulked from the 7 individual samples from each plot.

Rainfall

The rainfall data during the growing season for the three experimental years can be observed in Table 1.

Table 1. Summary of the rainfall (inches) data during the growing seasons, 1968-1970

	May	June	July	August	Sept.	Oct.	Total
1968	7.15	5.97	11.09	12.00	4.63	0.17	41.01
1969	5.78	8.51	12.70	9.23	6.64	2.68	45.54
1970	4.16	2.74	9.20	14.18	6.03	0.18	36.49

Results and Discussion

Experiment 1 (1968)

A total of 34.20 in. of rain was recorded during the 4-month experimental period from 26th May to 29th September (Table 1) and there was adequate grazing at all times.

The mean dry-matter, crude protein, crude fibre, ether extract, ash and nitrogen free extract contents of Digitaria grass and supplements are given in Table 2. The total quantity of supplement consumed on each treatment is shown in Table 3.

The total as well as the mean daily milk yields on each treatment are given in Table 3. The treatments had no significant effect on daily milk yield. The high stocking-rate group of cows yielded, on a per cow per week basis significantly more fat-corrected-milk (F. C. M) (P 0.2) than the low stocking rate group. Also the high stocking rate yielded significantly more milk ($P<0.0005$) than the low stocking rate group on a per hectare basis.

Under the low stocking rate, the medium level of concentrate feeding returned 58.9 per cent more (value of milk - cost of concentrate) than the high level and the low level returned 12.5 per cent more than the medium level. On the high stocking rate, the medium level of concentrate feeding returned 61.0 per cent more than the high level and the low level returned 15.8 per cent more than the medium level (Table 3)

Unequal subclass least square means analysis of the data gave the mean daily milk production per group for the high- and low-stocking rates as 29.96 ± 0.54 kg and 29.85 ± 0.54 kg respectively.

The variance analysis showed that the initial milk production of cows had very highly significant influence ($P<0.001$) on the subsequent milk yield. This factor indicated in this trial that overall potential of each cow during the trial depended on her stage of lactation.

Levels of stocking had no effect ($P = 0.834$) on milk yield. Although levels and fortnightly adjusted amounts of concentrates fed had a significant ($P<0.005$) effect on milk production, the increase in milk yield per unit increase in concentrate fed was uneconomic

Table 2. Proximate compositions of Digitaria grass and concentrate fed for experiment 1 expressed on dry basis

	Digitaria grass	Concentrate
% Dry matter	21.6	92.20
% Crude Protein	7.00	18.70
% Crude Fibre	30.30	7.82
% Oil (Ether Extract)	2.40	7.84
% Ash	8.20	5.78
% Nitrogen free extract	52.10	59.86
Phosphorus (ppm)	775.00	6,900.00
Calcium (ppm.)	4,200.00	2,400.00

and unjustifiable (Table 3). Both age and liveweights of the cows had significant influence ($P<0.0005$) and ($P<0.0005$) respectively, on milk yields. This may be because age indicates the number of lactations that a cow had had (production falls normally after 5 or 6 lactations); and metabolic body weight deterimines the level of maintenance before the remaining available energy is made available for milk synthesis.

Although the levels of stocking applied in this trial had no influence on milk yields, interaction between stocking rate and levels of concentrate had some influence ($P<0.03$) on milk yield. From least square means analysis of six combinations of levels of supplementation and stocking rates, the medium level of concentrates and high stocking rate gave the highest milk yield of 34.6 $\pm$ 1.94 kg per group per day. The high levels of concentrates and stocking yielded 31.22 $\pm$ 1.70 kg, the low levels of concentrate and stocking yielded 25.89 $\pm$ 1.75 kg of milk per day. For such local Zebu cows of low milk production on ample lush improved grass, a combination of low concentrate supplementation on high stocking rate appears to be more economic (Table 3) and (Fig. 1).

The values in Table 3 show that on the average, the cows on high stocking rate had significantly lower liveweights at the end of the experimental period than those on low stocking rate ($P<0.01$). Unequal subclass analysis of variance showed that week (as a continuous variable period), stocking rates, and initial liveweights had significant ($P<0.0001$) influence on liveweight gain. Although concentrate level had significant ($P<0.001$) effect on liveweight gain, concentrate fed by week has no significant effect on liveweight, hence the adjustment made fortnightly according to milk production did not have any detrimental effect on the liveweight changes. Age had no influence ($P<0.745$) on liveweight changes; and level of milk production of these Zebu cows had no influence ($P<0.395$) on the liveweight changes. Interaction between stocking rate effect and concentrate levels had a

significant effect on liveweight gain. The Approximated Duncans test indicated that the low concentrate level, and the combination of high stocking rate and the low concentrate level yielded more liveweight gains. This may be explained by the fact that as more starchy concentrates are fed to grazing ruminants the catabolic activity of the cellulonic bacteria may be reduced. This would be an advantage for the low level of concentrate feeding.

With a few exceptions to be discussed later, the gain per head decreases with increasing stocking rates, but not in a straight line Tables 3, 4 and 6. The cows on high stocking rate had lower ($P<0.01$) body weight gain than those on low stocking rate possibly because these high stocking rate cows used a higher proportion of their estimated intake for both milk production and maintenance than did the cows at the lower stocking rate. This is in line to Freer's (1960) findings.

Because of the small number of cows and because of inherent animal variation which can easily mask treatment effects and the interaction of grassland treatment with stocking rate results reported here may be indicative rather than conclusive.

From a genetic view point an interesting feature common to all tropical dairy breeds is the great within-herd variation in yield. This within-herd variation was reported by Robertson (1950) to be up to 50 per cent, the highest among all tropical breeds is the White Fulani cattle of Nigeria (Young et al. 1971). Another factor which may limit the production capacity of Zebu cattle is the 'temperament' factor involving a 'holding back' of milk which is a problem in the first few lactations of many Zebu cows. These factors coupled with genetic limitation to high level production by the Zebu cows make them unsuitable for economic urban dairy operations.

Table 3. Summary of Animal Production (Kg) on Digitaria pasture and values (in shillings) as influenced by Stocking Rates and Supplements feeding

Treatments Groups	Low Stocking Rate (0.295 ha/Cow)			High Stocking Rate (0.211 ha/Cow)		
	1	2	3	1	2	3
Total cummulative weight gain	51.99*	98.68	105.290	65.86	41.41	71.37
Value of body gain	114.01	145.04	154.77	96.82	60.88	104.91
Mean weight Gain/Cow	38.00	24.67	26.32	16.47	10.35	17.84
Mean weight Gain/ha	44.06	27.84	29.71	26.03	16.38	28.21
Mean weight Gain/Cow/Day	0.502	0.608	0.648	0.406	0.255	0.440
Total Milk Yield	740.75	677.97	577.53	819.82	665.20	681.72
Mean Milk Yield/Cow	185.19	169.49	144.38	204.96	166.30	170.43
Mean Milk Yield/ha	209.02	191.30	162.96	324.04	262.94	269.45
Mean Milk Yield/Cow/Day	2.21	2.02	1.72	2.44	1.98	2.03
Total Conc. Intake	311.45	179.07	67.84	339.21	171.15	68.06
Value of Milk @ 4/- per gallon	543.87	497.78	424.03	601.92	488.40	500.53
Value of Milk/Kg conc. intake	1.75	2.78	6.25	1.77	2.85	7.35
Value of Milk Yield/Hect.	153.47	140.46	119.65	237.91	193.05	197.83
Cost of Conc. @ 0.45/- per Kg	140.15	80.58	30.53	152.64	77.02	30.63
**Cost of Capital Investment	608.86	608.86	608.86	435.48	435.48	435.48
Margin over Conc. & Capital Investment (shillings)	-91.14	-46.62	-60.59	+110.62	+ 36.78	+139.33

* Data on 3 cows because the 4th cow was ill and lost 22.69 Kg

** Cost of fencing (on 3 years life span) pasture establishment (on 8 years life span), and fertilizer applied (on yearly basis)

Cost of fencing, and pasture establishment (ploughing, harrowing, twice and planting) is 515.98 shillings per h

ha = Hectare

Composition of Concentrate supplement

50% Guinea corn	(510 Kg)
30% Cotton seed	(306 Kg)
18% Groundnut cake	(183.8 Kg)
2% Mineral mix.	(20.47 Kg)

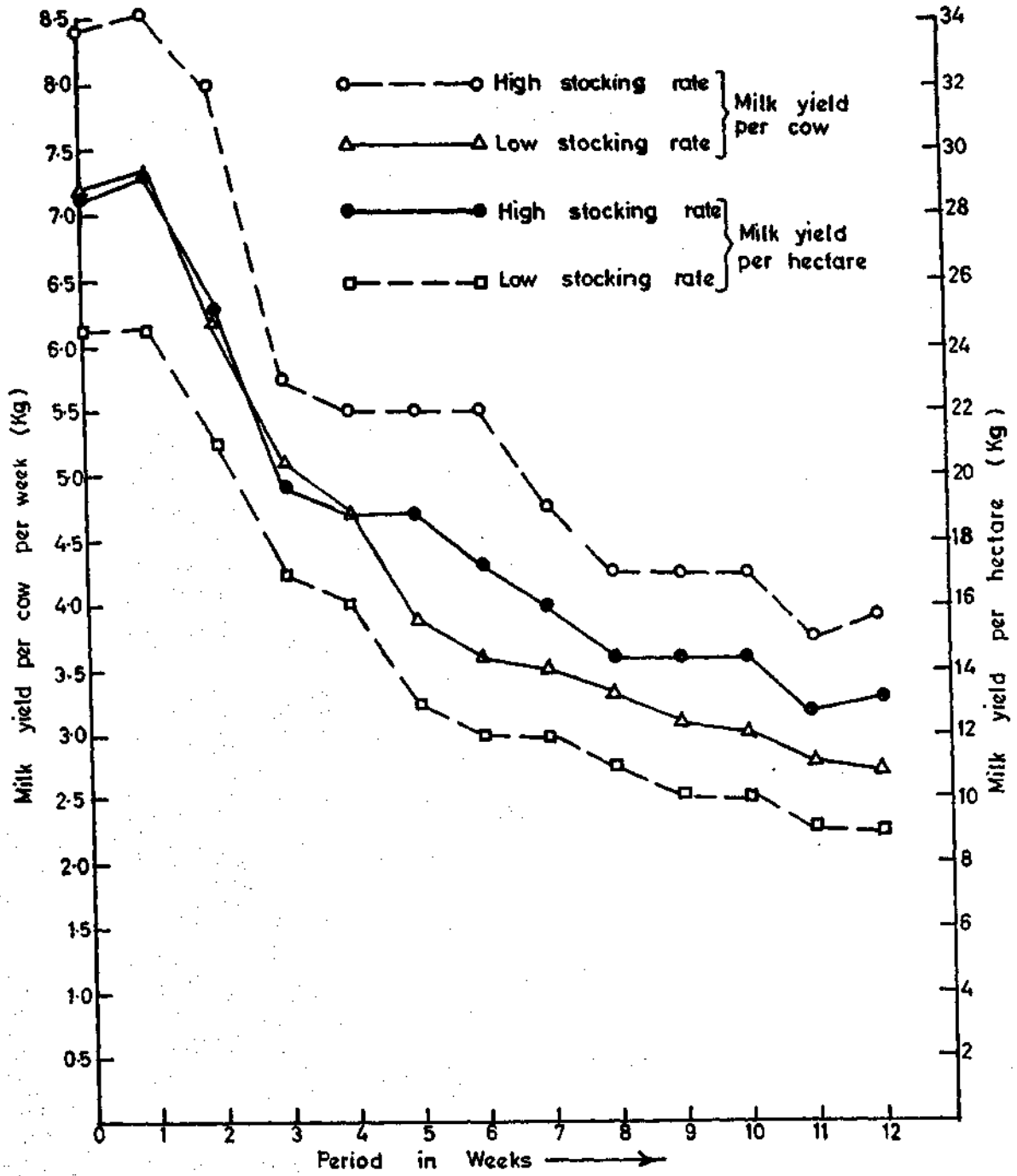


Fig. 1. The mean milk yield (Kg) per cow and per hectare at two stocking rates and three levels of supplementary feeding on Digitaria pasture in 1968

Experiments 2 and 3 (1969 and 1970)

As can be observed from Table 1 rainfall in 1970 was rather sporadic and less than that of 1969. This delayed commencement of the third trial for two weeks. The results reported here were those obtained during the corresponding periods in both years, mid July to mid October.

The means of the proximate analysis of over 200 forage samples from each experiment and of the concentrate fed are reported in Table 5.

The total as well as the mean daily milk yield, body weight changes, production per cow and per hectare and the values of these are reported in Tables 4 and 6. Capital costs incurred on pasture establishment, fencing, fertilizers and the overall return over these expenses in terms of revenue derived from milk sales and costed body weight gain are found in Tables 4 and 6.

Figure 2 shows that as grazing level increased in experiment 2 milk yield per hectare increased almost in a straight line while milk yield per cow increased up to the medium level (0.380 ha/cow) and then declined linearly with the two production lines intersecting at high stocking rate (0.253 ha/cow). This point may indicate an optimum level of production per cow and per hectare for this particular group of cows grazing such grass within the limits of experimental errors. The body weight gain per cow and per hectare (Fig. 3) had an inverse relationship with point of intersection at (0.316 ha/cow) grazing level. Beyond this point, production per hectare increased linearly and the slope of production per cow does not show any detrimental effect on the cow's production.

On the other hand in the third trial (1970) while the mean milk yield per cow per day declined slightly as stocking rate increased from 0.506 ha/cow to 0.380 ha/cow the production per hectare increased (Fig. 4).

Table 4. Summary of Animal Production (Kg) on Digitaria pasture and values (shillings) as influenced by Stocking Rates (Experiment 2 1969

Stocking Rates	Low (0.506 ha/cow)	Medium (0.380 ha/cow)	High (0.253 ha/cow
Total cummulative weight gain	147.30	93.50	44.40 kg
Value of the body gain	324.17	205.04	97.37
Mean weight Gain/cow	36.82	23.38	11.10
Mean weight Gain/hectare	72.78	61.53	43.87
Mean weight Gain/cow/day	0.44	0.23	0.13
Total milk yield	1730.06	2068.42	1950.31
Mean milk yield/cow	432.52	517.11	487.58
Mean milk yield/ha	854.78	1360.82	1927.19
Mean milk yield/cow/day	5.30	6.20	5.80
Mean milk yield/ha/day	10.50	16.20	22.90
Total concentrate Intake	360.70	296.80	303.10
Estimated available dig. D. M./cow/day (from Grass)	7.47	6.20	5.23
Value of milk yield at 4/- per gallon	1270.23	1518.66	1431.95
Value of milk yield/ha	627.58	999.12	1414.97
Value of milk yield/Kg Conc. Intake	3.52	5.12	4.72
Cost of conc. at 0.63/- per kg	227.24	186.98	190.95
*Cost of capital investment	1404.17	1054.51	702.07
Margin over conc. and capital invest. (sh)	-37.01	+482.21	+636.30

*Cost of capital Investment remained the same as in Table 3, except that fertilizer increased three folds on yearly basis.

ha = Hectare

Composition of concentrate supplement

72% Guinea corn
26% Groundnut cake
2% Mineral mix.

Table 5. Proximate compositions of Digitaria grass and concentrate fed (for experiments 2 and 3) expressed on dry basis

	Digitaria grass	Concentrate
% Dry matter	21.40	95.80
% Dry matter digestibility	65.50	
% Crude Protein	7.30	19.30
% Crude Protein digestibility	50.90	
% Crude Fibre	30.10	1.25
% Oil (Ether Extract)	2.40	3.79
% Ash	8.50	2.44
% Nitrogen free extract	51.70	73.22
Phosphorus (ppm)	775.00	2,700.00
Calcium (ppm)	3,950.00	2,400.00
Sodium (ppm)	13.02	
Potassium (ppm)	235.50	
Zinc (ppm)	46.25	39.90
Manganese (ppm)	99.83	
Mangnesium (ppm)	2039.50	
Copper (ppm)	14.50	1.88
Cobalt (ppm)	1.69	4.50

Table 6. Summary of Animal Production (Kg) on Digitaria pasture and values (shillings) as influenced by Stocking Rates (Exp. 3, 1970

Stocking Rates	Low (0.506 ha/cow)	Medium (0.380 ha/cow	High (0.253 ha/cow)
Total cummulative weight gain	54.72	77.52	85.73
Value of the body gain	120.00	170.00	188.00
Mean weight gain/cow	18.24	19.38	21.43
Mean weight gain/ha	36.05	51.00	84.70
Mean weight gain/cow/day	0.22	0.23	0.26
Total milk yield	2483.39	2435.51	1193.78
Mean milk yield/cow	88.69	86.98	42.64
Mean milk yield/ha	175.28	228.89	168.54
Mean milk yield/cow/day	7.39	7.25	3.55
Mean milk yield/cow/ha/day	14.60	19.07	14.03
Total concentrate intake	306.46	303.24	306.43
Estimated available dig. D.M./cow/day (kg) from grass alone	10.91	7.66	5.85
Value of milk yield at 4/- per gallon	1823.34	1788.19	876.49
Value of milk yield/ha	900.86	1176.44	866.10
Value of milk yield/kg conc. Intake	5.95	5.90	2.86
Cost of conc. at 0.63/- per kg	193.07	191.04	193.05
*Cost of capital Investment	1404.17	1054.51	702.07
Margin over conc. and capital investment (sh)	+346.10	+712.64	+169.37

* Cost of fencing (on 3 year life span), pasture establishment (on 8 year life span), and fertilizer applied (on yearly basis).

ha. = Hectare

Composition of Concentrate supplement

72% Guinea corn
26% Groundnut cake
2% Mineral mix.

Further increase in grazing level caused sharp decline in both production per cow per day and per hectare. The two production lines intersected at 0.253 ha/cow level similar to experiment 2 result (Figs. 4 and 2). This sharp decline of the two slopes was possibly due to a decline in the amount of, or the irregularity of, rain in 1970 which could affect herbage yield (Table 1). Figure 5 shows body weight changes per cow and per hectare. The two production levels were about equal at 0.506 hectare per cow level and increased with increased grazing level (0.380 ha/cow). Further increase in stocking rate caused body weight gain per cow to increase slightly with a sharp increase in gain per hectare. These changes were inversely related to the mean milk yield per cow per day and per hectare (Figs 4 and 5). This was possibly because good dairy cows would maintain their metabolic weights and convert most of the remaining energy in feeds into milk rather than into body fat.

The high stocking rate treatment yielded a significantly higher ($P<0.001$) body weight gain per hectare than both the low- and medium-stocking rates separated. This is in line with Smith's (1966) findings. The medium stocking rate yielded more body weight than the low stocking rate up to the third week of both trials, but as from the fourth week, the low stocking rate produced more pounds of beef. For the two experiments there was no significant difference between the medium- and low-stocking rates in their responses to milk production. Although these two grazing levels produced more milk per cow than the high stocking rate, the difference was non-significant. By the nineth week of the trials the stocking levels began to have some effect ($P<0.08$) on milk production. This effect was not significantly observed on body weight changes until the last and the twelveth week ($P<0.05$).

Breed effect had highly significant influence on both milk production ($P<0.001$) and body weight gain ($P<0.05$). But as the dry season advanced

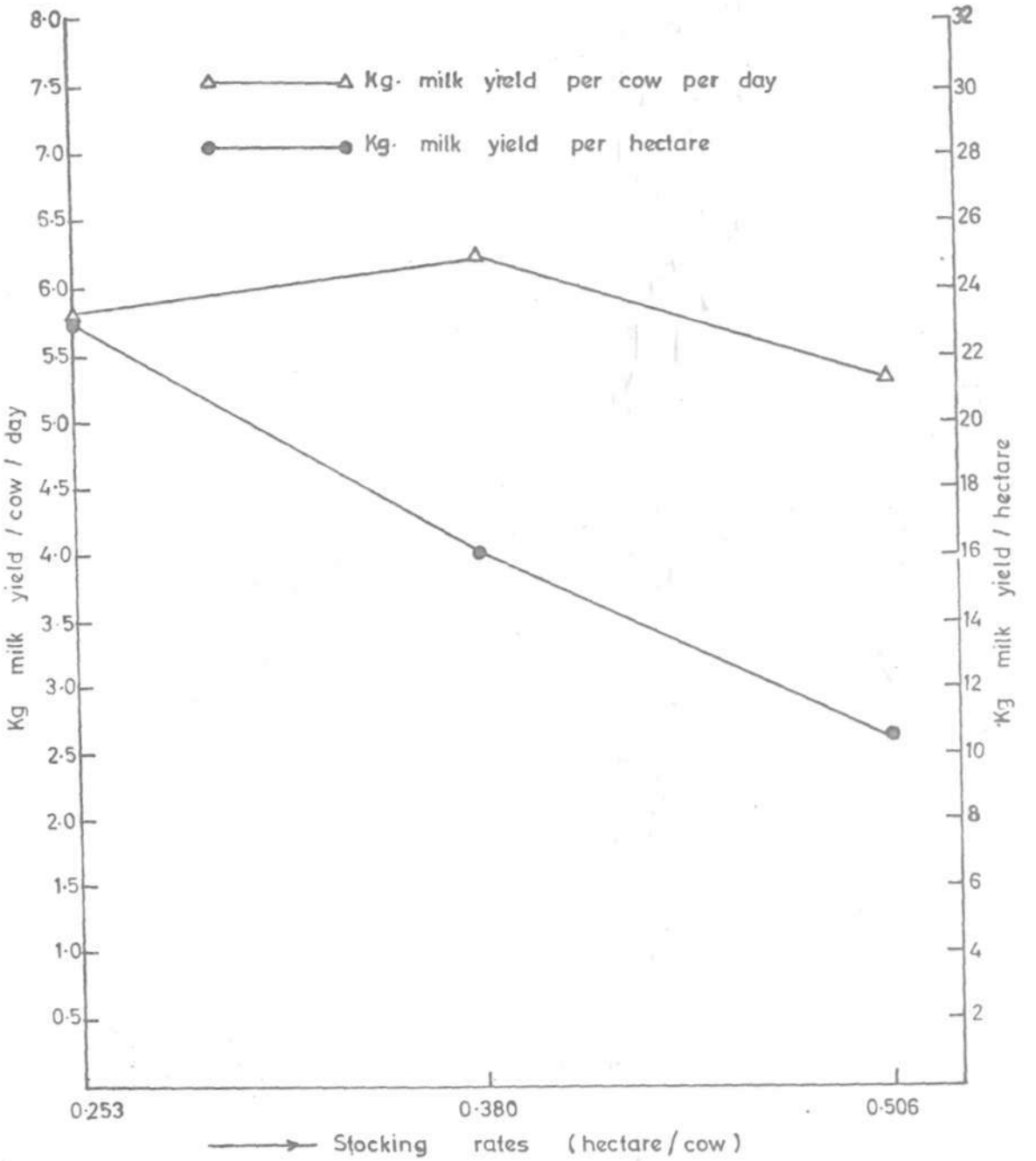


Fig. 2. The mean milk yield (Kg) per cow and per hectare at three stocking rates on unsupplemented Digitaria pasture in 1969

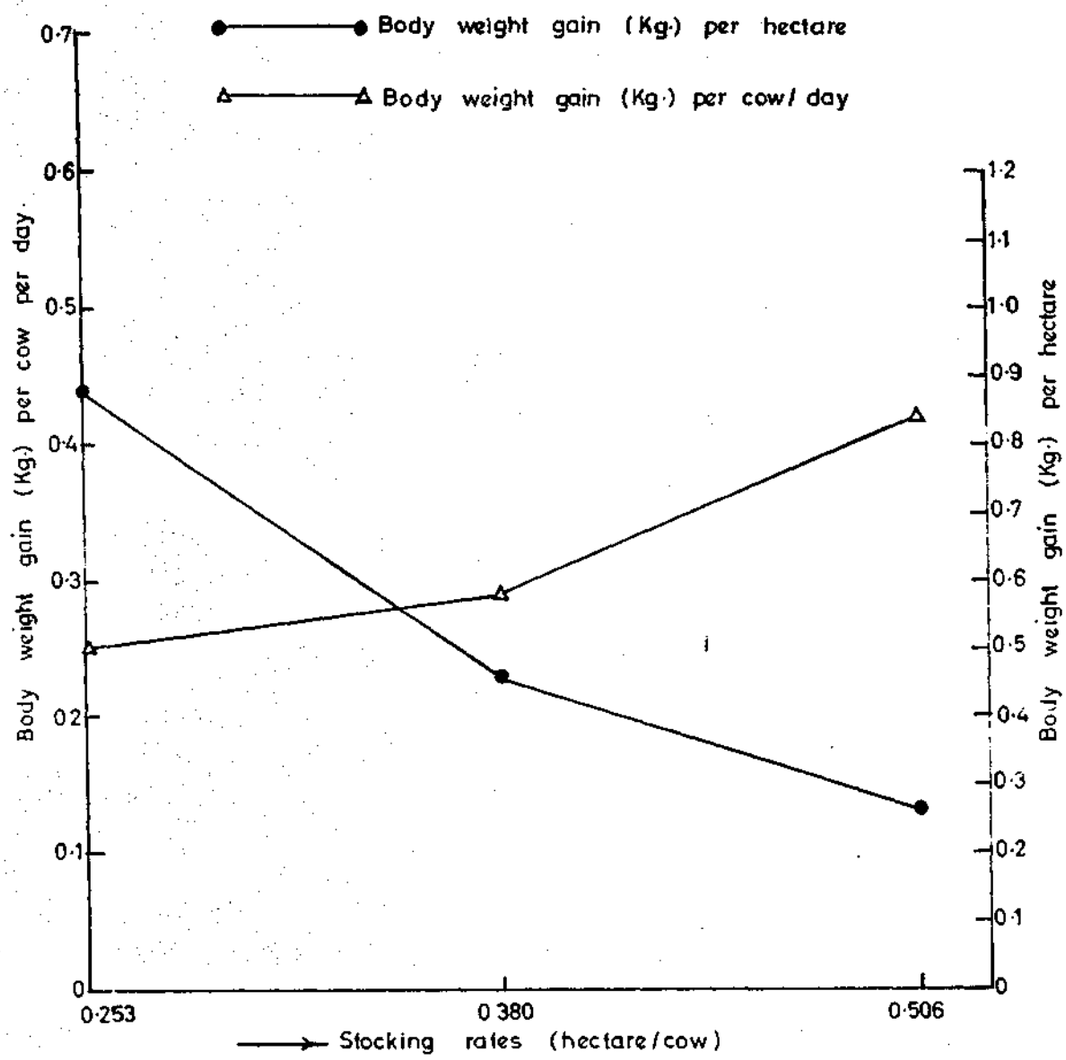


Fig. 3. The mean body weight gain per cow and per hectare (Kg.) at three stocking rates on unsupplemented Digitaria pasture in 1969

the difference between breed effects on milk production declined ($P<0.02$), but remained highly significant ($P<0.0001$) on body weight gain. Throughout the trials the mean milk yield per cow of Friesian-White Fulani crossbreds was approximately 100 per cent higher than the mean of the White Fulani cow; and the mean body weight gain of the crossbred cow was significantly ($P<0.005$) higher than that of the White Fulani cow.

From the first week of the trials, amounts of concentrate fed influenced the response by the cows in body weight ($P<0.08$) and this effect became more significant ($P<0.05$) by the fifth week when its effect ($P<0.01$) on milk yields was observed.

Although both breeds responded similarly to the levels of concentrate fed in terms of F. C. M. and body weight gain, the level of response was comparatively low in White Fulani ($P<0.01$). Miller (1961) attributed this to limited intake capability by the Zebu cattle. There were no significant differences due to concentrate supplementation at the three grazing levels. But at the end of the wet season (September), the unsupplemented group (0.254 ha/cow) produced 75 per cent as much as other treatments and 50 per cent as much in October and November when dry-matter content of grass began to have some effect ($P<0.005$) on milk yield. There was no significant difference in FCM production between levels of concentrate on the high stocking rate (0.253 ha/cow) groups (Tables 4 and 6).

Age had some effect on body weight gain changes ($P<0.09$) but not on FCM. This is indicative of the fact that a growing cow would require more energy for maintenance and growth than an adult one.

By the eleventh week (September) the crude protein content of Digitaria grass had fallen from a mean of 7-8 per cent to about 5 per cent. This had some effect ($P<0.07$) on body weight, and some influence ($P<0.10$) on milk yield.

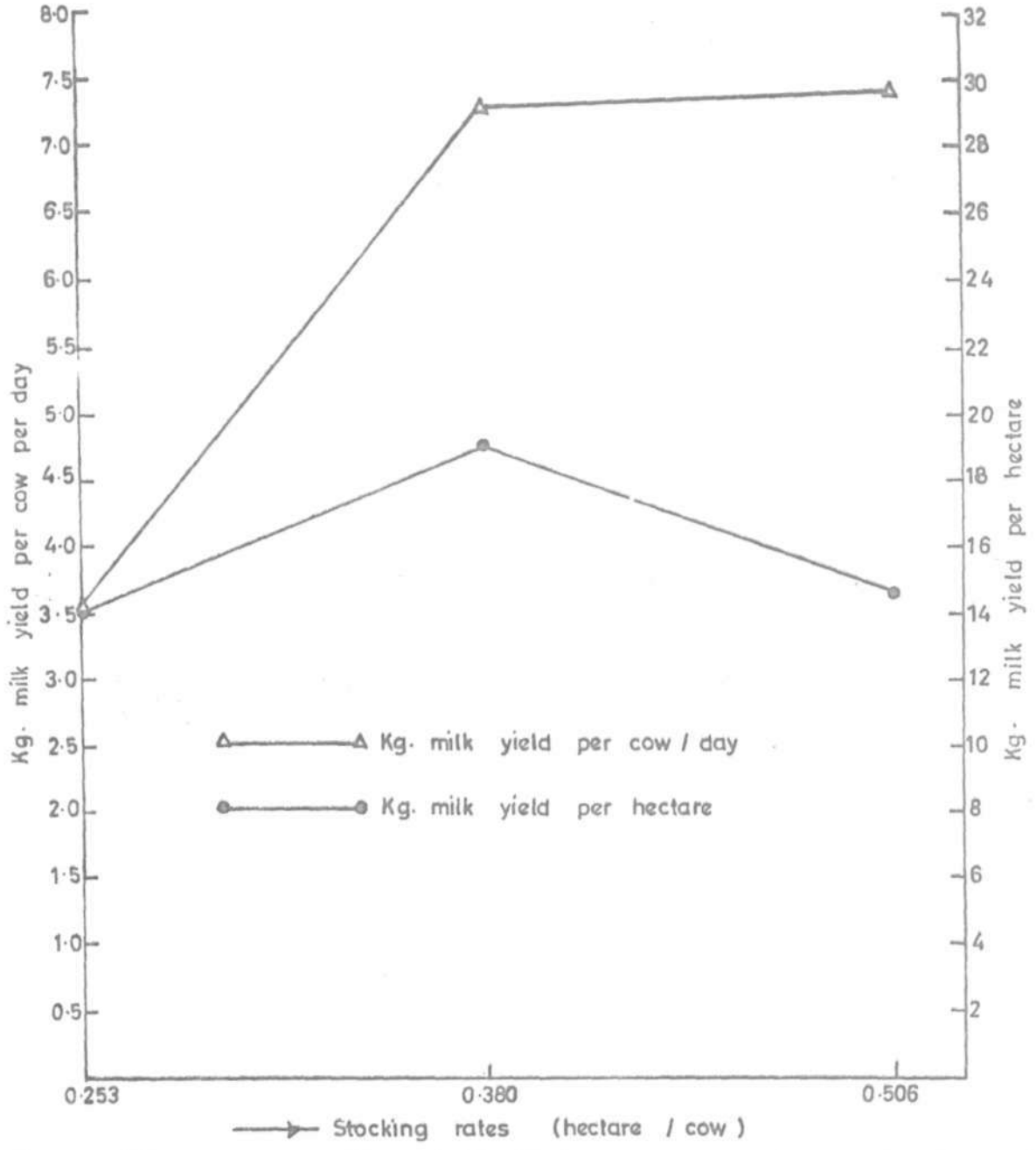


Fig. 4. The mean milk yield (Kg.) per cow and per hectare at three stocking rates on unsupplemented Digitaria pasture in 1970

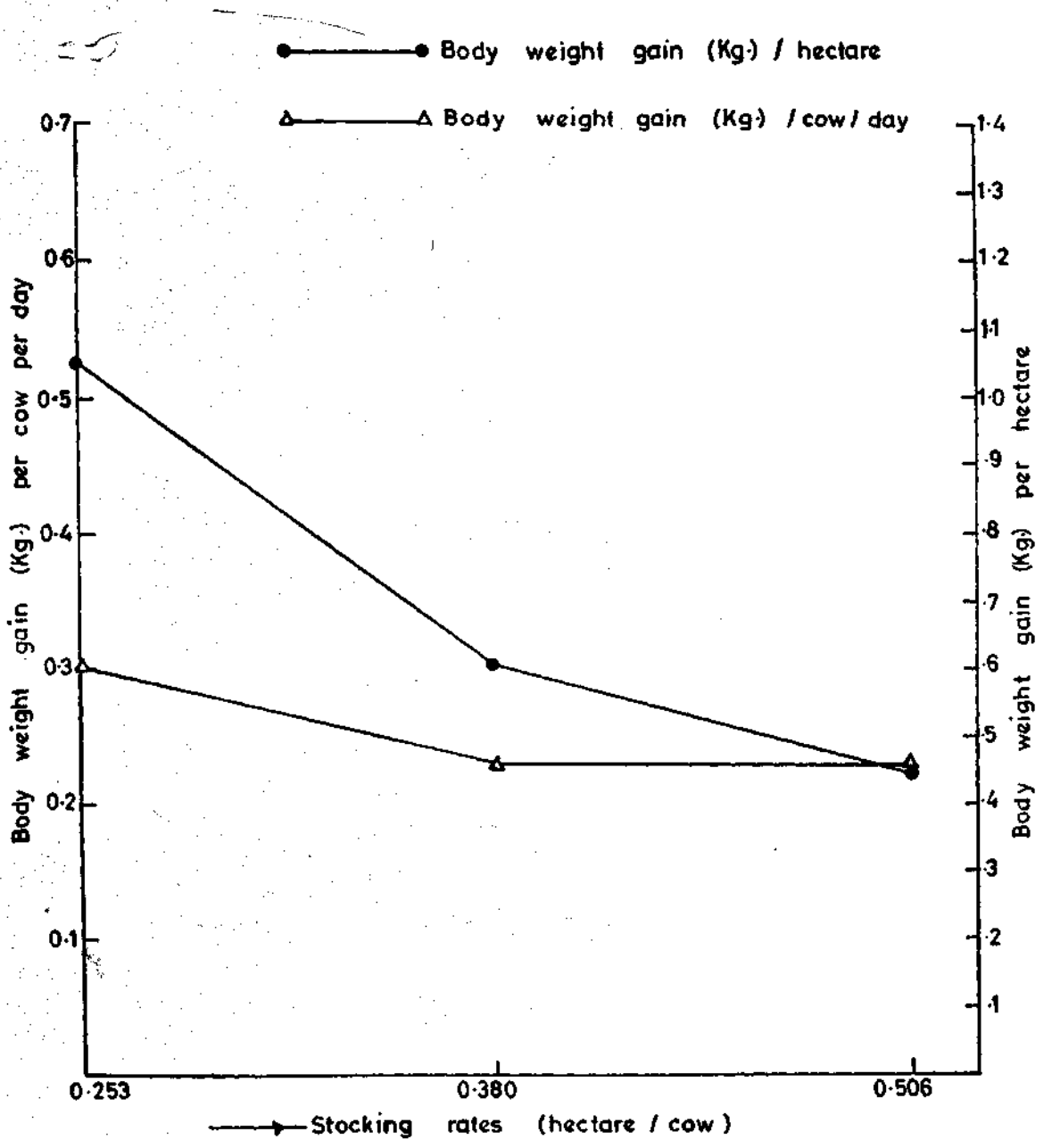


Fig. 5. The mean body weight gain per cow and per hectare (Kg) at three stocking rates on unsupplemented Digitaria pasture in 1970

Interaction between breeds and levels of concentrate fed became more noticeable on the crossbred cows than on the white Fulani as the dry season advanced. This indicates a lower energy requirement of the White Fulani cows for their maintenance and genetic-limiting level of production. At this stage of low crude protein level in the grass, and a limited amount of dry-matter, it would be desirable to transfer the cows from the paddocks to the pens where they could be put on a dry season intensive feeding programme.

Animal production figures (milk and body weight) from both trials were compared using Student's 't' tests. There was no difference in either (FCM) Fat corrected-Milk or body weight gain due to year ($P<0.3$). It is thus probable that within the limit of experimental errors, the results obtained in different years are repeatable and consistent.

Approximated Duncans tests, as well as figures 2, 3 and 5 show that for economical animal production (milk and body weight), high stocking rate (0.253 ha/cow) was a desirable level for these trials under the conditions existing.

Although Freer (1960) reported a close relationship between stocking rate and efficiency of milk production, results from 1968-1970 studies indicated that stocking rate has no significant effect on milk yield, but rather on body weight changes. These results were in line with his findings that with dairy cattle, the intensity of stocking should be taken to the level where maximum milk production per hectare is achieved (Fig. 2). On the whole the efficiency of pasture use in part depends on the productivity of the animals concerned, while attainment of a stocking rate which ensures a high grazing pressure is essential.

The results of the 1970 trial confirm the evidence from Mott (1960) that as stocking rate increases, the production per cow may be so reduced that yield per hectare may decrease also (Fig. 4). The results

of these three experiments clearly showed that although supplementary feeding at pasture gave some increase in milk yield the increases were small. This is in line with the findings of Castle et al (1960). Results of discrete comparisons of different levels of concentrate intake indicated that most Friesian - White Fulani crossbreds producing close to 6 kg milk daily could be supported by good pasture alone; but higher levels of production appear to need supplementation with concentrates. There still remains the question as to why certain cows in certain pasture situations benefit from extra concentrates and others in identical situations do not (Donker et al. 1968).

Results from the 1968 experiment indicated that in-take of the Zebu cows was not the major limiting factor. It would seem probable that the main factor is the animal's lack of genetic potential for milk production (Joblin, 1966). The increase in weight of lactating cows suggested that although supplementary feeding was unsuccessful in raising their milk yields, it may have a place in increasing the growth rates of young stock. It costs 1.39 shillings in terms of concentrate for every extra 2.2 kg (i.e. about 1.62 shillings worth) of milk increase under the high concentrate level.

In 1969 when crossbred cows were introduced into the trial, for every extra 1.07 kg of milk produced by cows on high grazing level with concentrate supplementation, it required 1 kg of concentrate. In 1970, for every extra 1.72 kg of milk produced by cows on the high stocking rate plus added concentrates the cow needed 1 kg of concentrate. It is indicative that at the present cost of concentrate (Table 4 and 6) and price received for milk, the feeding of the supplement in 1969 was uneconomic for the production level of the cows used and in 1970 the cost of the concentrate was about equal to the value received for the extra milk. This confirmed the findings of Castle et al. (1968) that the feeding of concentrates increased the yield of milk slightly but decreased the profit per cow. Similar to Pauka's (1971) report,

supplementation of good quality leafy pasture should not take place until herbage (D.M. and C.P.) becomes limiting at the end of growing season. However, for most of the year, especially where grazing area is restricted, supplementary feeding may be necessary for cows producing more than 2-3 gallons of milk per day (Glover et al. 1961 in Kenya, Groom et al. 1961 in Trinidad). It may be justifiable to practise heavy stocking with supplementary feeding of protein and energy in early dry season for high production from Digitaria grass. It is essential to have the cows on high stocking level because the high stocking rate converts grass into milk with greater efficiency than the low stocking rates (Bone et al. 1963). Besides, these cows would use a higher proportion of their estimated intake for both milk production and maintenance than would the cows at the lower stocking rates (Freer, 1960). On the other hand, Holmes et al. (1967) suggested that liberal supplementation of low quality pastures with cheap concentrates, such as cotton seed, might be justifiable under some tropical conditions.

The feeding of the supplements in these three experiments to the type of the cows used was uneconomic. The results thus give evidence that provided sufficient herbage of good leafy quality is available there are no advantages in feeding supplements to milking cows at pasture which are producing only about 1 gallon a day. But with an intensive crossbreeding programme and close selection for high milk production, it may become necessary to feed some concentrates without necessarily lead feeding the cows.

One cannot possibly draw a final conclusion based on these studies partly because of the small numbers of cows used in each experiment and partly because of the inherent animal variation which can easily mask treatment effects and the interaction of grassland treatment with stocking rate. Further investigations are needed on the Digitaria grass using only Friesian-White Fulani crosses and pure Friesian cows.

Results so far however, are indicative of repeatable positive answers. One may safely conclude that with improved well managed Digitaria pastures, more intelligent use of suitable locally available concentrates, good management and care of cattle to control disease, minimal injuries and stresses of local environment on the exotic breeds, a profitable urban dairy production can be supported in the grazing season by intensive grazing management at 0.253-0.380 hectare per cow with little or no added concentrate provided there is adequate regular rainfall.

Summary

Results are given of a three-year experiment investigating the production of lactating cows fed on a Digitaria pasture under different stocking rates with and without added concentrates. The studies were made with 24 Zebu cows at two stocking rates and three levels of supplementation in the first year. Both the second and third year experiments were carried out with 9 Friesian x White Fulani and 9 White Fulani cows.

Herbage intakes were estimated by grass cutting techniques. Animal performance in terms of milk yield and weekly body weight change was recorded.

Increasing the stocking rate increased milk production per hectare. This increase outweighed the loss in yield per cow which was presumably due to reduced intake of herbage per cow per day toward the end of each year's growing season.

Results from 1968 studies showed that levels of concentrates fed had no economic significance on milk yield. There were no significant effects of stocking rate on per cow per day production, but production per hectare had a significant ($P<0.001$) influence. Both age and live-weights of cows had significant effects ($P<0.0005$ and $P<0.0005$ respectively) on milk yields.

In 1969 and 1970, when crossbred cows were used in the studies, Fat-corrected Milk (FCM) and body weight gain were influenced by breed ($P<0.0001$). Both Friesian x White Fulani, and White Fulani breeds responded similarly to level (but not the amounts) of concentrate fed in FCM and body gain. Age had some effect on body weight gain ($P<0.09$) but not on FCM. There was no significant difference on FCM production between level of concentrate on the high stocking rate. There was no difference in either FCM or body weight change due to year ($P<0.3$).

On the whole there were no differences due to supplementation at the three grazing levels until the end of growing season when the

unsupplemented group (0.253 ha/cow) produced 75 per cent as much as other treatments and 50 per cent as much in October and November.

From these studies it is concluded that of the three levels of grazing imposed, the high stocking rate was most economical and desirable for the cows used.

To obtain maximum milk production from pasture it is essential to have available both pasture and cows of high productive potential. It was indicative that pasture management is mainly concerned with applying the optimum rate of stocking. There must, however, be a compromise between a lower stocking rate tending to produce the greater immediate milk for the individual cow, and a higher stocking rate giving a higher output of milk per hectare but tending to depress output per cow.

LITERATURE CITED

Adeniyi, S.A. (1969). Thesis, Univ. West Indies, Trinidad.

Alder, F.E., Head, M.J. and J.F.N. Bertin (1956). Carbohydrate supplements for beef cattle on grass/clover and grass/lucerne mixture. Proc. Br. Soc. Anim. Prod. pp.79-89.

Alder, F.E. and Richards, J.A. (1962). A note on the use of the power driven sheep shearing head for measuring herbage yields. J.Br. Grassl. Vol. 17, pp. 101-2.

Alder, F.E., Cowlishaw, S.J., Newton, J.E. and Chambers, D.T. (1967). The effect of level of nitrogen fertilizer on best production from grazed perenial rye grass/white clover pasture, J.Br. Grassld. Soc. Vol. 22, pp. 230-8.

Allden, W.G. and A.C. Jennings (1962). Dietary supplements to sheep grazing mature herbage in relation to herbage intake. Proc. Aust. Soc. Anim. Prod. Vol.4. p. 145-53.

Armstrong, D.G. (1960). Proc. Int. Grassl. vii. Reading, p. 485.

Arnold, G.W. and W. Holmes (1958). Studies in grazing versus controlled free grazing on milk yield, milk composition and pasture utilization. J. Agric. Sci. Vol. 51, pp. 248-56.

Agishi, E.C. (1970). Cost of planting Digitaria grass per acre. Personal communication.

Baird, D.M. and O.E. Sell (1954). Ration digestibility, grazing behaviour and performance of best cattle as affected by supplemental feeding on winter pasture. J. Anim. Sci. Vol.13, p.1005.

Baker, H.K., R.D. Baker, R.M. Deakins, J.L. Gould, J.Hodges and R.A. Powell (1964). Grassland recording. v. Recommendation for recording the utilized output of grassland on dairy farms. J. Brit. Grassl. Soc. Vol. 19, pp. 160-8.

Beynon, V.H. (1964). Grass and Livestock products. Present performance and future prospects. J. Br. Grassld. Soc. Vol. 19, pp.171-8.

Bone, J.S. and R.S. Tayler (1963). The effect of irrigation and stocking rate on the output from a sward. J. Brit. Grassld. Soc. Vol. 18, pp.190-6.

Brody, S. (1945). Bioenergetics and growth. pp.839-42. Reinhold publ. Corp. New York.

Butterworth, M.H., C.G. Groom, and P.N. Wilson (1961). The intake of pangola grass under wet and dry-season conditions in Trinidad. J. Agric. Sci. Camb. Vol. 56, p. 407.

Castle, M.E., A.D. Drysdale and J.N. Watson (1960). The effect of feed supplements on the yield and composition of milk from cows grazing good pasture. J. Dairy Res. Vol. 27, pp. 419-426.

Campling, R.C., D.S. Machusky, and W. Holmes, (1958). Studies in grazing managements vi. The influence of free and strip-grazing and of Nitrogenous fertilizers on production from dairy cows. J. agric. Sci. Vol. 51, pp. 62-9.

Castle, M.E., A.D. Drysdale and J.N. Watson (1964). The feeding of supplementary concentrates to dairy cows grazing good pasture. J. Brit. Grassld. Soc. Vol. 19, pp. 381-86.

Castle, M.E., A.D. Drysdale and J.N. Watson (1965). The effect of stocking rate and supplementary concentrate feeding on milk production. J. Brit. Grassld. Soc. Vol.

Castle, M.E., A.D. Drysdale and J.N. Watson (1968). The effect of stocking rate and supplementary concentrate feeding on milk production. J. Brit. Grassld. Soc. Vol. 23, pp. 137.

Clark, J. (1959). The measurement of grassland productivity on dairy farms in England and Wales. The measurement of grassland productivity Ed. J.D. Ivins, Butterworths Scientific Publications, London. pp. 185-93.

Conway, A. (1963). Effect of grazing management on beef production 1. comparison of the three systems of grazing. Ir. J. agric. Res. Vol. 2, pp. 87-94.

Conway, A. (1970). Grazing management for beef production. J. Brit. Grassld. Soc. Vol. 25, pp. 85-91.

Corbett, J.L. (1958). Effects of low protein supplement on the yields and composition of milk from grazing dairy cows. Proc. Br. Soc. Anim. Prod. pp. 3-12.

Corbett, J.L., Langlands, J.P. and Boyne, A.W., (1961). An estimate of the energy expensed for maintenance by strip-grazed dairy cows. Proc. European Congr. Anim. Prod. Hamburg.

Couper, D.C. and A. West-Sadler (1970). Suspension fencing, Samaru Agricultural Newsletter, Vol. 12, No. 1, p. 17.

Cox, C.P., Goot, A.S., Hoskin, Z.D. Line, C. and Rowland, S.J. (1956). The direct evaluation of pasture in terms of milk production of individually grazed cows. J. Brit. Grassld. Soc. Vol. II, p. 107-18.

Crampton, E.W., Donefer, E. and Lloyd, L.E. (1960). J. Anim. Sci. Vol. 19, pp.538.

Curie, J.R. (1948). The economics of ley farming. J. Brit. Grassld. Soc. Vol. 3, pp. 27-34.

De Geus, J. (1950). A note on ration grazing in Holland. J. Brit. Grassld. Soc. Vol. 5, pp. 251-2.

Dodsworth, T.L. and C. Ball (1962). Studies on the feeding of supplements to beef cattle on grass. Anim. Prod. Vol. 4, pp. 221-6.

Dodsworth, T.L. and C. Ball (1962). The effect of underticated cotton cake added to a grass diet fed to sheep. Anim. Prod. Vol. 4, pp. 227-32.

Donker, J.D., G.C. Marten and W.F. Wedin (1968). Effect of concentrate level on milk production of cattle grazing high-quality pasture. J. Dairy Sci. Vol. 51, pp. 67-73.

Forbes, T.J. A, Raven, J.H.D. Irwin and K.L. Robinson (1967). The utilization of grass fed indoors to young beef cattle, with or without supplementary barley. J.Br. Grassld. Soc. Vol. 22, pp. 158-63.

Freer, M. (1954). The utilization of irrigated pasture by dairy cows II. The effect of stocking rate. J. Agric. Sci. 54, 243-256.

Freer, M. (1959). The utilization of irrigated pastures by dairy cows. J. Agric. Sci. Cams. Vol. 52, pp. 129-36.

Freer, M. (1960). The utilization of irrigated pastures by dairy cows. II. The effect of stocking rate. J. Agric. Sci. Vol. 54, pp. 243-56.

Flux, D.S. and M.R. Patchell (1955). A comparison of the milk production of cows on different systems of break feeding. N.Z.J. Sci. Tech. Vol. 36, (A) pp. 557-9.

Grass Utilization Committee. (1958). Reports of the Committee on Grass Utilization. Cmd. 547, H.M.S.O., London.

Glover, J. and H.W. Dougall. (1961). Milk production from pasture. J. Agric. Sci. 56, 261-264.

Greenhalgh, J.F., D.J.L. Corbett and I. McDonald (1960). J.Agric. Sci. Vol. 55, p. 377.

Hamilton, R.A. (1952). The need and means of increasing self-efficiency on the farm. J. FMRS' Cl; Lond. pp. 53-77.

Hamilton, R.A. (1956). The utilization of grassland. I. Agriculture, Vol. 62, pp. 374-6.

Hancock, J. (1958). The conversion of pasture to milk. J. Agric. Sci. Vol. 50, pp. 284-296.

Hanrard, J. T. (1950). Monography of the Genns Digitaria. Leiden: Univ. Pers.

Harker, K. W. and A. D. McKay, (1962). A stocking rate trial on rough grazing in Buganda. E. Afr. agric. For. J. Vol. 27, p. 465.

Harkness, R. D. (1958). The effects of different grazing systems on pasture production. M. S. Thesis, Cornell University.

Harlan, R. J. (1958). Generalized courves for gain per head and gain per acre in rates of grazing studies. J. Range Mgt. Vol. 11. pp. 140-147.

Hart, M. L. (1956). Some problems of intensive grassland farming in the Netherlands. Proc. 7th Int. Grassl. Congr. pp. 70-79.

Hodgson, J., J. C. Taylor and C. R. Lonsdale (1971). The relationship between the intensity of grazing and the herbage consumption and growth of calves. J. Brit. Grassld. Soc. Vol. 26, pp. 231-7.

Holder, J. M. (1960). Observations of the grazing behaviour of lactating dairy cattle in a sub-tropical environment. J. Agric. Sci. Lamb Vol. 55, pp. 261-7.

Holmes, W., R. Waite, D. L. Fergusson and J. I. Campbell (1950). Studies in grazing management I. A comparison of the production obtained from close folding and rotational grazing of dairy cows. J. Agric. Sci. Vol. 40, pp. 381-91.

Holmes, W. (1954). High milk yields per acre from grassland. J. Brit. Grassld. Soc. Vol. 9, pp. 17-27.

Holmes, W. and S. D. Sykes. The influence of supplementary feeding in the summer period on feed intake and profitability of dairy cows. Proc. 8th Int. Grassld. Congr. 1961.

Holmes, W., Jones, J. G. W. and Drake-Brockman, R. M. (1961). The food intake of grazing cattle. II. The influence of size of animal on feed intake Anim. Prod. Vol. 3. pp. 251-60.

Holmes, W. (1962). J. Brit. Grassland Soc. Vol. 17. p. 30.

Holmes, J. C. and R. W. Lang (1963). Anim. Prod. Vol. 5, p. 17.

Holmes, W. (1964). Farm Business, Vol. 3, p. 33.

Holmes, W. and M.K. Curran (1967). Feed intake of grazing cattle. v. A further study of the influence of pasture restriction combined with supplementary feeding on production per animal and per acre. Anim. Prod., Vol. 9, Part 3, pp. 313-324.

Huffman, C.F. (1959). Summer feeding of dairy cattle , a review. J. Dairy Sci. Vol. 42, pp. 495-551.

Hull, J.L., Meyer, J.H. and Kromann, R. (1961). Influence of stocking rate on animal and forage production from irrigated pasture. J.Anim. Sci. Vol. 20, pp. 46-52.

Husted-Anderson, S. (1941). The grass consumption of cows on pasture Nutr. Abstr. Rev. Vol. 16, p. 990.

Hutton, J.B. (1962). Estimating the feed requirements of grazing dairy cows. N.Z.J. Agric. Vol. 105, pp. 537-47.

Invins, J.D. (1959). The interpretation of animal production data in grassland evaluation. The measurement of grassland productivity. Ed. J.D. Invins. Butterworths Scientific Publications, London, pp. 148-55.

Jarl, Follec. (1952). Use of forage in livestock production. Proc. 6th Int. grassld. Cong. Vol. 2, pp. 117-84.

Joblin, A.D.H. (1960). The influence of night grazing on the growth rates of Zebu cattle in East Africa. J. Brit. Grassld. Soc. Vol. 15, pp. 212-215.

Joblin, A.D.H. (1962). The use of grazing animal observations in the early stages of pasture evaluation in the tropics. II. The measurement of pasture consumption.

Joblin, A.D.H. (1963). Strip grazing versus paddock grazing under Tropical conditions. J.Br. Grassland Soc. Vol. 18, p. 69.

Joblin, A.D.H. (1966). The response of Toso Zebu milking stock to moderate levels of supplementary feeding. E.Afr. Agric. For. J. Vol. 31, p. 368.

Kennedy, W.K., J.T. Reid and M.J. Anderson (1959). Evaluation of animal production under different systems of grazing. J. Dairy Sci. Vol. 42, pp. 679-686.

Kleiber, M. (1959). Energy transformation in relation to the efficiency of milk production. Nutritional and Economic Aspects of feed utilization by dairy cows, Iowa State Coll. Press, pp. 51-74.

Koch, B.A. and A. Gambo (1971). Feeding Dairy cows at Shika Agric. Research Station, Samaru Agricultural Newsletter, Vol. 13, No. 5, pp. 102-105.

Kruger, L., Muller, W. Ginkel, E. and Schulze, G. (1955). Factors influencing value of Fodder consumed by dairy cows. Zuchtungskunde, Vol. 27, pp. 143-53.

Laird, R. and J. Walker-Love (1962). J. Agric. Sci. Camb. Vol. 50, p. 233.

Lambourne, L.J. (1956). A comparison between rotational grazing and set stocking for fat lamb production. N.Z.J. Sci. Tech. Vol. 37 (A) pp. 555-68.

Lampkin, K. and G.H. Lampkin (1960). Studies on the production of beef from Zebu cattle in East Africa. II. Milk production in suckled cows and its effect on calf growth. J. Agric. Sci. 55, (2) pp. 233-239.

Leaver, J.D., Campling, R.C. and Holmes, W.H. (1968). Use of supplementary feeds for grazing dairy cows. Dairy Sci. Abstr. Vol. 30. p. 355.

Legates, J.E., Murley, W.R. and Waugh, R.K. (1956). Hay consumption of individual cows on limited grain feeding. J. Dairy Sci. Vol. 39, pp. 937-48.

Line, C. (1961). Maximum milk production from pasture. Proc. 8th Int Grassl. Congr. Reading, 1960, pp. 598-601.

Lloyd, A.G. (1966). Economics aspects of stocking and feeding policies in the sheep industry in southern Australia. Proc. Aust. Soc. Anim. Prod. Vol. 6, pp. 137-47.

Maclusky, D.S. (1955). The quantity of herbage eaten by grazing dairy cows. Rep. Brit. Soc. Anim. Prod. pp. 45-51.

Maclusky, D.S. (1959). Studies of herbage production and consumption and the production of dairy cows in various grazing conditions. The measurement of grassland productivity. Ed. J.D. Ivins Butterworths Scientific publications, London. pp. 129-45.

MacMeekan, C.P. (1952). Interdependence of grassland and livestock in agricultural production. Proc. 6th Int. grassld. Congr. pp. 149-61.

McCollough, M.E. (1956). A study of techniques for measuring difference in forage quality using dairy cows. Georgia agric. exp. sta. tech. bull. N.S. 4.

McMeekan, C.P. (1956). Proc. 7th Int. Grassld. Conf. 146.

McMeekan, C.P. (1957). Proc. 7th Int. Grassld. Conf. p.146.

McMeekan, C.P. (1961). Grazing management. Proc. 8th Int. Grassld. Congr. Reading, 1960, pp.21-6.

McMeekan, C.P. and Walshe M.J. (1963). The interrelationships of grazing method and stocking rate in the efficiency of pasture utilisation by dairy cattle, J. Agric. Sci. Camb. Vol.61, pp.147-66.

Meyer, J.G., G.P. Lofgreen and F.K. Hart (1953). The value of certain supplements for beef cattle fed harvested green alfalfa. J. Anim. Sci. Vol. 12, pp.806.

Milford, R. (1961). Proc. 8th Int. Grassld. Congr. Reading, 1960.

Milford, R., D.J. Minson and C.E. Harris (1961). Exp. Grassl. Res. Inst., Hurley, No.13, p.77.

Milford, R. and Minson, D.J. (1966). Intake of tropical pasture species. Proc. 9th Int. Grassld. Congr. Brazil, 1965, pp.815-22.

Miller, T.B. (1961). Studies on Nutrition of Zebu cattle in Northern Nigeria. I. Energy intake and milk production, Empire J. Expt. Agric. Vol 29. pp.230-244.

Minson, D.J. (1963). J. Brit. Grassld. Soc. Vol. 18, p.39.

Minson, D.J. (1971a). J. Aust. Agric. Sci. (in press).

Morley, F.H.W. and Spedding, C.R.W. (1968). Agricultural systems and grazing experiments. Hers. Abstr. Vol. 38, pp.279-87.

Mott, G.O. (1960). Grazing pressure and the measurements of pasture production. Proc. 8th Intern. grassl. Cong. 606-611.

Mott, G.O. (1961). Proc. Int. Grassl. Congr. VIII. Reading, p.606.

Murley, F.H.W. and Spedding, C.R.W. (1968). Agricultural systems and grazing experiments. Herb. Abstr. Vol. 38, pp.279-87.

Nestel, B.L. (1964). Anim Production studies in Jamaica, 4. The cost of developing and maintaining pangola grass pasture. J. Agric. Sci. Camb. Vol. 62, pp.179-86.

Nestel, B.L. and M.J. Creek, (1972). Pangola grass. Herb Abstr. Vol. 32, pp. 265-71.

O.E.E.C. (1954). Pasture and fodder production in North-West Europe. (R.Ar/123(53)1). O.E.E.C. Paris.

Osbourn, D.F. (1969). The introduction of pangola grass into the Caribean Islands. J.Por.Grassld. Soc. Vol. 24, pp. 76-80.

Pauka, A. (1971). Biological and husbandry aspects of supplementary feeding of cows during the grazing season. Dairy Sci. Abstr. Vol. 33, pp. 748.

Petersen, R.G., H.L. Lucas, and G.O. Mott (1965). Relationship between rate of stocking and per animal and per acre performance on pasture, Agron. J. 57, 27-30.

Phipps, R.H. (1970). Some aspects of supplementary feeding of dairy cows in the lake cresent area of Uganda. E.Afric. Agric. For.J. Vol. xxxvl, pp. 182-184.

Raymond, W.F. (1948). Evaluation of herbage for grazing. Nature, Vol. 161, pp. 937.

Raymond, W.F. and Minson, D.J. (1955). The use of chromic oxide for estimating the feacal production of grazing animals J. Brit. Grassl. Soc. Vol. 10, pp. 282-94.

Raymond, W.F. (1957). The measurement of pasture output, Proc. Nutr. Soc. Vol 16, pp. 20-5.

Reid, J.T. (1959). Pasture evaluation in relation to feed efficiency. Nutrition and economic aspects of feed utilisation by dairy cows. Iowa Stat. Coll. Press. Ames. Iowa, pp. 135-51.

Riddet, W. (1951). Advantages of rationed grazing. Dairy farming annual. Massey Agric. Coll. Palmerston North. N.Z.

Riewe, M.E. (1961). Use of the relationship of stocking rate for gain in cattle in an experimental design for grazing trials Agron. J. Vol. 53, pp. 309-313.

Romney, D.M. (1961). Productivity of pasture in British Honduras. 2. Pangola pasture (as influenced by climate soil type and phosphate fertilizer) Trop. Agric. Trin. Vol. 38. pp, 39-47.

Sadar, V. (1961). Research and experience in rationed grazing in Slovenia. Proc. 8th Int. grassld. Congr. pp. 591-4.

Scarisbrick, D.H. (1971). A note on the liveweight change of sheep grazing at three stocking rates and two levels of nitrogenous fertilizer. J.Br.Grassld. Soc. Vol.26, p.183.

Sjollema, B. (1950). On the influence of the composition of pasture herbage on the production of dairy cows and on the benefit of supplementing the grass with protein-poor feeds. J.Brit. Grassl. Soc. Vol. 5, pp.179-94.

Smith, A.M. and Reid, J.T. (1955). The use of chromic oxide as an indicator of feacal output for the purpose of determing the intake of pasture herbage of grazing dairy cows. J. Dairy Sci. Vol.28, pp.515-24.

Smith, C.A. (1966). Studies on the hyparrhenia veld of Zambia vii. J.Agric. Sci. Vol. 66. pp. 49-56.

Speddong, C.N.W. (1966). The grazing sheep in relation to its environment. Proc. 9th Int. Congr. Anim. Prod. pp. 174-87.

Stobbs, T.H. and Joblin, A.D.H. (1966). The use of liveweight trials for pasture evaluation in the tropics. II. Variable stocking rate designs. J.Brit. Grassld. Soc. 21. pp. 181-185.

Stobbs, T.H. (1967). Techniques for the evaluation of tropical pastures in terms of liveweight-gain, Ph.D. thesis, Univ. East Africa.

Stobbs, T.H. (1969). The effect of grazing management upon pasture productivity in Uganda. I. Stocking rate. Trop.Agric. Trin. Vol. 46, pp.187-94.

Stobbs, T.H. (1970). The use of liveweight-gain trials for pasture evaluation in the tropics. J.Br. Grassland Soc. Vol.25, pp.73-77.

Stull, J.W. Brown, W.H. Valdez, C. and Tucker, H. (1966). 3 Dairy Sci. Vol.49. p.1401.

Toledo, J.M. (1968). Productivity of pasture of pangola grass (Digitaria decumbene) and guinea grass (panicum maximum) in terms of milk production, Dy Sci. Abstr. Vol. 33, p.745.

Van Der Molen, H. (1960). Ten years' experience with heavy applications of nitrogen on grassland in the Netherlands. The fertilizer society, London.

Vik, E. (1956). Comparison between day pasturing and night pasturing for dairy cows. Forskn. Fors. Landbr. pp.109-28.

Voisin, A. (1959). Grass productivity. Crosby Lockwood, London, pp. 251-65.

Waite, R., MacDonald, W. B. and Holmes, W. (1951). Studies in grazing management III. The behaviour of dairy cows grazed under close-folding and rotational systems of management. J. Agric. Sci. Vol. 41, pp. 163-73.

Walker, D. E. (1954). Meat production per acre. Proc. Puakura Farms conf. pp. 3-11.

Walker, B. and G. D. Scott (1968). Grazing Experiments at Ukiriguru. I. Comparisons of rotational and continuous grazing systems on natural pastures of hard pan soils. E. Afr. agric. for. J. Vol. 34.

Walker, B. (1968a). Grazing Experiments at Ukiriguru, Tanzania. II. Comparisons of rotational and continuous grazing systems on natural pastures of hard pan soils using an "Extra-period hatin-square change-over Design" E. Afr. agric. for. J. Vol 34, pp. 235-244.

Wallace, L. R. (1956). The intake and utilization of pasture by grazing dairy cattle Proc. 7th Int. Grassl. Congr. pp. 134-45.

Wallace, L. R. (1957). Proc. 7th Int. Grassl. Conf., p. 134.

Wheeler, J. L., Reardon, T. F. and Lambourne, L. J. (1963). Aust. J. Agric. Res. Vol. 14, p. 364.

Winter, K. A. V. S., Logan, M., Vernand W. J., Pigden (1964). Pasture for young dairy stock. Can. J. Anim. Sci. Vol. 44, p. 8.

Wood, R. S. (1966). Feeding supplementary concentrates to dairy cows on grass during July-September. Expt. Husb. No. 14, pp. 98-104.

Wright, N. C. (1940). Britains supplies of feeding stuffs. Emp. J. Exp. Agric. Vol. 8, pp. 231-48.

Young, J. G. and R. W. Hewetson (1971). Production limitations arising from the type of dairy animals available in tropical Australia. Tropical Grasslds, Vol. 5, No. 3, pp. 289-93.

APPENDIX

Appendix Table A*

A comparison table showing economic level of milk production from three sources of livestock feeds.

	MAIZE SILAGE	ELEPHANT GRASS SILAGE	DIGITARIA PASTURE
Total No. of Cows	22	23	30
Av. No. in Milk/Day	17	16	14
Days on Trial	182	182	124
Concentrate: Tons	14.9	12.0	5.9
Hay: Tons	10.4	10.4	0
Silage: Tons	108.9	113.4	0
Pasture, HO.	0	0	6
Milk Produced (Kgm)	19,538	14,683	13,509
Kg. Con. /Kg. Milk	0.77	0.82	0.44
Av. Production/Cow (Kgm)	6.3	5.0	7.5
Feed Cost/Kg. Milk (Pence)	5.7	7.7	2.85
Feed Cost/Pint of Milk (Pence)	3.4	4.5	1.62
Average Initial Weight (Kgm)	448	467	427
Average Final Weight (Kgm)	441	441	468
No. of Calves Born	11	8	14
Average Birth Weight (Kgm)	30	30	32
Dairy Conc.	392/- per ton		
Maize Silage	22/- per ton		
Elephant Grass Silage	31/- per ton		
Gamba Hay	115/- per ton		
Digitaria Pasture	150/- per Hectare		
Feed = 70% of total production cost.			
Total Cost/Pint	4.9	6.4	2.3

*Taken from Koch et al. (1971).

Appendix Table B. Comparisons of stocking rates and levels of supplementation applying Approximated Duncans tests

		L S R	X	H. S. R. Expt. 1, 1968	
				Milk yield per hectare	
Milk yield per cow					
H S R. yield more milk than not significant (P<0.2 0.1)	L. S. R. though			H. S. R. significantly (P<0.005 P>0001) than the L.S.R. per hectare	
L.S.R. x M.S.R.		L.S.R. X H.S.R. - Conc.		M.S.R. x H.S.R. - Conc.	H.S.R. - Conc. x H.S.R conc
MILK YIELD					
M.S.R. yield highly significant (P<0.001) more milk than L.S.R.		H.S.R. - conc. yielded significant (P<0.005) more milk than the L.S.R.		M.S.R. yielded slightly significant (P<0.05) more milk than H.S.R.- conc.	H.S.R. + conc yielded highly significant more (P<0.0001) than the H.S.R.- conc. but not economical
There was no significant difference between the two stocking rates		L.S.R. produced highly significant (P<0.0005) more milk than H.S.R.- conc.		The M.S.R. yield highly significant (P<0.001) more milk than the H.S.R. -conc.	H.S.R. - conc. yield highly significantly less milk than the H.S.R.+ conc.
LIVEWEIGHT					
The L S R yielded slightly significantly (P<0.01) more weight than the M S R		But there was surprisingly no significant difference between L S R & H S R -conc.		H.S.R.-conc. yielded significantly more beef (P<0.005) than the MSR	H S R + conc. yield highly significant (P<0.005) weight than the H S R-conc.
The L S R significantly (P = 0.005) more beef than the M S R		The H S R-conc. significantly (P<0.0001) produced more body weight than the L S R?		H S R-conc. produced significantly (P<0.005) more beef than the MSR	H S R + Conc. yielded slightly significant (P<0.03) more beef than H S R - conc.

APPENDIX TABLE C (1968) ANALYSIS OF VARIANCE FOR LIVEWEIGHT

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F-RATIO	PROBABILITY
Concentrate Level	2	7156.85992453	3578.42993164	6.596	0.0016
Stocking Rate	1	48541.48480106	48541.48437500	89.480	0.0000
Concentrate Level* Stocking Rate	2	16377.04548536	8188.51953125	15.095	0.0000
Initial Liveweight	1	1540891.15301655	1540891.00000000	2840.441	0.0000
Initial Milk Production	1	4157.32388209	4157.32031250	7.664	0.0060
RESIDUAL	280	151895.25000000	542.48291016		
TOTAL	287	2742088.00000000			

ANALYSIS OF VARIANCE FOR MILK PRODUCTION

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F-RATIO	PROBABILITY
Concentrate Level	2	15224.02260626	7612.00781250	11.400	0.0000
Stocking Rate	1	34.91734422	34.91734314	0.052	0.8193
Concentrate Level*Stocking Rate	2	4640.49179425	2320.24584961	3.475	0.0323
Initial Liveweight	1	28262.45340554	28262.45312500	42.325	0.0000
Initial Milk Production	1	72542.31925547	72542.31250000	108.638	0.0000
RESIDUAL	280	186967.43750000	667.74072266		
TOTAL	287	284409.81250000			

APPENDIX TABLE D (1968) LEAST SQUARE MEANS ANALYSIS FOR LIVEWEIGHT

SOURCE	SUBCLASS LEVELS	MEAN	STANDARD ERROR
	CONCL		
Concentrate Level (Concl)	1	820.0749512	2.393735
Concl	2	815.5419922	2.518193
Concl	3	828.3889160	2.440112
	STK. RT.		
Stocking Rate (STK. RT.)	1	835.0476074	1.996250
STK. RT.	2	807.6230469	1.996231
	CONCL STK. RT.		
Concl * STK RT	1 1	826.9311532	3.364706
Concl * STK RT	1 2	813.2182617	3.391808
Concl * STK RT	2 1	840.2119141	3.827872
Concl * STK RT	2 2	790.8715820	3.371027
Concl * STK RT	3 1	837.9987793	3.378029
Concl * STK RT	3 2	818.7783203	3.459466

LEAST SQUARE MEANS ANALYSIS FOR MILK PRODUCTION

SOURCE	SUBCLASS LEVELS	MEAN	STANDARD ERROR
	CONCL		
Concl	1	71.8704529	2.655749
Concl	2	69.7839508	2.793830
Concl	3	55.1057129	2.707202
	STK RT		
STK RT	1	65.9544830	2.214734
STK RT	2	65.2189484	2.214734
	CONCL STK RT		
Concl * STK RT	1 1	62.4678802	3.733000
Concl * STK RT	1 2	75.2730103	3.763069
Concl * STK RT	2 1	75.9586639	4.246863
Concl * STK RT	2 2	63.6092224	3.740013
Concl * STK RT	3 1	53.4368439	3.747782
Concl * STK RT	3 2	56.7745514	3.838133

APPENDIX TABLE E (1969 & 1970)

ANALYSIS OF VARIANCE FOR LIVEWEIGHT

SOURCE	D.F.	SUMS OF SQUARES	MEAN SQUARES	F-RATIO	PROBABILITY
Trial	1	91820.81202657	91820.75000000	12.719	0.0004
Breed	1	1919004.66264030	1919004.00000000	265.829	0.0000
Discrete concentrate	1	516148.39713575	516148.37500000	71.499	0.0000
Breed * Dis. Conc.	1	53403.06133461	53403.05859375	7.398	0.0068
Age	1	288285.15077972	288285.12500000	39.935	0.0000
Dry-Matter	1	2908.69312574	2908.69311523	0.403	0.5260
Crude Protein	1	89.50858509	89.50857544	0.012	0.9114
RESIDUAL	420	3031953.00000000	7218.93359375		
TOTAL	427	5560539.00000000			

ANALYSIS OF VARIANCE FOR MILK PRODUCTION

SOURCE	D.F.	SUMS OF SQUARES	MEAN SQUARES	F-RATIO	PROBABILITY
Trial	1	612.63447418	613.63427734	17.746	0.0000
Breed	1	1690.22651376	1690.22631836	48.961	0.0000
Discrete Concentrate	1	381.85666506	381.85644531	11.061	0.0010
Breed * Dis. Conc.	1	225.13382557	225.13381958	6.522	0.0110
Age	1	102.60971738	102.60971669	2.972	0.0854
Dry-Matter	1	0.79299438	0.79299432	0.023	0.8796
Crude Protein	1	11.05253148	11.05253124	0.320	0.5719
RESIDUAL	420	14499.05468750	34.52154541		
TOTAL	427	21162.20312500			

APPENDIX TABLE F (1969 & 1970)

LEAST SQUARE MEAN ANALYSIS FOR LIVEWEIGHT

SOURCE	SUBCLASS LEVELS	MEAN	STANDARD ERROR
	TRIAL		
Trial (1969)	1	916.5998835	7.984694
Trial (1970)	2	869.8242188	7.777499
	BREED		
Breed	1 (C.B.)[a]	984.0805664	7.200201
Breed	2 (W.F.)[b]	802.3435059	6.965395
	DIS. CONC.		
Discrete Concentrate	1	930.8527832	7.230467
Discrete Concentrate	2	855.5712891	5.058538
	BREED DIS. CONC.		
Breed * Dis. Conc.	1 1	1034.1638184	10.523781
Breed * Dis. Conc.	1 2	933.9968262	8.309319
Breed * Dis. Conc.	2 1	827.5412598	10.210171
Breed * Dis. Conc.	2 2	777.1452537	8.924991

LEAST SQUARE MEAN ANALYSIS FOR MILK PRODUCTION

SOURCE	SUBCLASS LEVELS	MEAN	STANDARD ERROR
	TRIAL		
Trial	1 (1969)	12.0802965	0.552162
Trial	2 (1970)	15.9010572	0.537834
	BREED		
Breed	1 (C.B.)	16.6874695	0.497913
Breed	2 (W.F.)	11.2938805	0.481675
	DIS. CONC.		
Discrete Concentrate	1	15.0144939	0.500006
Discrete Concentrate	2	12.9668598	0.349811
	BREED DIS. CONC.		
Breed * Dis. Conc.	1 1	16.9033813	0.727747
Breed * Dis. Conc.	1 2	16.4715424	0.574611
Breed * Dis. Conc.	2 1	13.1255894	0.706060
Breed * Dis. Conc.	2 2	9.4621706	0.617186

a = Friesian x White Fulani Crossbred

b = White Fulani.

PERFORMANCE OF LACTATING COWS ON DIGITARIA PASTURE UNDER DIFFERENT STOCKING RATES WITH OR WITHOUT ADDED CONCENTRATES

by

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AN ABSTRACT OF A MASTER'S THESIS

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Results are given of a three-year experiment investigating the production of lactating cows fed on a Digitaria pasture under different stocking rates with and without added concentrates. The studies were made with 24 Zebu cows at two stocking rates and three levels of supplementation in the first year. Both the second and third year experiments were carried out with 9 Friesian x White Fulani and 9 White Fulani cows.

Herbage intakes were estimated by grass cutting techniques. Animal performance in terms of milk yield and weekly body weight changes was recorded.

Increasing the stocking rate increased milk production per hectare. This increase outweighed the loss in yield per cow which was presumably due to reduced intake of herbage per cow per day toward the end of each year growing season.

Results from 1968 studies showed that levels of concentrates fed had no economic significance on milk yield. There were no significant effects of stocking rate on per cow per day production, but production per hectare had a significant ($P<0.001$) influence. Both age and liveweights of cows had significant effect ($P<0.0005$ and $P<0.0005$ respectively) on milk yields.

In 1969 and 1970, when crossbred cows were used in the studies, Fat-corrected Milk (FCM) and body weight gain were influenced by breed ($P<0.0001$). Both Friesian x White Fulani, and White Fulani breeds responded similarly to level (but not the amounts) of concentrate fed in FCM and body gain. Age had some effect on body weight gain ($P<0.09$) but not on FCM. There was no significant difference on FCM production between levels of concentrate *on* the high stocking rate. There was no difference in either FCM or body weight due to year or experimental procedure in both years ($P<0.3$).

On the whole there were no differences due to supplementation at the three grazing levels until the end of growing season when the unsupplemented group (0.253 ha/cow) produced 75 per cent as much as other treatments and 50 per cent'as much in October and November.

From these studies it is concluded that of the three levels of grazing imposed, the high stocking rate was most economical and desirable for the cows used.

To obtain maximum milk production from pasture it is essential to have available both pasture and cows of high productive potential. It was indicative that pasture management is mainly concerned with applying the optimum rate of stocking. There must, however, be a compromise between a lower stocking rate tending to produce the greater immediate milk for the individual cow, and a higher stocking rate giving a higher output of milk per hectare but tending to depress output per cow.

Errata

P. 7, para. 2, line 4

Holmes, W. and J.G. Jones (1964). The efficiency of utilization of fresh grass. J. Brit. Grassld. Soc. Vol,19, pp. 119-129.

P. 25, para. 4

Robertson, A. (1950) - Conference on the improvement of livestock under tropical conditions, Dec. 1950, Edinburgh, Scotland.

P. 16, para. 4

Corbett, J. L. and A. W. Boyne (1958). The effects of a low-protein food supplement on the yield and composition of milk from grazing dairy cows and on the composition of their diet. J. agric. Sci. 51, pp. 95-106.

P. 40, para. 1, line 6

Groom, C.G., Butterworth, M.H. and P.N. Wilson (1961). The intake of Pangola grass under wet and dry-season conditions in Trinidad. J. Agric. Sci. Camb. Vol. 56, p. 407.