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Researches into Sterility of Cows in South Africa.

The Influence of: (i) Dry Rations, (ii) Lack of Exercise, and (iii) Lack of Sunlight on Reproduction in Beef Heifers and Cows.

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In a previous publication, Quinlan (1929) published a report of his researches into sterility of cows in South Africa. That report covered investigations into the local pathological genital causes of sterility as observed under the environmental conditions prevailing in South Africa. The histological anatomy of the diseased genital organs of a number of cows was studied after the clinical pathology had been examined periodically over a period of months. The therapeutic measures adopted to overcome pathological genital lesions were described. An attempt was made to ascertain whether there were concurrent ductless glands and genital pathology in permanently sterile cows by making a macroscopic and histological study of the hypophysis, epiphysis, thymus, thyroid, and adrenal glands.

Since the publication of the above-mentioned work, observations have been made on certain factors which are popularly associated with the aetiology of low fertility in cattle. The object of some of these observations was to ascertain the effects of continuous dry rations on reproduction in beef cattle, when fed in such quantities as to produce condition better than that usually associated with the ideal for normal genital physiology.

Since the experimental issue could be broadened by restriction of exercise and restriction of exposure to the sun's rays, the influence or inactivity and darkened stalls on reproduction was studied concurrently.

The close relationship between nutrition and normal functioning of the genitalia of cattle has been indicated by the foremost authorities on genital pathology. The importance of a correctly balanced ration, containing a sufficiency of vitamins A, B, C, D, and E, to maintain physical and genital fitness is emphasised if the

highest fertility is to be attained: Williams (1921, '32), Richter (1926), Wester (1921), Zschokke (1900), Oppermann (1922), Albrechtsen (1917), Nielsen (1926), Hammond (1927, '33), Stalfors (1930), Korenchevsky (1933), *et al.* In fact, all workers who have discussed the causation of low fertility in a general way have stressed the probability of constitutional aetiology due to errors in diet.

The association of unsuitable environmental conditions outside the nutritional aspect has long been known to be incompatible with the highest fertility. Hammond (1933) points out that lack of exercise and dry rations are not conducive to regular breeding. He also indicates that, by analogy with experiments done on ferrets, the ripening of the ovum is delayed by the shortening hours of daylight, just as fowls lay fewer eggs in autumn unless they are lighted and fed high protein foods with salts. Inhygienic housing, obesity, malnutrition, lack of exercise, feeding for forced milk production, and controlled breeding with the object of prolonging lactation, are factors which must be considered artificial and which tend to cause a deviation from normal physiological genital activity. Similarly too, early breeding, and careless management during calfhood have been inculpated as aetiological factors. Williams (1932) stresses the detrimental influence on the subsequent breeding records of heifers bred too young. Withycombe, Potter and Edwards (1930) have shown that calving at the age of two years reduced the percentage of calves produced by the same cows at the ages of three and four, but not at the ages of five and six. There is no questioning the detrimental influence of vitamin deficiencies in diet on the gonads: Korenchevsky (1933), Sampson, Dennison, and Korenchevsky (1932), Sampson and Korenchevsky (1932), Siperstein (1921). Roux (1936) has shown that when sheep are maintained on low-level rations for extended periods of time, follicular development is inhibited and the number of follicles present in the ovaries is greatly reduced.

An immense literature has been published on this aspect in laboratory animals within recent years. This is, however, outside the scope of this paper and will not be reviewed in detail.

Genetic tendency to difficult breeding in association with any of the above factors appears to exaggerate the difficulty.

It is realised that unsuitable food or lack of food, unsuitable conditions of hygienic enviroment, and sex hygiene will detrimentally influence the physical well-being of cattle so that general constitutional causes will favour local genital infection.

The present article is not concerned with this aspect of infertility. Local genital causes, the result of infections following on lowered vitality, have been previously dealt with (Quinlan, 1929). The object of the present work is to record the behaviour of the genital tract of beef heifers and cows, when placed in an environment enforcing some factors which are popularly associated with low fertility: The factors considered are lack of sunlight, lack of exercise, dry rations, and high condition.

Usually insufficiency of light and exercise are associated with unhealthy stabling and general bad management, but in this experiment these associated hygienic factors can be ruled out.

The precise causes of reproductive failure in many cases of so-called functional sterility or infertility are obscure. Few references can be found in the literature on sterility of cattle to indicate that there are any experimental data on the influence of lack of exercise, lack of sunlight, and lack of green food on cattle. The object of the present experiment was to try and assemble data on these points.

It appears to be true that any factor which causes a deviation from ideal breeding condition or what is visualised as ideal breeding condition, will tend to lessen the bovine birth-rate. It is highly probable, however, in view of the results which will be discussed in this paper, that some secondary concurrent factors are necessary to cause that deviation in sex-physiology which produces difficult breeding in cattle fed on dry rations and showing obesity, or those which are housed under conditions enforcing restriction of exercise and sunlight.

The immediate causes of erratic behaviour of the genital tract appear to lie in the functioning of the internal secretory glands, most probably the ovary and the pituitary [Parkes (1933), Cole and Miller (1933), Fairlie (1935), Zavadovskii, Wunder, Paduceva, and Margvelasvili (1935), Cole and Miller (1935), *et al*].

From observations made on the ductless glands of cattle by Quinlan (1929), there would appear to be no constant histological change in these glands in cases of so-called functional sterility. The change appears to be in function not in structure. Further, it appears that return to normal can take place quickly when ideal conditions are restored.

Parkes (1933) states that the absence of antipituitary hormone causes the ovary to degenerate so far as appreciable follicles are concerned, but even in long standing hypophysectomies normal primordial ova, surrounded by one or more layers of follicular epithelium, are still found. This indicates that the ovary requires only the necessary stimulation to awaken normal function. Cole and Miller (1933) and Zavadovskii, *et al.* (1935), have shown that normal oestrus and ovulation can be produced in sheep by injections of the gonad stimulating hormone during anoestrum. However, the more recent work of Cole and Miller (1935) upon sheep during anoestrum, with oestrin and gonadotropic hormone indicates that, while the former is effective in producing oestrus and while ovulation is induced by the latter hormone, the simultaneous administration of the two hormones does not result in a combination of effects. Hill and Parkes (1931) (1933) have shown that the ovary may remain normal during enforced quiesence in hypophysectomised rabbits. Quin (1935) injected eight sheep in a state of anaphrodisia, which had not shown oestrus for 12 months, with oestrin from stallion's urine and obtained 50 per cent. fertility from mating during the oestrus following injection.

These data show that, although there may be a prolonged ovarian quiescence, or absence of the psychological phenomena associated with oestrus, the ovary needs only the necessary stimulation to resume normal physiological activity. It appears, however, that at least in some cases of prolonged quiescence in cattle, in other words

delayed breeding, either from withholding service or from the absence of normal oestrus, there is a tendency to difficult breeding. Quinlan (1929) has seen degenerative atrophy of the uterine mucosa in pure-bred imported heifers of the beef breeds, which were retained for some years as virus-reservoirs for red-water and gallsickness vaccine. Some of the cows actually failed to breed when eventually mated, while others conceived but aborted during the early weeks of pregnancy.

Forced milk-production under the environmental conditions and the usual methods of nutrition adopted to obtain high milk-yields, act upon the oestrogenic mechanism. The demand made upon the animal system is, in many cases, reflected on the genital tract. Very heavy milking cows may not show the psychological symptoms of oestrus. This has been shown in the case of the rabbit by Hammond (1930).

In South Africa, where the nutritional and general environmental conditions are inadequate to allow high inherited milk-yields from finding full expression, these genetical potentialities constitute limiting factors in regular breeding.

The question of functional sterility of dietetic origin is of more than ordinary interest in South Africa, where in certain localities the veld grazing is definitely deficient in phosphates and for the greater part of the year there is protein deficiency in addition. In those areas the bovine birth rate is abnormally low. From observations made at the Veterinary Research Station at Armoedsvlakte, Vryburg, it has been seen that failure to breed is due to failure to conceive during what appears to be normal oestrum and also to temporary anaphrodisia which may extend over a period of months (Bisschop, 1935).

In experimental observations at Onderstepoort, in which the mineral content of the ration was carefully measured and was definitely sub-optimum, and in further experiments made on a herd running on Armoedsvlakte veld, it has been shown that there is a low bovine birth rate and that abnormal calves showing weakness and congenital amaurosis are born [Theiler, Green, and du Toit (1927); du Toit and Bisschop (1929); du Toit and Malan (1934; Theiler (1933)]; Bekker (1932) showed the detrimental influence of phosphorus deficiency on reproduction in ewes grazing on Armoedsvlakte veld. The addition of bone meal to the diet improved fertility. Roux (1936) has shown that the liberal feeding of bone meal, as opposed to its absence, ensures greater sexual activity in sheep, although individual differences are not entirely eliminated; the duration of the sexual season is prolonged by an increased number of dioestrous cycles being experienced, and by the number of dioestrous cycles of abnormal duration being reduced.

Greatest sexual activity was obtained by supplementing the natural pasture with green grazing and a mineral lick throughout the year. Individual differences are considerably lessened by such treatment.

Whetham (1933) has drawn attention to the influence of the duration of light on egg production in the fowl. Hammond (1933) says, " It is supposed that light stimulates the anterior-pituitary by way of the eye and that in autumn, with decreasing daylight, fowls with a genetically low level of anterior-pituitary will fall below the critical level for egg production and so sterility from this cause will result. It is during the autumn and winter months that the low producing strains cease laying. In some animals very much the same sort of thin occurs: Ferrets, which do not normally ripen ova during the autumn and winter months, may be made to do so by giving them electric light after dark (Bissonette, 1932). We can assume, therefore, that the genetic constitution of the ferret is such that its pituitary activity is dependent upon light stimulation ". Hill and Parkes (1934) have confirmed the effect of illumination with electric light in producing oestrus in the female ferret.

Hammond (1933) further suggests that it is probably the change in the light ration, not the actual amount, which is the cause of pituitary stimulation, as most breeds of sheep in England ripen ova with declining sunlight in September and cease with increasing daylight in February.

This suggestion of Hammond would appear to show that if light, as a stimulating factor to the anterior pituitary, is sufficient an increase of the intensity of light will not influence it further. This is borne out by our observations on the ovarian activity of sheep on the high veld in this country. In November and December, during the warmest and longest days of the South African summer, ovarian activity in sheep is at its lowest. Further, the veld nutrition is usually at its best at this time.

Marshall (1932) indicates that the response of different animals to light must vary greatly, as some animals have no restricted breeding period even in temperate zones. Llewellyn (1932), quoting Cook (1894), states that in North Greenland evidence of sexual periodicity exists in the Eskimos. At the onset of winter, sexual desire fails and menstruation during the winter months is absent. Sexual activity again reawakes in the spring. Llewellyn indicates that the hiatus in the sexual cycle is due to absence of sunlight, that light and heat rays seem essential for the maintenance of the sexual cycle. He suggests that this is a species of hibernation localized to the hypophyso-gonadal system. The suggestion that it is a rare peculiarity is denied by Cook, since he states that their own party suffered from muscular debility in a similar manner to the Eskimos.

Hogan (1932) made observations on the influence of direct sunlight on swine as compared with swine kept in indoor quarters. He come to the conclusion that there was no improvement in those which had access to sunlight.

The importance of light on the productive activity of certain voles and ferrets has been indicated by Baker and Ranson (1932) and Bissonnette (1931). According to Whetham (1933) " the mammalian female responds more completely than the male, the female fails

to respond on a reduced supply of light, while the male appears to be unaffected and similarly with an increased light supply it is the female which responds more completely ".

Marshall and Bowden (1934) have indicated that light radiations of particular wave-lengths and sufficient intensity are an efficient cause of reproductive activity, but that the recurrence of the oestrous cycle is conditioned by other factors which, in the absence of variation in the daily duration of light, may play an important rôle.

Rowan (1925, 1929) maintains that it is muscular exercise rather than light that caused change in the gonads of birds, but Bissonnette (1931) showed that exercise was not essential. Stalfors (1930) indicates the necessity for open air for high production as well as a supply of vitamins A, B, C, and D for cattle.

The above literature is confined mostly to fowls and laboratory animals. There are no experimental data on the influence of light and exercise on the reproductive activity of cattle, horses, sheep, pigs, and dogs. It has been mentioned that lack of exercise, lack of sunlight, and lack of green feed have been associated with low fertility in cattle, but such conclusions have been based on circumstantial evidence without experimental proof.

Much work has been done on the influence of diet on fertility in laboratory animals [Hart, Steenbock, Humphrey, and McCallum 1911); Reynolds and Macomber (1920, 1921, 1924); Benedict (1911); Sure (1926); Simmonds, Becker, and McCallum (1927); Evans (1923); Evans and Bishof (1922); Evans and Burr (1927); Macomber (1927)]. It appears that, on a diet insufficient in calcium conception can take place, but the embryo dies early and is aborted. Moench (1931) says that, with the present-day diet in humans, sterility in women is unlikely to occur from that cause. He states that: " Diät und ihr Einfluss auf die Fruchtbarkeit zu eng begrenzt ist und dass wir anstatt nur von Diät lieber von dem allgemeinen Gesundheidszustande und seinem Bezug auf die Fertilität sprechen sollten. Ich halte den allgemeinen Gesundheitszustand in dieser Beziehung für äusserst wichtig und werde ich später bei dem Thema der Spermuntersuchung wieder darauf zuruckkommen. Leider wird aber oft gerades das Thema des allgemeinen Gesundheitszustandes recht stiefmütterlich behandelt und abgetan. Anstatt der Diät halte ish die köperliche Betätigung, die physiche arbeit die das Individuum leistet, für äusserst wichtig und glaube dass genügende Köperliche Bewegung ein sine qua non bester Gesundheit und damit auch guter Fertilität ist. Von der Diät braucht man, glaube ich, nur zu verlangen, dass sie ausreichend ist und dass sie keine wichtigen Insuffizienzen aufweist, die eine Avitamitose hervorrufen würedn ".

It will be seen that Moench stresses the necessity for exercise or physical work. He points out that, provided the diet is sufficient, work and exercise are more important factors in attaining the best health for normal sexual activity. In the case of obese women, he stresses the point that infertility is caused by too much food in relation to exercise. Obesity results in diminished circulation, oxidation, lessened blood to the ovary, and consequent subnormal

ovarian activity. In these observations he is supported by Lahm (1927). Woodward (1920) has shown that the length of life of the bovine sperm can be raised by exercising the bull. This probably indicates greater chances of fertility under ordinary conditions of mating: that is where the sperm is not deposited in the vagina at the most favourable time for conception. Highly vital, long-lived sperm would probably survive longer in the genital tract of the female than less vital sperms [Quinlan, Maré, and Roux (1932, 1933)].

Guggisberg (?) indicated that the main object in a diet should be sufficiency in vitamin content, especially B, C, and E. In this connection, Moench states: " Dem kann ich aus eigener Erfahrung zustimmen. Es ist jedoch schwer, didaktische Regeln über Diät und Fertilität aufzustellen—vieles ist noch gar nicht geklärt und bei manchen Fragen kommt man schliesslich wieder in das Gebiet des inneren Drüsensystems zurück "

The importance of dietetic errors and lack of exercise in infertility has been indicated by Orr and Fraser-Darling (1932). They associate these errors with unnatural and unhygienic environment and suggest that these factors may influence the normal physiology of the genitalia through the endocrine system and at the same time effect a reduction in the natural resistence to genital infection. These conclusions are arrived at after a critical review of the literature on the subject of sterility and infertility by a Committee of the Department of Agriculture of Scotland, comprising Mr. William Orr, M.R.C.V.S. and Dr. Fraser-Darling. The work contains an excellent bibliography on the subjects of physiological and genetical etiology of sterility in domestic animals by Miss N. V. Cytovich. Meigs and Converse (1933) have kept cows on grain and dry rations without pasture. They observed that, when the ration contained a liberal allowance of alfalfa hay of high feeding quality, the cows maintained their health and reproductive capacity up to more than seven years. When the roughage consisted of Timothy hay of bad quality, there was a definite lowering of the normal standard of health and the reproductive capacity of the cows was seriously interfered with. There was difficulty in conception and a marked tendency to throw off premature calves which were either dead, weak, or blind.

Hart, Steenbock and Humphrey (1920) observed that cows fed on a ration of grain and straw calved prematurely or threw dead or weak calves. This observation was confirmed by Huffman (1928) and Reed and Huffman (1925). The latter authors and Jones, Eckles and Palmer (1926) drew attention to the quality of Timothy hay as a highly important factor in genital functional activity of cattle. Copeland (1932) recorded a detrimental effect on reproduction in heifers fed on cotton seed hulls, as a sole dry roughage, when they were allowed to pasture for only six months in the year. Roux (1936) has observed marked sexual inactivity in sheep maintained on a carbonaceous roughage (teff hay) and a lick of bone meal and salt.

Hart and Guilbert (1928) and Webster (1935) have indicated the possible effects of phosphorus deficiency in cows under range conditions. The adverse influence of phosphate deficiency on

reproduction in range cattle and sheep in South Africa has been shown by Theiler, Green, and du Toit (1927), Theiler (1933), and Bekker (1932).

Eckles, *et al.* (1935) showed that low phosphorus levels result in an upset of genital physiology, both in the oestrous cycle and reproduction in rats. They state that uncomplicated phosphorus deficiency did not influence the oestrous cycles of cattle. Oestrus was regular and not different from control animals of a like age. However, the breeding efficiency appeared to be reduced. They suggest that anaphrodisia is due to complicated deficiencies. They also state that a low phosphorus ration renders cows more susceptible to contagious abortion than those maintained on a normal diet.

Since there is also a protein deficiency during the greater part of the year on the range where these experiments were conducted, both factors must be considered in the etiology. Guilbert and Goss (1932) have indicated that protein levels of $3\frac{1}{2}$ to 5 per cent. result in cessation of oestrus and long intervals between oestrus in the rat; further the rats failed to breed when mated.

Evans and Bisshop (1922) showed that protein deficiency decreases the percentage of normal oestrous cycles as well as the total number of cycles and that vitamin A deficiency greatly disturbs ovulation rhythm by prolonging the stage of cornified vaginal cells.

Cunningham and Hobkirk (1935) have induced sterility in male rats fed on diets of excessively high protein-content (65-82 per cent.), and also by feeding diets containing 15 to 18 per cent. protein. In the latter case a large part of the protein was derived from maize or maize and gelatine. All dietary constituents hitherto known to be essential for male fertility were included in the diets.

Roux (1936), working with ewes, obtained results indicating that the inclusion of a protein rich concentrate, cotton seed meal, in a low level carbonaceous ration and the exclusion of bone meal, causes a marked reduction of sexual activity, especially after eighteen months of treatment. The inclusion of the same protein rich concentrate in high level rations consisting of the same feeds, does not have this inhibiting effect.

Halverson and Sherwood (1930) showed that the feeding of cotton seed meal to cattle was associated with reproductive difficulties. Calves were born weak, and eye lesions were sometimes present. Hart, Guilbert and Goss (1932) have associated reproduction difficulties with lack of green food; at least the difficulty disappeared when green food became available. Infectious abortion was, however, present, but the authors concluded that there were data sufficient to lead them to suspect that feed deficiencies were the cause. Hart, Steenbock, Humphrey, and Hulce (1924) have shown the value of vitamin A, and calcium in obtaining normal reproduction in cattle. Fitch *et al.* (1932) showed that uncomplicated calcium deficiency did not lessen the breeding efficiency of a group of seven cows maintained on a calcium deficient ration for three years. Hogan (1932) indicates that rations for brood sows should contain not less than 0·4 per cent. of calcium.

Malan (1935) concludes from the results of his observations at Onderstepoort Laboratory that vitamin A deficiency in the ration of pregnant ewes and cows produces abortions or weakly young that are often blind and unable to rise. He observed, further, that the absence of this vitamin in the diet is in some ways associated with the absence of the psychological symptoms of oestrus. Both ewes and cows on dry rations containing a minimum of vitamin A show oestrus only very infrequently and even then, if mated will become pregnant only in a very small percentage of cases.

Lack of minerals such as phosphorus, the deficiency of which in the diet will produce clinical symptoms, has lead almost invariably in the Onderstepoort experiments on mineral metabolism to temporary infertility.

Experimental Observations.

The experiment was commenced on June 20th, 1929, when 27 grade Sussex-Afrikander heifers approximately fifteen months old were received at the Veterinary Research Laboratory and Experiment Station, Ermelo, Transvaal. The heifers were purchased from a private ranch in the western Transvaal; they were considered well grown and comparatively even with respect to type (Appendix, Figs. 1-18). Soon after their arrival at the Experiment Station they were divided at random into three groups, A, B, and C, and branded.

One heifer died two months after the commencement of the experiment. During the first six months, five heifers were found to be pregnant and they were withdrawn from the experiment; four of them were redrafted into the experiment about a year later.

A purchased Sussex bull was used in the experiment (Appendix I, Fig.19). The bull was bred by the School of Agriculture, Potchefstroom, Transvaal; it was two years old when transferred to the Ermelo Experiment Sation, and the serving of the heifers was commenced one month after his arrival, 17.10.30.

During the first month at the Experiment Station, the heifers were tested for tuberculosis, contagious abortion, and vaccinated against anthrax and quarter evil. Subsequently they have been retested for contagious abortion, and they have been tested annually for tuberculosis. The results of all tests were negative. The bull was tested annually for tuberculosis and contagious abortion; the results of the tests were negative. The bull was healthy and vigorous throughout the period of the experiment.

1. *Groups restricted in light and exercise*: *A and B.*

Stabling.—Groups A and B were housed in a wood-and-iron stable, 46×23 feet, with a cubic capacity of 8217 cubic feet. The stable was fitted with a double row of suitable mangers and hay racks, the heifers being fastened to the former by means of neck-halters and halter-chains. The two doors of the stable, each 4×6 feet 9 inches, opened to the east and to the west. The ventilation of the stable could be considered fair. Every endeavour was made to exclude light from the stable. Groups A and B can, therefore, be considered

to have been housed in a dark stable and, but for the daily two watering periods of about twenty minutes each, these groups were confined to their stable day and night.

2. *Group not restricted in light and exercise*: *C*.

Group C was kept in a similar type of stable to that occupied by groups A and B. The dimensions of the stable were $46 \times 15\frac{1}{2}$ feet and cubic capacity 6328 cubic feet. It provided for a single row of cattle, the length ran from north to south, and a single 4×6 feet 9 inches door opened to the east. The ventilation of this stable was as good as, if not slightly better than, that occupied by the other two groups. The heifers in group C were fastened in a similar way to those in the other stable and they had similar mangers and hay racks.

In both stables each animal had a feeding space of $4\frac{1}{2}$ feet. The floors of the stables were of flat stone. A native was in constant attendance keeping the floors clean and grooming the cattle; the latter were bedded down at night on the refuse of their roughage.

Management.—The feeding of the three groups was identical: the cattle were stall-fed, no green feed was given, and they were not put out on grazing.

At the commencement of the experiment the rations fed per capita per diem were:—

Crushed yellow maize: 4 lb.
Wheaten bran: 1 lb.
Teff hay: ad lib. (about 15 lb.).

As the heifers matured, the bran portion of the ration was increased to 2 lb. (per capita per diem) and the teff hay ration to 25-30 lb.

During three winter months, June, July, and August, maize silage was fed at the rate of 10-15 lb. per capita per diem and the hay ration was reduced.

The concentrate ration was fed dry, the ration of each cow being measured and fed in two equal portions daily. When silage was fed, the concentrate ration was mixed with the silage.

No minerals or mineral mixtures were fed to the animals during the course of the experiment.

The teff hay was fed in the hay racks twice daily.

Groups A and B received all their feed in the stable; Group C received the two concentrate rations and the evening hay ration in the stable, and the morning hay ration in an exercise yard 50 by 68 ft., in which this group was kept from 8.30 a.m. to 4.30 p.m. daily.

The following analyses of feeds used in the experiments have been extracted from the analyses given by Vipond (1914). The maize, ensilage and teff hay were analysed at Onderstepoort by S. J. Myburgh [S.Afr.(M.)]. In the case of the South African analyses of feeds, only the total percentages of feed constituents are given, whereas in the American analyses, the digestible percentages of feed constituents are also given.

Feed Analyses.

Feed.	Gm. per 100 gm. Feed.							
	Water.	Carotene mg/100 gm.	Crude Protein.	Carbo-hydrates.	Ether-soluble Extract (fat).	Crude Fibre.	Ash.	Phosphoric Oxide (P_2O_5).
Maize Flint [S. Afr. (V)]	8·6	—	11·0	72·3	5·0	1·7	1·4	0·6
Maize Flint (Amer.)	11·3	—	10·5	70·1	5·0	1·7	1·4	0·7
Wheat Bran [S. Afr. (V)]	11·0	—	19·2	54·2	2·5	7·0	6·1	1·7
Wheat Bran (Amer.)	13·0	—	14·0	56·0	4·0	9·0	4·0	2·7
Teff Hay [S. Afr. (V)]	8·2	—	6·0	43·1	1·1	34·8	6·7	0·2
Teff Hay [S. Afr. (M)]	5·9	1·6	8·0	—	—	26·8	6·3	0·3
Maize Silage [S. Afr. (V)]	75·7	—	2·3	10·9	0·8	8·4	1·9	0·44
Maize Silage [S. Afr. (M)]	73·7	0·4	2·6	—	—	5·8	2·7	0·47
Maize Silage (Amer.)	79·1	—	1·7	11·0	0·8	6·0	1·4	0·1

Feed.	Gms. per 100 gm. Feed.		Albuminoid Ratio in Total Percentage.	Gm. Digestible matter per 100 gm. Feed.				Albuminoid Ratio in Digestible Matter.
	Potash (K_2O).	Lime (CaO).		Protein.	Ether-soluble Extract (fat).	Carbo-hydrates and Fibre.	Starch Value.	
Maize Flint [S. Afr. (V)]	0·45	trace	$7\frac{1}{2}$	—	—	—	—	—
Maize Flint (Amer.)	0·4	·02	$7\frac{3}{4}$	8·0	4·3	66·2	83	$9\frac{1}{2}$
Wheat Bran [S. Afr. (V)]	—	·13	$3\frac{1}{4}$	—	—	—	—	—
Wheat Bran (Amer.)	1·5	0·2	$4\frac{3}{4}$	10·0	3·0	45·0	47	$5\frac{1}{4}$
Teff Hay [S. Afr. (V)	1·4	0·2	$10\frac{1}{4}$	—	—	—	—	—
Teff Hay [S. Afr. (M)]	1·4	0·2	—	—	—	—	—	—
Maize Silage [S. Afr. (V)]	1·4	0·4	7	—	—	—	—	—
Maize Silage [S. Afr. (M)]	1·4	0·4	—	—	—	—	—	—
Maize Silage (Amer.)	0·4	—	$8\frac{3}{4}$	0·9	0·7	11·3	$11\frac{1}{2}$	$14\frac{1}{4}$

Groups A and B, which were kept in the dark stable, were restricted to a limited amount of exercise. These groups were let out to water twice daily and the walk to water was the only exercise they obtained. At these times, 8.30 a.m. and 4.30 p.m., oestrous observations were made. The animals were let out into a yard, 13 by 38 yd., from which they were driven into the farm yard to the water trough. While in the former yard, it was estimated that each animal walked 25 yards. While at the water trough the amount of walking was controlled as much as possible. It was estimated that each animal walked a total amount of 295 yards daily. The tendency for animals to run or to walk about was checked.

The Group C cattle went through the same daily routine with the exception that instead of returning to the stable after watering in the morning, as in the case of Groups A and B, the former group was allowed free exercise and abundant sunshine in a kraal, 50 by 68 feet, from 8.30 a.m. to 4.30 p.m. daily. It was calculated that, apart from the exercise in the kraal, Group C cattle walked 100 yards more each per day than those of Groups A and B. While it was impossible to estimate the amount of exercise obtained by the Group C cattle during a day, constant walking to and from the hay racks and being disturbed by one another, must have amounted to an appreciable amount daily. The exercise kraal had no shade or shelter apart from that afforded by a 6½ ft. stone wall on the east and a row of trees 30 yards distant on the west. The kraal was exposed to sunlight between 7.0. a.m. to 5.0 p.m. in summer and from 8.0 a.m. to 4.0 p.m. in winter.

During very wet weather Group C was stabled during the day.

It is, therefore, seen that while Groups A and B were kept in a dark stable and were exposed for a very short period, approximately ¾ hour daily, and had a very limited amount of exercise, Grop C could indulge in sunlight and exercise for eight hours daily.

The fact that none of the groups received green feed is stressed.

Further, general good management was given the cattle in all the groups. The cattle were handled with great care at all times. They were dipped in a 14-day strength arsenite of soda dip when deemed necessary, the essential precautions of cows in calf being taken in which case hand-dressing was, in preference, resorted to. It was found necessary to trim hoofs of the cattle at least once annually; this was particularly necessary in the case of Groups A and B.

The calves were allowed to suckle their mothers, care being taken not to allow the calves too much milk at first and then to thoroughly strip the udders of the cows by hand. During the first month from birth, the calves were allowed to suckle their mothers thrice daily, and thereafter twice daily. The calves were put in with their mothers after the latter had consumed their concentrate rations.

Teff hay was available to the calves during the day and when deemed necessary a small supplementary concentrate ration was fed to the calves. They were weaned at about six months old when they weighed about 400 lb.

Climatic Conditions.—The conditions at the Experiment Station may be considered to be representative of those of the eastern high-veld of the Transvaal. The altitude of Ermelo is 5,690 feet. The annual rainfall is in the vicinity of 27 inches, 90 per cent. of which falls during the summer months, October to March.

As a rule summer day-temperatures are high but the nights are cool, especially after thunder storms which are frequently experienced during the afternoons and evenings.

It may be said that the great majority of the days are bright and sunny. The winter nights are cold and frosty, but the day temperatures are mild to warm.

The following table of records supplied by the adjoining Government Forest Nursery, gives some indication of the rainfall and temperatures of the Experiment Station. The records for 1932 have been chosen as being fairly representative.

Months (1932).	Rainfall.	Temperatures.	
		Maximum.	Minimum.
	Inches.	Range.	Range.
January	3·06	33·6–58·0	58·2–46·0
February	4·87	84·8–63·5	59·8–50·0
March	3·79	80·6–56·6	66·0–41·4
April	0·17	80·5–61·2	52·0–38·5
May	1·64	75·2–52·0	44·0–27·4
June	0·25	71·8–40·3	43·3–22·0
July	0·00	71·5–52·0	36·0–19·0
August	0·00	79·8–61·6	43·6–23·0
September	1·32	87·3–58·2	54·1–30·5
October	1·62	89·5–48·8	56·3–38·0
November	7·46	86·4–63·8	59·2–42·5
December	4·55	86·4–64·3	59·0–44·5

The total rainfall for the year 1932 was 28·73 in. It will be seen that temperatures fall rapidly from May and rise rapidly from September.

Observations.—Oestrous observations were made twice daily when the groups were let out to water at 8.30 a.m. and 4.30 p.m. Group C was let out first. The cattle were let out into the yard adjoining the stable and they were allowed to stand about in this yard for a few minutes before being brought into the larger yard to the water trough. The cattle were driven to the exercise yard in the morning and to their stable in the afternoon.

Groups A and B were let out together and the above procedure was carried out with the exception that these groups returned to their stable in the morning as well as in the afternoon.

The total time taken for the observations of the three groups was approximately 90 minutes a day.

At the commencement of the experiment, an ox was used as a "teaser" in testing for oestrus. However, it was soon found that the use of the ox was not necessary, as oestrus was easily observed or readily indicated. In most instances, individuals showing oestrus were anxious to mount others as soon as the former were loosened or as they entered the open yard. The mounting of the cow showing oestrus was usually vigorous and a clear mucous discharge from the vulva was seen. Frequently the cow stood near the cow it intended mounting, and the former was noticed to depress its back. Cows not showing oestrus willingly mounted cows showing oestrus, and the fact that the former are pregnant made no difference to their reactions. Cows showing oestrus readily stood to be mounted by other cows, the former appeared to be nervous and often bellowed.

In some cases a mucous discharge from the vagina was observed about 36 to 48 hours before oestrus was observed. This was usually seen in the stable when the cows were lying down.

Observations were not made to determine the duration of oestrus; however, the duration of oestrus did not appear to exceed 24 hours.

Haemorrhage, as indicated by a discharge of blood from the vagina, was observed to occur about 36-48 hours after oestrus was observed. Haemorrhage, however, did not consistently follow oestrus. On the other hand, haemorrhage was observed in some cases in non-pregnant individuals when oestrus was not shown immediately previous to haemorrhage. Heifer No. 3602 showed oestrus on 1.4.30, she showed haemorrhage on 24.4.30, and showed oestrus again on 11.5.30. It appeared that the heifer must have experienced a silent oestrus between 1.4.30 and 11.5.30.

A stable record sheet was kept on which to record all observations.

The serving of Groups A and C was commenced when the heifers were approximately 31 months old, while the heifers of Group B were given service 5 to 6 months later. The Sussex bull, No. 4242, previously referred to, was used for serving throughout the first three periods of the experiment. He was replaced by a younger bull, No. 6021 (Appendix I, Fig. 20) of the same breed at the commencement of the fourth period.

It was endeavoured to give service about 12 hours after the onset of oestrus. In some instances it was found that when oestrus was observed at 8.30 a.m., oestrus had passed off by 5 p.m. of the same day. This was no doubt due to the fact that oestrus had commenced some hours before it was observed. The time of the onset of oestrus could not be determined unless continuous observations were made.

During the first season of mating, services were given in a cattle crush, but subsequently the bull became too large and services had to be given in a yard. The bull was not held during service. In almost every instance, double services were given, the second following about 15 minutes after the first. It was found that, in a few

cases, individuals would accept only one service, although in such cases they mounted the bull after the second service. Usually such individuals conceived from the one service. All females were put back into the stable after service.

All cows were mated again or given service about three months after calving.

Individuals showing a recurrence of oestrus were served at the first recurrence of oestrus. In the case of abortions service was delayed for one or two dioestrous cycles.

The cows were under close observation during pregnancy. When due to calve, they were kept in a loose box or semi-open shed during the nights. Only in the case of the first calf of No. 3594 was assistance given at parturition, and the assistance was considered slight.

All calves were weighed as soon as possible after birth; afterwards they were weighed at monthly intervals.

All the cows were weighed at monthly intervals, but the weighing was discontinued during advanced stages of pregnancy in order to eliminate undue excitement and the probabilities of abortion.

Discussion.

It appears best to consider the data in three main sections which, under the headings of Breeding Tables A, B, C, and D, are termed First, Second, Third, and Fourth Periods. The First Period extends from the time of the commencement of the experiment up to the first calving; the Second Period, from the time of first calving up to the second calving, etc. Tables I to IV contain details of individual animals, but this information has been condensed in group form and it is presented in Table V, Breeding Table E.

Further tables have been compiled to permit more detailed analyses of such phases of the study as: Oestrus, gestation, etc.

The most important aspects of the study will be considered under the following sections:—

(1) Dioestrous cycles.

(2) Age and weight at successful service and at calving.

(3) Number of services required to establish pregnancy.

(4) Gestation periods.

(5) Birth weight of calves.

(1) *Dioestrous Cycles.*—Oestrous observations commenced when the heifers were approximately 15 months old. As the cattle were purchased from a private owner at that age, previous records of oestrus are not available.

Considerable variation exists with regard to the time of the first oestrus (Table I, Column 3). All the heifers exhibited their first oestrus before they were 24 months of age, although a period of slightly more than eight months elapsed before all the heifers had experienced their first oestrus. The following are the frequencies of the commencement of sexual activity during the months indicated:—

Group.	1929.	1930.								Total.
	June (10 (days).	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	
A.....	—	1	—	—	5	1	—	1	1	9
B.....	—	—	—	1	2	3	—	1	—	7
C.....	—	1	2	1	1	—	—	2	1	8

There is, very apparently, no difference between the first occurrences of oestrus recorded for Groups A and B. In Group C, although three heifers showed oestrus during July and August, three individuals showed oestrus only in January and February (1930). No significance can be attached to the above variations as they may be ascribed to individual differences.

The dioestrous cycles detailed in Tables I to IV, have been analysed in Tables VI to X. When considering the total number of dioestrous cycles, it must be borne in mind that the numbers of cattle constituting the groups varied, and that alterations in numbers within groups occurred after the First Period. Also, it must be pointed out that as Group B was served 5-6 months later than Groups A and C, the first period of oestrous observations for Group B was correspondingly longer.

The dioestrous cycles of Groups A and C during the first period deserve attention (Table VI). The observations during the first period were recorded for nine heifers in Group A and 8 in Group C, the difference of the total dioestrous cycles is 41. The maximum dioestrous cycles in Group A for this period was 19 and in Group C 17 (Table I), hence assuming that an additional heifer in Group C would have recorded 19 dioestrous cycles, the remainder (41-19), 22 appears to be a significant difference. The cause of this difference can be seen by examining the distribution of the frequencies of the periodicity of oestrus in Table VI. In Group A, in seven instances dioestrous cycles ranged between 55 to 90 days, while in Group C, in twelve instances the dioestrous cycles ranged between 55-117 days, the longer periods being more frequent in the case of the latter group. Also, it will be seen from Table V that in the case of Group A in 76 per cent. of cases oestrus recurred after the normal interval of 18 and 23 days, while the equivalent figure for Group C is 70 per cent. Age, or difference in age, does not bear any influence upon this point, as the average ages of the cattle were approximately the same at the time of final or successful service. During this first period, it will

be noticed (Table V) that in Group B in 80 per cent. of cases oestrus recurred after 18 to 23 days and although the range of dioestrous cycles was from 10-122 days, only seven dioestrous cycles, or 4·8 per cent., fell between 49 and 122 days.

During the Second and Third Periods (Tables VII, VIII, and IX), the length of time of oestrous observations was approximately equal for all groups, as all cows wer eserved about three months after parturition. During these periods, the total number of dioestrous cycles may be influenced by the length of time between calving and the first subsequent oestrus.

After the first calving, there was no significant difference between the total number of dioestrous cycles of the three groups (Table VII). The slightly larger total in the case of Group B was due to the larger number of shorter dioestrous cycles (Table VII) and the somewhat shorter interval (69·5 days) between calving and first oestrus as compared to Groups A (79·4 days) and C (89·5 days) (Table V).

After the second calving, the differences in the total dioestrous cycles are greater: Groups A: 15, B: 30, C: 6 (Table VIII). These differences resulted largely from the differences that existed between the periods between second calving and first subsequent oestrus, which were:—Groups A: 77·4 days, B: 56·3 days, C: 104·9 days (Table V). It will be noticed that, for this third period, the percentages of cases in which oestrus recurred after 18 to 23 days were: Group A: 57·1, B: 50·0 and C: 33·3. It is very apparent that Group B showed far greater ovarian activity during the third period than did either of the other two groups and especially Group C.

After the third calving, there is not that amount of significant difference in the total dioestrous cycles of the groups (Table IX) and there is also little difference in the period between parturition and first subsequent oestrus of Groups A (51·1 days) and B (54 days), but in the case of Group C the period is 83·2 days. It is seen that in the case of the fourth period the percentage of cases in which oestrus occurred after the normal interval of 18 to 23 days was considerably less than during the previous periods, viz., Group A: 30·8, Group B: 36·8 and Group C: 50·0.

From Tables VI to IX it has been ascertained that the mode of the dioestrous cycles of the groups for all four periods is twenty days. The range of the dioestrous cycles were from 10 to 123 days, but the highest percentage of dioestrous cycles fell between 18 and 23 days. It is, however, significant that there is a marked decrease in the percentage of cases in which the dioestrous cycle fell between the normal interval of 18 to 23 days as the experiment advanced.

It is seen from Table I that, during the long first period of oestrous observations, there were abnormally short and abnormally long dioestrous cycles during the first seven months. Therefore, it may be said that the heifers became more regular with respect to oestrus after they were approximately twenty-four months old.

(2) *Age and Weight.*—The details of ave and weight of the cattle are given in Tables I to IV; these details have been compiled for the groups and presented in Table V.

As previously stated, Group B was served 5-6 months later than the other two groups. The fact that certain individuals required a number of services before pregnancy was established resulted in a great diversity of age within groups. This is especially noticeable in Group A (Table V, column 5) in which the range of age at the end of the fourth period was from 77 to 91 months (and the average 82 months) at the fourth calving, whereas the corresponding figures for Groups B and C were, range 82-95 months, average 85 months, and range 77-85 months, average 80 months respectively.

All the cows were weighed monthly before the morning feeding and watering. Detailed weights (at the time of successful service) are given in Tables I to IV, and the averages for the groups are included in Table V.

It may be said that the condition of all groups has been very satisfactory throughout the period of the experiment. The cows gained weight during gestation and the great majority were in prime condition during the later part of pregnancy. They lost weight while suckling their calves, but gained in weight rapidly after the calves were weaned.

The birth-weights of the calves were recorded, and they were subsequently weighed at monthly intervals.

Calving data are given in detail in Table VI, and a summary for the groups is included in Table V.

During the use of the original bull, a slight increase is apparent in the average birth-weight of the calves of all groups as the age of the cows advanced, but here is a marked decrease in the weights of the calves served by the second bull used in the experiment (Table V, Column 7).

There is no significant difference between the birth-weights of the calves of Groups A and C, during the first three periods, but during the fourth period the calves of Group A were on an average 7·0 pounds heavier than Group C. The calves of Group B were considerably lighter during the first three periods than those of Groups A and C, but during the fourth period the same differences did not occur. It is interesting to note that the Group B cows were heavier or weighed more than the cows in the two other groups (Table V, column 3).

(3) *Number of Services required to Establish Pregnancy.*—The dates of all final or successful services are given in Table XI.

Table V, column 4, contains the frequencies of the services required to establish pregnancy. It is apparent that more services were required in Group A to establish pregnancy than was the case in Groups B and C. With regard to Group A, it cannot be said that the total number of services required to establish pregnancy increased with the ages of the cows. During the first period No. 3995 (Group A) required three services to establish pregnancy, during the second period only one, and during the third period four services. The services required by No. 3598 (Group A) were 2, 4, and 3 for the three periods.

In Group B, certain cows are of particular interest. In the first and second periods pregnancy was established in cows Nos. 3604, 3607, and 3608 by serving during one oestrus. However, in the third period No. 3604 required four services at different oestrous periods, Cow No. 3607 required ten services, and No. 3608 two services to establish pregnancy. During the first, second, and third periods cow No. 3602 required 1, 4, and 1 services respectively to establish pregnancy.

In Group C only three cows required re-serving during the three periods.

It is, therefore, apparent that Group C was outstanding with regard to the small number of services required to establish pregnancy. It is interesting to note that, during the fourth period in only one case did a cow require more than one service, viz. three, to establish pregnancy. This cow was No. 3614 in Group C. She required four services. The cow calved, 5.1.34, and, as she did not show oestrus within 209 days after parturition, she was examined and a persisting corpus luteum expressed from the ovary. She showed oestrus two days later and three further oestrous periods before becoming pregnant.

(4) *Gestation Periods.*—The gestation periods of each cow for the four periods are given in Tables I to IV, and the averages and ranges of gestation periods for the groups are given in Table V, column 6.

The frequencies of the gestation periods recorded are given in Table XII. It is apparent that there is no significant difference between the gestation periods of the three groups, neither is there any indication of differences between the duration of gestation of the first, second, third, and fourth periods.

With the exception of the gestation period of 264 days which was recorded for cow No. 3606 in Group B, the range of gestation for all groups was 271-289 days. Out of a total of 95 gestation periods, 81·05 per cent. fell between 276 and 286 days. Considering all groups the mode was 281 days (Table XII).

With the view of indicating the gestation periods of male and female offspring in each of the groups during the four periods, certain data have been extracted from Table XI and given in Table XIII. It appears from this table that there is no significant difference between the gestation periods of male and female calves; also there is no significant difference between the groups during the four successive periods, nor does any particular group show significant variation during the four successive periods.

The mode gestation period was previously stated to have been 281 days. From Table XIII it is computed that the average gestation period was 279·6 days.

With the exception of the calf of No. 3606 which was born during the second period, the gestation period of which was 264 days, all calves were exceedingly healthy when born and they made rapid progress in growth. The calf of No. 3606 was born with congenital ichthyosis and it died when 14 days old.

CONCLUSIONS.

(1) The effects of a dry ration, high condition, the absence of sunlight, and exercise upon the sexual activity and reproduction of beef females have been studied. The results obtained during six years of observations are reported upon; the period includes four calvings.

(2) When a dry ration consisting of maize, wheaten bran, and teff hay is fed for nine months and silage is added to the ration during the remaining three months of the year, very satisfactory results may be expected.

The ration induces satisfactory growth of young heifers and maintains mature animals in good condition.

Sexual maturity is reached before the age of 24 months, and sexual activity and reproduction are in no way impaired.

(3) High condition causes no ill effects either upon general health or the reproductive processes.

(4) The restriction of sunlight and exercise in no way detrimentally affects the health, growth, and vigour of heifers and cows being fed dry rations. The onset of maturity is not delayed. Up to the age of 32 months or prior to being bred, a large number of dioestrous cycles are seen to have been experienced by the heifers receiving restricted sunlight and exercise. The animals receiving an abundance of sunlight and exercise, experienced a larger number of abnormally long dioestrous cycles. The mode of the dioestrous cycles is 20 days, and although cycles as short as 10 days and as long as 123 days are experienced, about 75 per cent. of dioestrous cycles fall between 18 and 23 days. It appears that as the ages of the animals advanced, under the special environmental conditions enforced, the percentage of dioestrous cycles between 18-23 days decreased.

(5) A restriction of sunlight or exercise appears to shorten rather than to lengthen the period between calving and the first subsequent oestrus. Oestrus is observed to occur as soon as 15 and 21 days after calving. Although, in the majority of cases, the period of inactivity is in the vicinity of 60 days, many cases of over 100 days occur, and cases even over 200 days may be encountered. There appears to be a tendency for the period of inactivity to shorten as the ages of the cows advance between 3 and 6 years.

(6) Unrestricted sunlight and exercise result in fewer services being required to establish pregnancy. Failure to conceive after the first and second service cannot be considered exceptional and this appears to be the case especially in young animals. The number of services required to establish fertility decreases as the ages of cows advance.

(7) The length of the gestation period is unaffected by limiting sunlight and exercise. Out of a total of 95 gestation periods, the mode is 281 days, the average 279·6 days, and 81 per cent. of the periods fall between 276 and 286 days. There is no tendency for the gestation periods to alter with advancing age. There is no difference between the gestation periods of males or females.

(8) Unrestricted sunlight and exercise do not reflect any advantage upon the weight of calves produced. Few of the calves obtained are seen to have weighed under 60 pounds at birth, while weights up to 98 and 99 pounds were recorded. It is seen that the change of the bull greatly influenced the birthweight of the calves.

(9) High conditioned heifers, under conditions of restricted sunlight or exercise, show no tendency towards abnormal sexual activity when breeding is delayed until the heifers are 35 months of age. The reproductive functions of the animals are unaffected when breeding is delayed for this period. Cows which maintain a higher condition throughout the periods of gestation, lactation, and rest are likely to produce calves which are small and light in weight.

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APPENDIX I.

I. FEMALES UPON WHICH OBSERVATIONS WERE MADE.

Group A.

Fig. 1.—As heifers 28 months old and 13 months in the experiment (July, 1930).

Fig. 2.—38 months old and 6-7 months pregnant (May, 1931).

GROUP A.

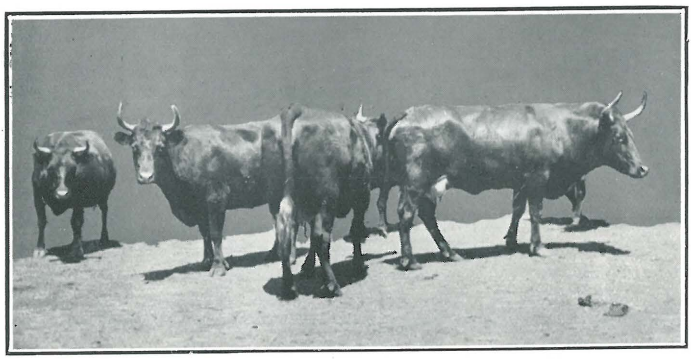

Fig. 3.—66 months old and 7-8 months pregnant (September, 1933).

Fig. 4.—84 months old, after fourth calving (March, 1935).

Fig. 5.—No. 3595, 2 months pregnant (October, 1934).

GROUP A.

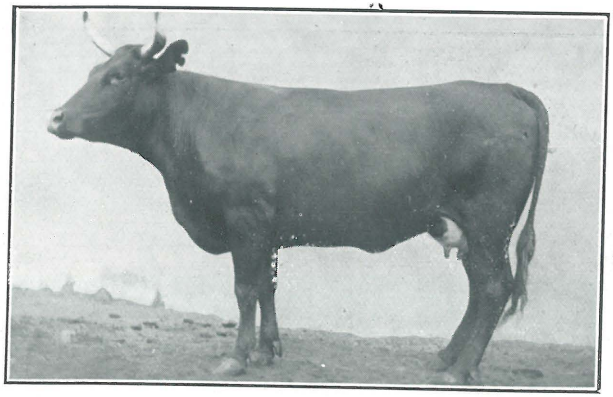

Fig. 6.—No. 3598, 8½ months pregnant (October, 1934).

GROUP B.

Fig. 7.—As heifers 28 months old and 13 months in the experiment (July, 1930).

Fig. 8.—38 months old and 1 month pregnant (May, 1931).

GROUP B.

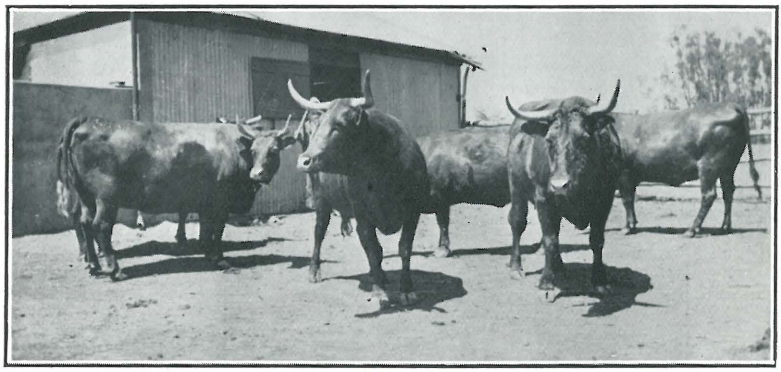

Fig. 9.—66 months old and 4 months pregnant (September, 1933).

Fig. 10.—84 months old, before fourth calving (March, 1935).

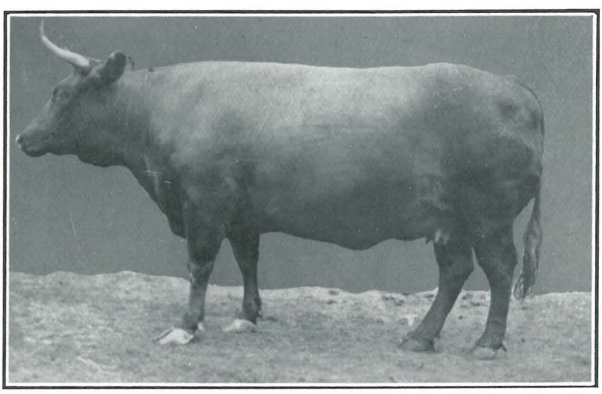

Fig. 11.—No. 3606, 4 months pregnant (October, 1934).

GROUP B.

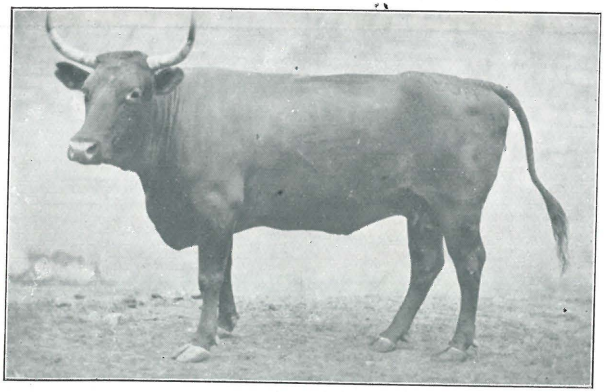

Fig. 12.—No. 3609, 4 months pregnant (Ocotober, 1934).

GROUP C.

Fig. 13.—As heifers 28 months old and 13 months in the experiment (July, 1930).

Fig. 14.—38 months old and 6-7 months pregnant (May, 1931).

GROUP C.

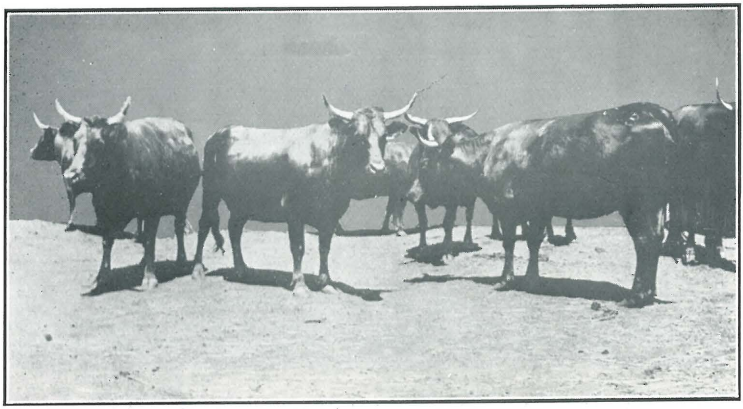

Fig. 15.—66 months old and 7-8 months pregnant (September, 1933).

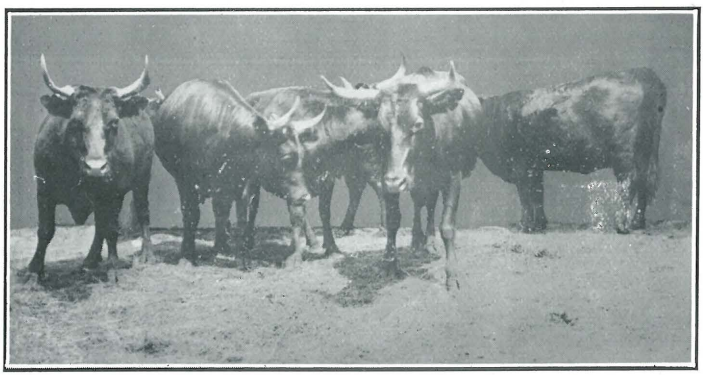

Fig. 16.—84 months old after fourth calving (March, 1935).

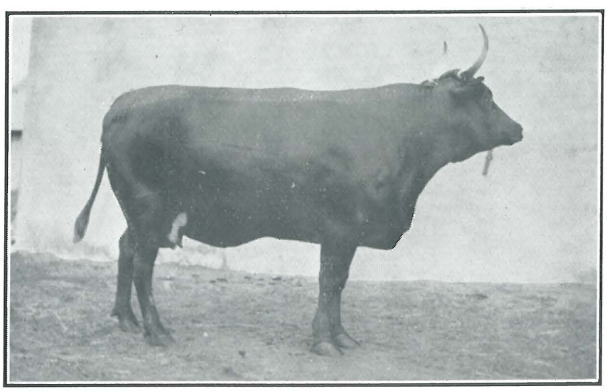

Fig. 17.—No. 3611; 5 months pregnant (October, 1934).

GROUP C.

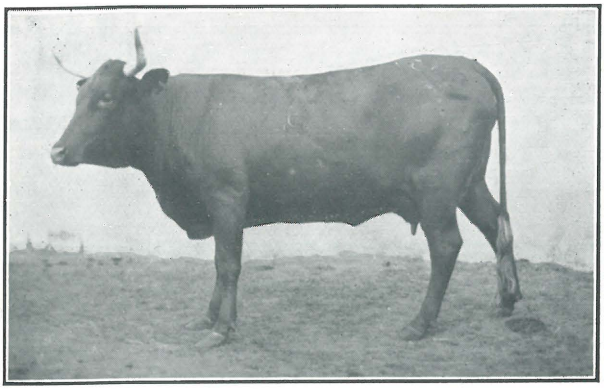

Fig. 18.—No. 3620, 8 months pregnant (October, 1934).

II. PURE BRED SUSSEX BULLS USED IN THE EXPERIMENT.

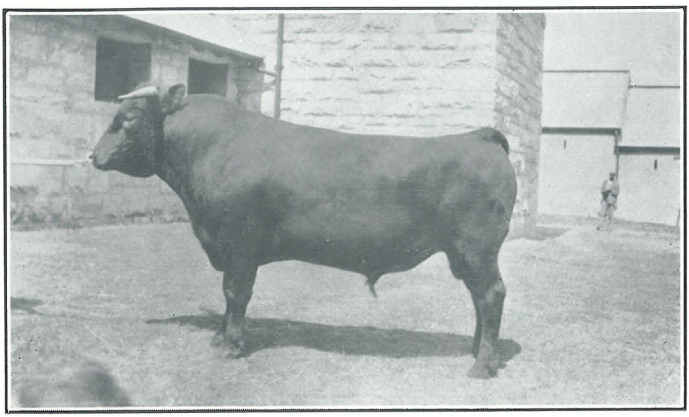

Fig. 19.—No. 4242: Used from 17.10.30-21.12.33.

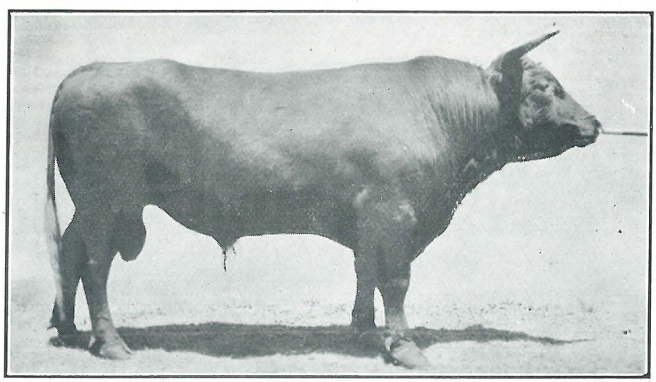

Fig. 20.—No. 6021: Used from 22.12.33- 5.10.34.

III. CALVES OUT OF THE EXPERIMENTAL COWS.

(*a*) Group A Calves.

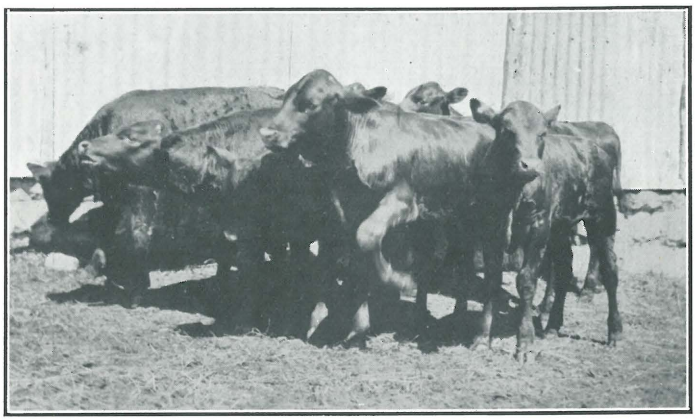

Fig. 21.—1st Calves, 3-4 months old.

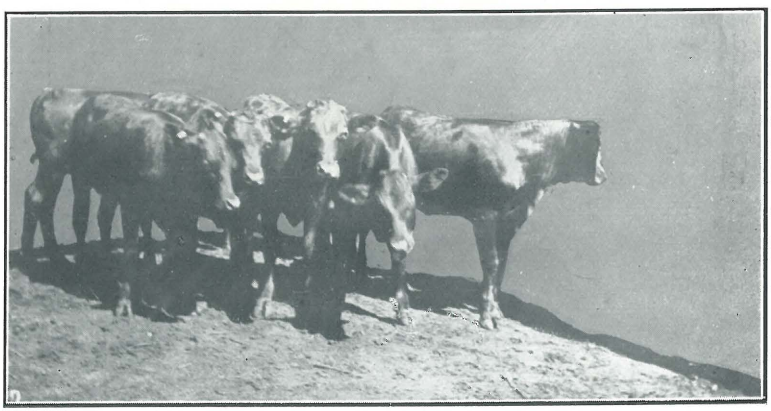

Fig. 22. –1st Calves, 5-6 months old.

Fig. 23.—1st Calves, 8-9 months old.

III. CALVES OUT OF THE EXPERIMENTAL COWS.

(*a*) Group A Calves.

Fig. 24.—2nd Calves 7 months old and younger.

Fig. 25.—2nd Calves approximately 12 months old.

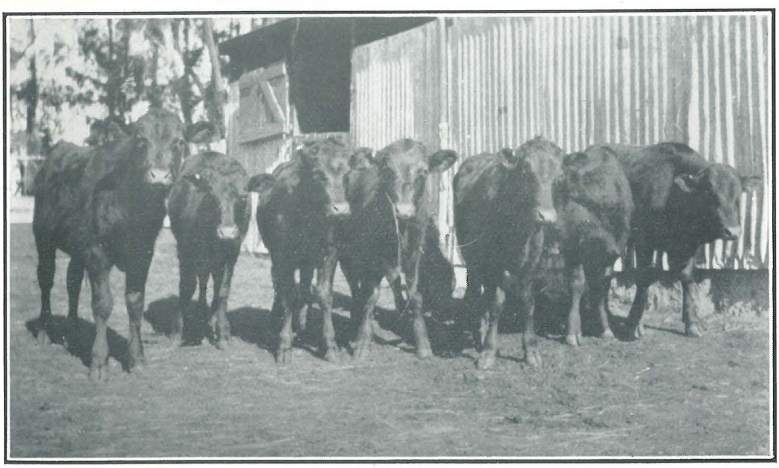

Fig. 26.—3rd Calves, 9 months old.

III. CALVES OUT OF THE EXPERIMENTAL COWS.

(*a*) Group A Calves.

Fig. 27.—3rd Calves 15-16 months old.

Fig. 28.—4th Calves, 3-4 months old.

Fig. 29.—4th Calves, 8-9 months old.

(*b*) Group B Calves.

Fig. 30.—1st Calves, 1-6 months old.

Fig. 31.—1st Calves, 9-10 months old.

Fig. 32.—1st Calves, 17-18 months old.

(*b*) Group B Calves.

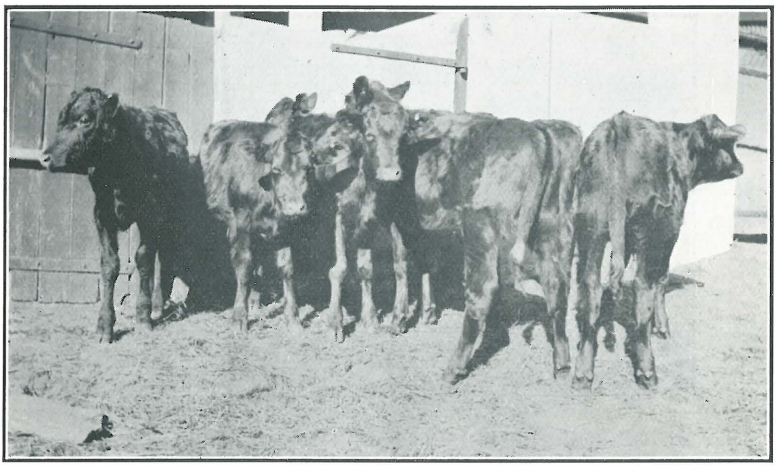

Fig. 33.—2nd Calves, 3-4 months old.

Fig. 34.—2nd Calves, 24-26 months old.

Fig. 35.—3rd Calves, 12-13 months old.

(*b*) Group B Calves.

Fig. 36.—4th Calves, 5-6 months old.

(*c*) Group C Calves.

Fig. 37.—1st Calves, 3-4 months old.

(*c*) Group C Calves.

Fig. 38.—1st Calves, 5-6 months old.

Fig. 39.—1st Calves, 8-9 months old.

Fig. 40.—2nd Calves, 7 months and younger.

(*c*) Group C Calves.

Fig. 41.—2nd Calves, 9-12 months old.

Fig. 42.—3rd Calves, 15-16 months old.

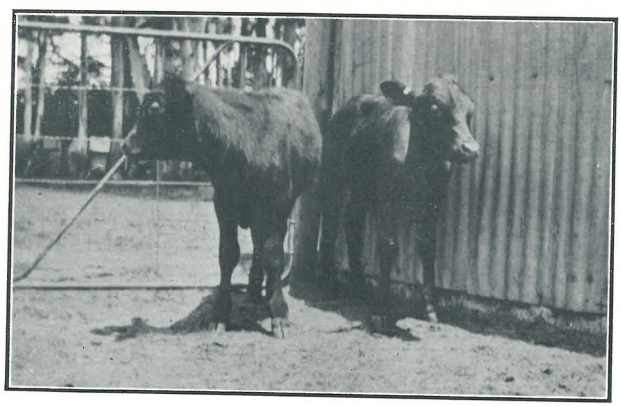

Fig. 43.—4th Calves, 3-4 months old.

(*c*) Group C Calves.

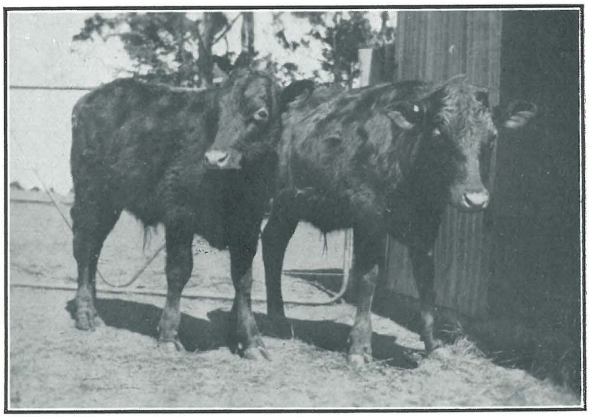

Fig. 44.—4th Calves, 8-9 months old.

APPENDIX II.

The following Tables, I-XIII, show in summarized form the data accumulated during the course of the observations up to the end of the fourth gestation period; that is from June, 1929, to July, 1935:—

TABLE I.

Breeding Table A : First Period, 1929-1931.

Group and D.O.B. No.	Approximate Age at which Oestrous Observations began (20.6.29).	Date on which First Oestrus was Observed.	*Observation Periods*—Groups A and C : June, 1929–December, 1930. Group B : June, 1929–April, 1931. The Periodicity of Oestrus in Days.	Total Number of Di-oestrus Periods.	Approximate Age at Final Service.	Weight at Final Service.	Number of Services required to Establish Pregnancy.	Gestation Period.	Sex of Calf.	Birth-Weight of Calf.
GROUP A.	Months.				Months.	Lb.		Days.		Lb.
3591.....	15	3.10.29	40 18 18 21 20 19 20 21 21 21 20 21 20 20 21 21 22 21 23	19	32	937	2 (*a*)	—	—	—
3592.....	15	27. 2.30	19 22 19 20 20 21 20 21 21 20 19 21	12	31 : 37 (*b*)	930	1 : 2 (*b*)	277	Male	82·0
3593.....	15	5.10.29	25 21 38 18 19 38 39 39 19 20 19 20 22 21 19	15	31	882	1	277	Female	60·0
3594.....	15	30. 7.29	55 23 20 17 26 10 28 21 38 20 20 21 20 20 20 19 21 20 40	19	31	989	1	285	Male	86·5
3595.....	15	16.10.29	63 15 61 19 37 19 20 20 19 19 21 18 18 39 17 18	16	33	1,108	3	275	Male	75·5
3597.....	15	25. 1.30	38 14 24 22 19 19 20 20 20 20 20 19 21	13	31	916	1	280	Male	75·0
3598.....	15	24.11.29	16 16 18 28 21 24 22 23 23 20 24 22 23 21 21 21 23	17	32	907	2	281	Female	73·5
3599.....	15	16.10.29	14 22 50 22 84 18 21 20 20 22 38 22 19 21	14	32	917	2	281	Female	72·0
3600.....	15	17.10.29	19 21 55 90 20 20 20 19 23 22 22 24 21 23	14	32	1,034	2	280	Female	90·5
GROUP B.										
3601.....	15	26.11.29	122 19 19 20 20 21 20 21 20 19 19 22 20 21 19 21 20 19 19 18	20	36	901	1	277	Female	66·0
3602.....	15	26.11.29	14 18 18 20 38 21 19 18 19 19 20 19 21 19 20 20 24 20 19 20 20 22 21 19 18	25	37	1,109	1	272	—	—
3604.....	15	30.10.29	22 27 10 28 21 21 20 21 22 21 21 21 21 21 21 19 24 18 21 21 20 22 20 20 20 22	26	37	1,111	1	281	Female	51·0
3605.....	15	24.11.29	24 61 40 43 21 19 21 23 21 20 21 19 24 17 17 23 21 21 20 20	20	36	1,132	1	278	Female	61·0
3606.....	15	30.10.29	59 72 24 37 40 19 20 20 22 19 23 22 20 20 20 20 20 21 20 20	20	37	1,092	1	287	Male	86·0
3607.....	15	18. 1.30	21 23 28 20 79 18 19 49 20 19 21 20 20 20 20	15	36	1,025	1	287	Female	80·0
3608.....	15	15. 9.29	43 43 39 54 20 22 21 22 22 23 23 22 19 20 24 23 23 22 22 24 19	21	37	1,142	1	279	Male	70·0
GROUP C.										
3611.....	15	13. 1.30	72 20 22 18 20 21 21 20 21 23 19 21	12	31	1,057	2	279	Male	65·5
3612.....	15	30. 7.29	117 18 63 16 40 22 23 22 23 23 20 46 27	13	32	1,009	1	271	Male	65·0
3613.....	15	30. 9.29	105 44 20 42 21 19 20 20 21 82	10	31	1,092	1	288	Male	96·0
3616.....	15	5. 8.29	40 16 22 51 63 20 21 21 21 21 20 21 21 22 22 22 21	17	31	1,181	1	286	Female	77·5
3617.....	15	9. 1.30	81 22 37 21 20 21 20 21 20 20	10	31	842	1	289	Female	75·0
3618.....	15	1.10.29	77 23 105 22 20 22 21 21 20 22 20 23	12	31	1,007	1	282	Male	87·5
3619.....	15	13. 2.30	20 36 18 18 36 18 55 18 54	9	32	842	1	277	Male	69·0
3620.....	15	7. 8.29	55 77 23 48 20 16 24 19 20 38 21 19 20 20 20	15	31	937	1	282	Female	75·0

NOTE.—(*a*) No. 3591 was killed *in extremis* and was found to be non-pregnant.
(*b*) No. 3592 aborted after 4½ months pregnancy, conceived again after two services. Inverted uterus after calf-birth.
(*c*) No. 3602 aborted 272 days after conception, cause unknown.

TABLE II.

Breeding Table B: Second Period, 1931-1932.

Group and D.O.B. No.	Approximate Age at Second Calving.	Period between Calving and First Oestrus.	The Periodicity of Oestrus (days).	Total Number of Di-oestrus Periods.	Period between Calving and last Oestrus or next Service.	Approximate Age at Final Service.	Weight at Final Service.	Number of Services to Establish Pregnancy.	Length of Gestation Period.	Sex of Calf.	Birth-weight of Calf.
GROUP A.	Months.	Days.			Days.	Months.	Lb.		Days.		Lb.
3593	40	61	44 19 123 20	4	267 (*c*)	54	1,002	3	281	Male	82·0
3594	40	104		—	104	44	1,125	1	279	Male	77·0
3595	42	66		—	66	44	1,340	1	284	Female	67·0
3596	—	— (*a*)	21	1	—	46	960	1	277	Male	73·5
3597	40	85	33 19	2	137	45	1,053	1	272	Female	68·0
3598	41	92	80 42 96	3	310	51	1,020	4	284	Female	77·0
3599	41	81		—	81	44	1,074	1	282	Male	80·0
3600	41	67	50	1	117	45	1,210	1	286	Female	94·0
GROUP B.											
3601	45	57	20 20	2	97	49	1,079	1	282	Male	79·0
3602	46	Aborted 13.1.32 (*b*)	21 21 21 44 79	5	—	53	1,171	4	284	Female	56·5
3603	—	— (*a*)	21 21 23 20	4	—	48	1,175	1	281	Male	79·5
3604	46	51	23	1	74	49	1,325	1	281	Female	60·0
3605	45	46	43	1	89	48	1,290	1	286	Female	75·0
3606	46	73		—	73	49	1,075	1	264	Female	52·0
3607	45	91		—	91	48	1,150	1	285	Female	77·0
3608	46	99		—	99	49	1,177	1	279	Female	77·5
3609	—	— (*a*)		—	—	48	1,065	1	282	Female	83·5
GROUP C.											
3611	40	73	66 45	2	184	46	1,015	1	281	Male	78·0
3612	41	100		—	100	44	1,120	1	274	Female	67·0
3613	40	124		—	124	44	1,225	1	284	Female	84·0
3614	—	— (*a*)		—	—	45	980	1	282	Female	71·0
3616	40	73	22 20 57	3	172	46	1,208	2	281	Female	80·0
3617	40	127		—	127	44	963	1	284	Male	90·0
3618	40	72	22 22	2	116	44	1,095	1	286	Male	94·0
3619	41	63	21 60	2	144	45	1,018	1	277	Female	66·0
3620	40	84	21 22	2	127	44	1,034	1	280	Male	69·0

NOTE.—(*a*) Nos. 3596, 3603, 3609, and 3614 were drafted back into the experiment on 11.12.31.

(*b*) No. 3602 aborted and was served about 3 months after the abortion.

(*c*) No. 3593 conceived to this service, but aborted after 4½ months and was served again 19 days after the abortion, to which service she conceived and eventually calved.

TABLE III.

Breeding Table C: Third Period, 1932-1933.

Group and D.O.B. No.	Approximate Age at Second Calving.	Period between Calving and First Oestrus.	The Periodicity of Oestrus (days).	Total Number of Di-oestrus Periods.	Period between Calving and last Oestrus or next Service.	Approximate Age at Final Service.	Weight at Final Period. Service.	Number of Services to Establish Pregnancy.	Length of Gestation Period.	Sex of Calf.	Birth-weight of Calf.
GROUP A.	Months.	Days.			Days.	Months.	Lb.		Days.		Lb.
3593	63	58		—	58	65	1,105	1	281	Female	69·0
3594	53	56	22 21	2	99	56	952	1	282	Female	74·5
3595	53	61	21 19 39 40 78 22 54	7	334	64	1,353	4	278	Male	71·0
3596	55	85		—	85	58	899	1	275	Female	64·0
3597	54	84	19	1	103	57	958	1	281	Male	81·0
3598	60	70	22 112 20 67	4	224	70	978	3	276	Female	53·0
3599	53	98	64	1	162	58	1,061	1	283	Male	87·0
3600	54	107		—	107	58	1,062	1	285	Male	99·0
GROUP B.											
3601	58	39	39 44	2	122	62	1,000	1	282	Female	78·0
3602	63	102		—	102	66	1,114	1	286	Male	69·5
3603	57	128		—	128	61	1,204	1	281	Male	68·0
3604	58	38	80 23 28 21	4	190	64	1,375	4	281	Female	53·0
3605	57	37	21 67	2	125	61	1,274	1	276	Male	76·0
3606	58	36	42 21 21	3	120	62	1,272	1	276	Female	75·0
3607	57	29	41 51 50 21 62 33 22 21 19 88 39	11	319	72	—	10	280	Male	69·0
3608	58	29	52 24 21 Aborted 22.8.33 44 21	5	266	67	—	1, aborted 2	279	Female	70·0
3609	57	69	21 21 22	3	133	61	1,170	2	280	Male	98·0
GROUP C.											
3611	55	126	22 20	2	168	61	1,105	1	279	Female	75·0
3612	53	70	27	1	97	56	1'022	1	276	Male	75·5
3613	53	115		—	115	57	1,107	1	277	Male	82·0
3614	54	164		—	164	59	892	1	284	Male	75·0
3616	55	77		—	77	58	1,127	1	284	Female	86·0
3617	53	117	77 42	2	236	61	850	3	279	Female	73·0
3618	53	57	43	1	100	56	1,011	1	286	Female	87·0
3619	54	99		—	99	57	983	1	274	Female	71·0
3620	53	119		—	119	57	925	1	286	Male	76·0

TABLE IV.

Breeding Table D: Fourth Period, 1933-1934.

Group and D.O.B. No.	Approximate Age at Third Calving.	Period between Calving and First Oestrus.	The Periodicity of Oestrus (days).	Total Number of Di-oestrus Periods.	Period between Calving and last Oestrus or next Service.	Approximate Age at Final Service.	Weight at Final Service.	Number of Services to Establish Pregnancy.	Length of Gestation Period.	Sex of Calf.	Birth-weight of Calf.
GROUP A.	Months.	Days.			Days.	Months.	Lb.		Days.		Lb.
3593	74	44	21 20	2	85	77	816	1	285	Female	59·0
3594	65	21	41 21 20	3	103	68	960	1	283	Female	77·5
3595	73	41	21 21	2	83	76	1,202	1	273	Male	65·0
3596	67	67	20	1	87	70	892	1	272	Female	61·0
3597	66	55	20 21	2	96	69	985	1	278	Male	75·0
3598	79	79		—	79	82	1,000	1	276	Female	53·0
3599	67	62	42	1	104	70	1,083	1	279	Male	78·0
3600	67	40	24 44	2	108	71	1,127	1	282	Female	54·5
GROUP B.											
3601	71	39	21 20 21 20	4	121	75	917	1	282	Male	51·0
3602	75	77	19	1	96	78	997	1	—	—	—
3603	70	27	44 22	2	93	73	1,300	1	272	Female	57·0
3604	73	36	19 41	2	96	76	1,317	1	273	Male	59·0
3605	70	33	22 21 24	3	100	73	1,214	1	277	Male	53·0
3606	71	120		—	120	75	1,247	1	276	Male	66·0
3607	81	52	20 40 40	3	152	86	1,263	—	—	—	—
3608	76	49	19 24	2	92	79	1,122	1	279	Female	70·0
3609	70	52	24 22	2	98	73	1,094	1	276	Male	79·0
GROUP C.											
3611	70	64	21	1	85	73	1,148	1	278	Female	60·0
3612	65	47	23 27	2	97	68	1,075	1	269	Female	51·0
3613	66	186		—	186	72	1,130	1	269	Female	47·5
3614	68	211	20 20 82	3	333	79	1,002	4	—	—	—
3616	67	49	22 22	2	93	70	1,065	1	276	Male	77·0
3617	70	60	51	1	111	74	864	1	278	Female	44·0
3618	65	37	45 69	2	151	70	1,034	1	Aborted 28.11.34. Died 4.12.34.		
3619	66	60	41	1	101	69	998	1	272	Male	57·0
3620	66	35	23 41	2	99	69	891	1	280	Male	72·5

TABLE V.

Breeding Table E.

	Di-oestrus Periods.			Approximate Age at Final or Successful Service.		Weight at Final or Successful Service.		Number of Services required to Establish Pregnancy. Frequencies.										
	Total.	Range.	Mode.	Range.	Average.	Range.	Average.	1	2	3	4	5	6	7	8	9	10	11	12
GROUP A.		Days.	Days.	Months.	Months.	Lb.	Lb.												
1st Period.....	139	10– 90	20	31–33	32	907–1,108	958	4	3	1	—	—	—	—	—	—	—	—	—
2nd Period.....	11	19–123	19	44–54	47	960–1,340	1,098	6	—	1	1	—	—	—	—	—	—	—	—
3rd Period.....	15	19–112	22	56–70	61	952–1,353	1,056	6	—	1	1	—	—	—	—	—	—	—	—
4th Period.....	13	20– 44	21	68–82	73	816–1,202	1,008	8	—	—	—	—	—	—	—	—	—	—	—
GROUP B.																			
1st Period.....	147	10–122	20	36–37	35	901–1,142	1,073	7	—	—	—	—	—	—	—	—	—	—	—
2nd Period.....	13	20– 79	21	48–53	49	1,065–1,325	1,167	8	—	—	1	—	—	—	—	—	—	—	—
3rd Period.....	30	19– 88	21	61–72	64	1,000–1,375	1,201	6	2	—	1	—	—	—	—	—	—	1	—
4th Period.....	19	19– 44	—(*a*)	73–86	76	917–1,317	1,162	8	—	—	—	—	—	—	—	—	—	—	—
GROUP C.																			
1st Period.....	98	16–117	20	31–32	31	842–1,181	995	7	1	—	—	—	—	—	—	—	—	—	—
2 d Period.....	11	20– 66	22	44–46	45	980–1,225	1,073	8	1	—	—	—	—	—	—	—	—	—	—
3rd Period.....	6	20– 77	—(*a*)	56–61	58	850–1,127	1,002	8	—	1	—	—	—	—	—	—	—	—	—
4th Period.....	14	20– 82	—(*a*)	68–79	72	864–1,148	1,023	8	—	1	—	—	—	—	—	—	—	—	—

	Approximate Age at Calving.		Length of Gestation Period.		Birth-weight of Calves.		Sex of Calves.		Period between Calving and First Oestrus.		Period between Calving and last Oestrus or next Service.	
	Range.	Average.	Range.	Average.	Range.	Average.	Male.	Female.	Range.	Average.	Range.	Average.
GROUP A.	Months.	Months.	Days.	Days.	Lb.	Lb.			Days.	Days.	Days.	Days.
1st Period.....	40–42	41	275–285	279·5	60–90	76·9	4	4	61–104	79·4	66–267	153·7
2nd Period.....	53–63	56	272–286	280·6	67–94	77·3	4	4	56–107	77·4	58–334	146·5
3rd Period.....	65–79	70	275–285	280·7	64–99	77·9	4	3	21– 79	51·1	79–108	93·1
4th Period.....	77–91	82	272–285	278·5	53–78	65·4	3	5	32– 87	60·3	79–155	103·2
GROUP B.												
1st Period.....	45–46	46	272–287	280·1	51–86	69·0	2	4	46– 99	69·5	73– 99	87·2
2nd Period.....	58–63	58	264–286	280·4	52–83	71·7	2	7	39–128	56·3	102–266	148·2
3rd Period.....	70–81	73	276–286	280·1	53–98	73·4	5	4	27–120	54·0	92–152	107·6
4th Period.....	82–95	85	272–282	276·1	51–79	62·1	5	2	—	—	—	—
GROUP C.												
1st Period.....	40–41	40	271–289	281·8	65–96	76·3	5	3	63–127	89·5	100–184	136·8
2nd Period.....	53–55	54	274–286	281·0	66–94	77·7	4	5	57–164	104·9	77–236	130·6
3rd Period.....	65–70	67	274–286	280·5	71–87	77·8	4	5	35–211	83·2	85–333	139·6
4th Period.....	77–85	80	269–280	274·6	44–79	58·4	3	4	15– 95	53·2	73–171	103·2

NOTE.—(*a*) No mode.

TABLE VI.

Frequencies of the Periodicity of Oestrus: First Period, 1929-1931.

Periodicity of oestrus in days:—

Number of Individuals.	10	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	33	36	37	38	39	40	42	43
Group A: 9.....	1	2	1	2	2	8	19	31	27	12	8	4	1	1	—	2	—	—	1	5	3	2	—	—
Group B: 7.....	1	1	—	—	2	7	23	38	28	14	8	7	—	—	1	2	—	—	1	1	1	2	—	3
Group C: 8.....	—	—	—	3	—	6	4	23	19	11	7	1	—	—	1	—	—	2	1	1	—	2	1	—
TOTAL: 24.....	2	3	1	5	4	21	46	92	74	37	23	12	1	1	2	4	—	2	3	7	4	6	1	3

Number of Individuals.	44	46	48	49	51	54	55	59	60	61	63	72	75	77	79	81	82	84	90	105	117	122	Totals.
Group A: 9.....	—	—	—	—	—	—	2	—	1	1	1	—	—	—	—	—	—	1	1	—	—	—	139
Group B: 7.....	—	—	—	1	—	1	—	1	—	1	—	1	—	—	1	—	—	—	—	—	—	1	147
Group C: 8.....	1	1	1	—	1	1	2	—	—	—	2	1	—	2	—	1	1	—	—	2	1	—	98
TOTAL: 24.....	1	1	1	1	1	2	4	1	1	2	3	2	—	2	1	1	1	1	1	2	1	1	384

TABLE VII.

Second Period, 1931-1932.

Periodicity of oestrus in days:—

Number of Individuals.	19	20	21	22	23	33	42	43	44	45	50	57	60	66	79	80	96	123	Totals.
Group A: 8.....	2	1	1	—	—	1	1	—	1	—	1	—	—	—	—	1	1	1	11
Group B: 9.....	—	3	5	—	2	—	—	1	1	—	—	—	—	—	1	—	—	—	13
Group C: 9.....	—	1	2	4	—	—	—	—	—	1	—	1	1	1	—	—	—	—	11
TOTALS: 26.....	2	5	8	4	2	1	1	1	2	1	1	1	1	1	1	1	1	1	35

TABLE VIII.

Third Period, 1932-1933.

Periodicity of oestrus in days:—

Number of Individuals.	19	20	21	22	23	24	25	26	27	28	33	39	40	41	42	43	44	50	51	52	54	62	64	67	77	78	80	88	112	Totals.
Group A: 8.....	2	1	2	3	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	1	–	1	1	–	1	–	–	1	15
Group B: 9.....	1	–	10	2	1	1	–	–	–	1	1	2	–	1	1	–	2	1	1	1	–	1	–	1	–	–	1	1	–	30
Group C: 9.....	–	1	–	1	–	–	–	–	1	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	1	–	–	–	–	6
TOTALS: 26.....	3	2	12	6	1	1	–	–	1	1	1	3	1	1	2	1	2	1	1	1	1	1	1	2	1	1	1	1	1	51

TABLE IX.

Fourth Period, 1933-1934.

Periodicity of oestrus in days:—

Number of Individuals.	19	20	21	22	23	24	27	40	41	42	44	45	51	69	82	Totals.
Group A: 8.....	—	4	5	—	—	1	—	—	1	1	1	—	—	—	—	13
Group B: 9.....	3	3	3	3	—	3	—	2	1	—	1	—	—	—	—	19
Group C: 9.....	—	2	1	2	2	—	1	—	2	—	—	1	1	1	1	14
TOTALS: 26.....	3	9	9	5	2	4	1	2	4	1	2	1	1	1	1	46

TABLE X.

The Dioestrous Periods, 1929-1934.

Group.	First Period, 1929–1931.			Second Period, 1931–1932.		
	Dioestrous Periods.		Percentage of Cases in which Oestrus Recurred after the Normal Interval of 18–23 Days.	Dioestrous Periods.		Percentage of Cases in which Oestrus Recurred after the Normal Interval of 18–23 Days.
	Range.	Mode.		Range.	Mode.	
	Days.	Days.		Days.	Days.	
A	10– 90	20	76·0	19–123	19	27·3
B	10–122	20	80·0	20– 79	21	76·9
C	16–117	20	70·0	20– 66	22	63·6
ALL GROUPS	10–122	—	75·3	19–123	—	55·9

Group.	Third Period, 1932–1933.			Fourth Period, 1933–1934.		
	Dioestrous Periods.		Percentage of Cases in which Oestrus Recurred after the Normal Interval of 18–23 Days.	Dioestrous Periods.		Percentage of Cases in which Oestrus Recurred after the Normal Interval of 18–23 Days.
	Range.	Mode.		Range.	Mode.	
	Days.	Days.		Days.	Days.	
A	19–112	22	57·1	20–44	21	30·8
B	19– 80	21	50·0	19–44	19, 20, 21, 22 and 24	36·8
C	20– 77	—	33·3	20–82	20, 22, 23, 41	50·0
ALL GROUPS	19–112	—	46·8	19–82	—	39·2

Table XI.

Calving Data, 1930-1935.

Group and Cow No.	1930 — 1931 — 1932.					1931 — 1932 — 1933.					1932 — 1933 — 1934.					1933 — 1934 — 1935.				
	Date of Service.	Date of Calving.	Gestation Period.	Sex of Calf.	Birth-weight of Calf.	Date of Service.	Date of Calving.	Gestation Period.	Sex of Calf.	Birth-weight of Calf.	Date of Service.	Date of Calving.	Gestation Period.	Sex of Calf.	Birth-weight of Calf.	Date of Service.	Date of Calving.	Gestation Period.	Sex of Calf.	Birth-weight of Calf.
Group A.			Days.		Lb.			Days.		Lb.			Days.		Lb.			Days.		Lb.
3591	27·11·30	Killed, *in extremis*.		Non-pregnant																
3592	5. 5.31	6. 2.32	277	Male	82·0	Died 11.2.32	Inverted uterus.	—	—	—	—	—	—	—	—	—	—	—	—	—
3593	18.10.30	21. 7.31	277	Female	60·0	13. 4.32 18. 9.32	Aborted 30. 8.32 27. 6.33	281	Male	82·0	24. 8.33	1. 6.34	281	Female	69·0	26. 8.34	7. 6.35	285	Female	59·0
3594	1.11.30	13. 8.31	285	Male	86·5	25·11·31	30. 8.32	279	Male	77·0	7.12.32	15. 9.33	282	Female	74·5	27.12.33	6.10.34	283	Female	77·5
3595	24.12.30	25. 9.31	275	Male	75·5	30.11.31	9. 9.32	284	Female	67·0	8. 9.33	14. 5.34	278	Male	71·0	5. 8.34	5. 5.35	273	Male	65·0
3596*	—	—	—	—	—	5. 2.32	5.11.32	277	Male	83·5	29. 1.33	31.10.33	275	Female	64·0	26. 1.34	25.10.34	272	Female	61·0
3597	28.10.30	3. 8.31	280	Male	75·0	19.12.31	16. 9.32	272	Female	68·0	28.12.32	5.10.33	281	Male	81·0	9. 1.34	14.10.34	278	Male	75·0
3598	10.11.30	18. 8.31	281	Female	73·5	24· 6.32	4. 4.33	284	Female	77·0	20. 1.34	23.10.34	276	Female	53·0	—	—	—	—	—
3599	23.11.30	31. 8.31	281	Female	72·0	20.11.31	28. 8.32	282	Male	80·0	6. 2.33	16.11.33	283	Male	87·0	28. 2.34	4.12.34	279	Male	78·0
3600	17.11.30	24. 8.31	280	Female	90·5	20.12.31	1.10.32	286	Female	94·0	16. 1.33	28.10.33	285	Male	99·0	13. 2.34	22.11.34	282	Female	54·5
Group B.																				
3601	9. 4.31	11. 1.32	277	Female	66·0	17. 4.32	24. 1.33	282	Male	79·0	26. 5.33	4. 3.34	282	Female	78·0	3. 7.34	11. 4.35	282	Male	51·0
3602	16. 4.31	(Aborted	13.1.32 at 27	2 days)	—	29. 8.32	8. 6.33	284	Female	56·5	18. 9.33	1. 7.34	286	Male	69·5	5.10.34	8. 7.35	276	Female	67·0
3603*	—	—	—	—	—	9. 4.32	15. 1.33	281	Male	79·5	23. 5.33	28. 2.34	281	Male	68·0	1. 6.34	28. 2.35	272	Female	57·0
3604	28. 4.31	3. 2.32	281	Female	51·0	17. 4.32	23. 1.33	281	Female	60·0	1. 8.33	9. 5.34	281	Female	53·0	13. 8.34	13. 5.35	273	Male	59·0
3605	4. 4.31	7. 1.32	278	Female	61·0	5. 4.32	16. 1.33	286	Female	75·5	21. 5.33	21. 2.34	276	Male	76·0	1. 6.34	5. 3.35	277	Male	53·0
3606	21. 4.31	2. 2.32	287	Male	86·0	15. 4.32	4. 1.33	264	Female	52·0	4. 5.33	4. 2.34	276	Female	75·0	4. 6.34	7. 3.35	276	Male	66·0
3607	1. 4.31	13. 1.32	287	Female	80·0	13. 4.32	23. 1.33	285	Female	77·0	14. 4.34	19. 1.35	280	Male	69·0	—	—	—	—	—
3608	16. 4.31	20. 1.32	279	Male	70·0	28. 4.32	1. 2.33	279	Female	77·5	25.10.33	31. 7.34	279	Female	70·0	—	—	—	—	—
3609*	—	—	—	—	—	3. 4.32	10. 1.33	282	Female	83·5	23. 5.33	27. 2.34	280	Male	98·0	5. 6.34	8. 3.35	276	Male	79·0
Group C.																				
3611	8.11.30	14. 8.31	279	Male	65·5	14. 2.32	21.11.32	281	Male	78·0	8. 5.33	11. 2.34	279	Female	75·0	7. 5.34	9. 2.35	278	Female	60·0
3612	3.12.30	31. 8.31	271	Male	65·0	9.12.31	8. 9.32	274	Female	67·0	14.12.32	16. 9.33	276	Male	75·5	22.12.33	17. 9.34	269	Female	51·0
3613	29.10.30	12. 8.31	288	Male	96·0	14.12.31	23. 9.32	284	Female	84·0	16. 1.33	20.10.33	277	Male	82·0	24. 4.34	18. 1.35	269	Female	47·5
3614*	—	—	—	—	—	6. 1.32	14.10.32	282	Female	71·0	27. 3.33	5. 1.34	284	Male	75·0	21. 9.34	—	—	—	—
3616	24.10.30	5. 8.31	286	Female	77·5	24. 1.32	31.10.32	281	Female	80·0	16. 1.33	27.10.33	284	Female	86·0	28. 1.34	31.10.34	276	Male	77·0
3617	20.10.30	4. 8.31	289	Female	75·0	9.12.31	18. 9.32	284	Male	90·0	12. 5.33	15. 2.34	279	Female	73·0	6. 6.34	11. 3.35	278	Female	44·0
3618	1.11.30	9. 8.31	282	Male	87·5	3.12.31	14. 9.32	286	Male	94·0	23.12.32	5.10.33	286	Female	87·0	4. 3.34	Died 4.12.34.	Aborted 28.11.34.		
3619	14.11.30	18. 8.31	277	Male	69·0	9. 1.32	12.10.32	277	Female	66·0	19. 1.33	20.10.33	274	Female	71·0	29. 1.34	28.10.34	272	Male	57·0
3620	22.10.30	30. 7.31	282	Female	75·0	4.12.31	9. 9.32	280	Male	69·0	6. 1.33	19.10.33	286	Male	76·0	26. 1.34	2.11.34	280	Male	72·5

* Drafted into experiment 11.12.31.

TABLE XII.

Gestation Periods: Frequencies.

(a) First Calving.

Groups.	Gestation Periods in Days.																					Totals.
	264	269	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	
A	—	—	—	—	—	—	1	—	2	—	—	2	2	—	—	—	1	—	—	—	—	8
B	—	—	—	—	—	—	—	—	1	1	1	—	1	—	—	—	—	—	2	—	—	6
C	—	—	1	—	—	—	—	—	1	—	1	—	—	2	—	—	—	1	—	1	1	8

(b) Second Calving.

A	—	—	—	1	—	—	—	—	1	—	1	—	1	1	—	2	—	1	—	—	—	8
B	1	—	—	—	—	—	—	—	—	—	1	—	2	2	—	1	1	1	—	—	—	9
C	—	—	—	—	—	1	—	—	1	—	—	1	2	1	—	2	—	1	—	—	—	9

(c) Third Calving.

A	—	—	—	—	—	—	1	1	—	1	—	—	2	1	1	—	1	—	—	—	—	8
B	—	—	—	—	—	—	—	2	—	—	1	2	2	1	—	—	—	1	—	—	—	9
C	—	—	—	—	—	1	—	1	1	—	2	—	—	—	—	2	—	2	—	—	—	9

(d) Fourth Calving.

A	—	—	—	1	1	—	—	—	—	1	1	—	—	1	1	—	1	—	—	—	—	7
B	—	—	—	1	1	—	—	3	1	—	—	—	—	1	—	—	—	—	—	—	—	7
C	—	2	—	1	—	—	—	1	—	2	—	1	—	—	—	—	—	—	—	—	—	7
A (four calvings)	—	—	—	2	1	—	2	1	3	2	2	2	5	3	2	2	3	1	—	—	—	31
B „	1	—	—	1	1	—	—	5	2	1	3	2	5	4	—	1	1	2	2	—	—	31
C „	—	2	1	1	—	2	—	2	3	2	3	2	2	3	—	4	—	4	—	1	1	33
TOTALS	1	2	1	4	2	2	2	8	8	5	8	6	12	10	2	7	4	7	2	1	1	95

TABLE XIII.

Gestation Periods.

Group.	Sex.	First Period.			Second Period.			Third Period.			Fourth Period.			All Periods.		
		No.	Gestation Period.		No.	Gestation Period.		No.	Gestation Period.		No.	Gestation Period.		No.	Gestation Period.	
			Range.	Aver-age.		Range.	Aver-age.		Range.	Aver-age.		Range.	Aver-age.		Range	Aver-age.
			Days.	Days.		Days.	Days.		Days.	Days.		Days.	Days.		Days.	Days.
A.....	M.	4	275–285	279·2	4	277–282	279·7	4	278–285	281·7	3	273–279	276·7	15	273–285	279·3
	F.	4	277–281	279·7	4	272–286	281·5	3	275–282	279·3	5	272–282	279·6	16	272–286	280·0
B.....	M.	2	279–287	283·0	2	281–282	281·5	5	276–286	280·6	5	273–282	276·8	13	273–287	280·5
	F.	4	277–287	280·8	7	264–285	280·1	4	276–282	279·5	2	272–279	275·5	17	264–287	279·0
C.....	M.	5	271–288	279·4	4	280–286	282·8	4	276–286	280·7	3	272–280	276·0	16	271–288	279·7
	F.	3	282–289	285·7	5	274–284	279·6	5	274–286	280·4	4	269–278	273·5	17	269–289	279·8
ALL GROUPS..	M.	11	271–288	280·0	10	277–286	281·3	13	276–286	281·0	11	272–282	276·5	45	271–288	279·7
	F.	11	277–289	281·7	16	264–286	280·3	12	274–286	279·7	11	269–282	276·2	50	264–289	279·5

M. = Males. F. = Females.