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Bionomic Studies on Cattle in the Semi-Arid Regions of the Union of South Africa. IV.—The Ovarian Cycle of Heifers during Summer.

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I. Introduction.

Theiler, Green, and du Toit (1924), showed that, in general, the soils and natural pastures of South Africa, are deficient in phosphates. On the Veterinary Research Station, " Armoedsvlakte ", where conditions are representative of a large part of the semi-arid regions of the Union of South Africa, this deficiency was the cause of inferior growth, production and reproduction in cattle.

To determine how far bovine function could be improved, in such semi-arid regions, by the correction of the phosphorus deficiency in the diet, large scale experiments with cattle, were commenced at Armoedsvlakte in 1925. Du Toit and Bisschop (1929) described the results obtained by phosphorus supplementation to halfbred Afrikaner, Fries, Redpoll and Sussex cattle. The results were so encouraging that the authors suggested that phosphatic supplementation to ranch cattle might prove to be the solution to the failure experienced by cattle breeders in the semi-arid regions of the Union in trying to improve the native stock, by " grading " them up with sires of European breeds.

Bisschop (1938) reported that the results of the experiments since 1928 had shown that such hopes could not be substantiated. He stated: " Instead of maintaining the improvement evident in the first crosses and instead of progressively approaching the conformational, productive and reproductive excellence of their paternal ancestors, in their respective " home " environments, the topcrossed generations of the exogenous bonemeal fed grades manifested a distinct phenotypical deterioration,—in some cases even to below the standard of their unimproved, maternal ancestors. Such deterioration, however, confined itself specifically to the exogenous grades, i.e., to the $\frac{3}{4}$ and $\frac{7}{8}$th bred Fries, Redpoll and Sussex cattle. The comparable Afrikaner generations maintained their original standard of excellence.

" The above facts demonstrated clearly that although one of the limiting factors, inherent in the prevailing environment, had been successfully combated by phosphatic supplementation, further limiting factors still caused phenotypic deterioration in the higher grades of imported cattle breeds."

Once it was realized how complex the environment is and how potent its forces are upon animal function, the researches at Armoedsvlakte became more critically bionomic. As fast as suitable techniques can be devised, the prevailing environment is being analysed into the constituent factors of its climatic, nutritional, pathological and sociological complexes, and their effects determined, singly and collectively, upon bovine function. It is obvious that such investigations, if they are to produce results of value, must be continued for many years. In the meantime a second line, along which bionomic investigations are being conducted, is yielding much information of both practical and academic importance. In these latter researches the prevailing environmental forces *as a whole*, are measured in terms of the functional reactions of the experimental cattle, i.e., in terms of their growth, development, production, reproduction, and of their vital functions, such as respiration, circulation, heat elimination and preservation, etc. etc.

The Sex Physiological Researches at Armoedsvlakte.

As part of the latter line of bionomic researches at Armoedsvlakte, a series of sex physiology experiments were commenced in 1938. The object of these investigations was to study the development of the genital system in bovines under the prevailing conditions, from birth up to breeding age,—to obtain information concerning the age at which the different types and breeds on the Station reach sexual maturity,—to determine the duration of their ovarian cycles and oestrous periods,—to observe the effect upon these sexual phenomena of changing environment during the various seasons of the year,—and finally to investigate the physiological changes in the ovaries during the ovarian cycle.

The present article is concerned only with the sexual reactions of heifers to summer conditions at Armoedsvlakte,—during January and February, 1940.

III. Literature.

Text books, state that the frequency of the ovarian cycle in cattle varies from 17-24 days, and that the duration of oestrus ranges from 18-24 hours. No detailed information is available, as to the environmental conditions to which these standards are applicable.

Andersen (1936), working with Zebu cattle in Kenya, reported that their ovarian cycle varied from 17·9 to 24·2 days, with a mean of 20·1 days. He found the duration of oestrus to be extremely short, i.e., from 81 to 171 minutes. He also reported an apparent seasonal fertility in Zebu cattle, in that fertile matings appeared to occur more frequently at certain times of the year. With regards to this latter observation, Bonsma (1939) reports that in South Africa,

the most favourable seasons for service are March and April and again August and September; that is of course, on ranches where " free " or " all the year round " breeding is practised. Although very little has been published regarding the sexual reaction of cattle to uncontrolled environmental conditions, a fair number of articles appear in the literature dealing with their reactions to controlled or artificial conditions. These articles have been discussed by Quinlan and Roux (1936) when they reported upon an investigation in which beef cows and heifers were kept for six years in an environment enforcing some factors popularly associated with low fertility; i.e., lack of sunlight, lack of exercise, dry rations, and high condition. They found that these abnormal conditions did not influence either the duration or the rhythm of the ovarian cycle. Although abnormal cycles as short as 10 days and as long as 123 days were noted, 75 per cent. of 516 ovarian cycles, fell within the range of 18 to 23 days, with a mode of 20 days. Quinlan, Roux and van Aswegen (1939), kept heifers from birth up to maturity under similar conditions, and found that 91 per cent. of 383 ovarian cycles ranged from 18-23 days, with a mode of 20·3 days. In terms of the ovarian cycle, their results conform to the standards found in text books on gynaecology. It would appear from the results of these two investigations, which were both carried out on high grade Sussex females, on the same experimental station, that under similar conditions similarly bred cattle will react in a like manner. That differences in reaction do occur, due to environment and breed peculiarities, seem to be supported by Schmaltz (1921) who reports that " steppe cattle do not come into breeding before their fourth year ". Marshall and Hammond (1926) and Hammond (1927), have made similar observations. Quinlan, Roux and van Aswegen (1939) found that their high grade Sussex heifers reached sexual maturity on the average at 529 days, while Hammond (1940) reported to the senior author cases of Jersey heifers in the U.S.A. (observed by Dr. Ten Broeck), which calved at about a year old.* In this country too, the indigenous breeds of cattle appear to be very late in arriving at sexual maturity compared with heifers of European breeds. The breed differences in the age of sexual maturity, quoted above, vary from well below to well above the limits of variation (5 to 15 months, with a mode of 9 months) published in the text books.

With reference to oestrus in cattle, apart from the work of Andersen (1936), no literature is available to throw light upon what effects, if any, environmental influences exert upon its duration.

IV. The Plan of the Experiment.

(*a*) *Animal Material.*

All the highgrade and purebred heifers born during the 1938 calving season, were tested for oestrus from the age of 6 months onwards; at first only once a day, later twice a day,—at 8 a.m. and

* Note.—In a letter, dated 24/2/41, Dr. Carl TenBroeck wrote to the senior author stating that in the case of 22 Jersey heifers, exposed to the bull from birth, the average age at first calving was 491 days. One animal had a calf at 369 days, and there were several that had calved around 400 days.

4 p.m. In this way it was possible to establish the age of sexual maturity, and after this had been reached, to determine the ovarian periodicity for each heifer. It was not possible, by means of these tests, to obtain information concerning the exact duration of oestrus. Various other methods, such as 6-hourly tests, running teaser bulls with the heifers during the day, etc., were tried, but these failed to provide the detailed data required. After a short " trial period ", it was finally decided to conduct tests at hourly intervals during day and night, for a sufficiently long period to obtain comparable data concerning the duration of oestrus in the heifers of the Afrikaner, Fries, Redpoll and Sussex herds.. Such data would allow a comparative study, not only of the sex physiological reactions of the four breeds mentioned, to the prevailing environment, but also of indigenous as against exogenous cattle types, and within the latter, of possible differences between milk, dual purpose and beef types. Of the 70 heifers included in the experiment, 59 received a bonemeal supplement, while the remaining 11 did not. A comparison between bonemeal fed and " control " heifers would therefore also be possible.

At Armoedsvlakte controlled breeding is practised. The calving season lasts from early in November to the middle of January. At the time when the hourly tests were commenced, on 3.1.1940, the heifers were therefore, approximately 2 years old.

(*b*) *The Season during which the Test was conducted.*

The hourly tests were conducted for 6 weeks from January 3rd to February 15th, 1940. The period was selected as representative of annual optimum environmental conditions at Armoedsvlakte. By comparing the sexual activity under such conditions, with that exhibited by the same experimental heifers during a midwinter period, (this part of the programme is now in progress), valuable information concerning the sex reaction during different seasons of the year would be obtained.

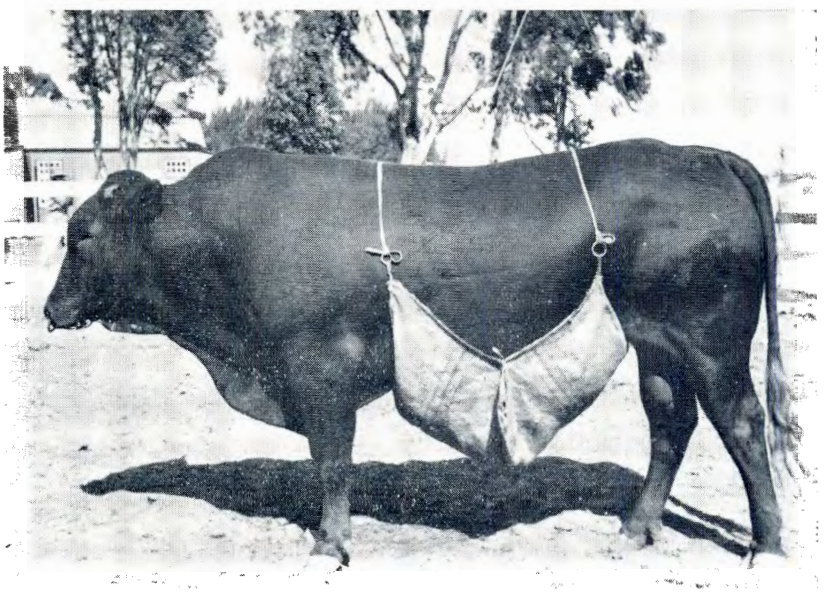
(*c*) *The hourly Tests.*

As a result of the twice a day tests, which were continued as a routine procedure, it was known when heifers were likely to come into oestrus. Heifers were removed from the general herd to the " test group ", 18 days after their last oestrus. They remained in the " test group " till the end of their oestrous period, or, if oestrus was not observed, until the 24th day.

During the day time, the test group of heifers was kept under constant supervision in a well-grassed camp. From 9 a.m. until after 6 p.m., the hourly tests were conducted in this camp; the bulls being brought to the heifers. Depending upon the number of heifers in the group (this of course varied from day to day) the test occupied from a few minutes, up to 20 minutes. After completion of a test the bulls were taken away and the heifers allowed as much free grazing as possible, since for the night tests, they had to be kraaled during the time, when usually they do most of their feeding in summer.

After the 6 p.m. test, the " test group " animals were brought to special paddocks, supplied with electric lights, at the homestead. These paddocks consisted of a collection pen, from where the heifers were drafted one by one at each hourly test, into smaller pens in which the bulls were accommodated. Here the actual testing took place, and then the heifers were passed into a large " rest paddock " where they remained in between tests. Here good quality teff hay was available and the heifers were disturbed as little as possible.

Five vasectomised " teaser " bulls, used in the twice a day tests, were also used in the hourly tests. They were well-trained and quick in " spotting " a heifer near to, or in heat. The strain of the hourly tests however, especially during hot days, began to tell upon their sexual activity, and in order that no signs of oestrus should pass unobserved, due to sluggish bulls, four " aproned " bulls were used, whenever necessary, from January 15th onwards, until the end of the test. Two bulls were used at every test, and no bulls were used for more than 8 consecutive hourly tests. Their feeding and management were such as to maintain the highest sexual activity.



Photgraph of an " aproned " bull.

The heifers too, were a potential source of inaccurate data. Due to the enforced change in their grazing habits, and to constant handling, some heifers showed signs of weariness, towards the end of their stay in the " test group ", especially if oestrus occurred towards the termination of their 7 days " under test ". To counteract this, the actual tests were conducted expeditiously, and the animals interfered with as little as possible during the intervals between testing. Since all the heifers except Nos. 8016 and 6944 were accustomed to " teasers " and to coitus, the data collected were not influenced by the psychological reactions to which heifers are subject when mated for the first time.

Both in the day camps and in the night paddocks the " test group " heifers were under the constant observation of trained men, i.e., of men experienced in " spotting " the signs of oestrus. Any such signs noticed, not only during actual tests, but at any time during the day or night, were recorded.

Table No. 1 gives details concerning the symptoms of oestrus of which a record was kept, and the symbols used to record them.

TABLE No. 1.

	Symptoms of Oestrus.	Symbol used.
1	Heifer served	⊕
2	Heifer stands for bull, but is not served (Aproned bulls)	⊖
3	Heifer stands for other heifers	—
4	Heifer mounts other heifers	M.
5	Heifer shows a mucous discharge from vulva	T.
6	Heifer shows a haemorrhagic discharge from vulva	●
7	Bull interested in heifer, prior to her allowing coitus	○
8	Bull interested in heifer, subsequent to coitus, but heifer will no longer stand	✧

Table No. 2 gives extracts from the daily observation register and shows a few representative oestrous periods in terms of the symbols employed.

V. THE ARMOEDSVLAKTE ENVIRONMENT.

Situated at an altitude of 4,000 feet, on latitude 26° 55′ S., and on longitude 24° 35′ E., in the semi-arid, summer rainfall area of the Union of S. Africa, the Armoedsvlakte environment is that of a high and dry inland plateau. In addition to climatic draw-backs such as a short rainy season,—low total precipitation,—very low effective rainfall,—very low relative humidity, extremes of temperature, both seasonal and diurnal, etc., the soils are shallow,—physically loose and poor in humus, and chemically very poor in phosphorus. Under these conditions, it is obvious why the vegetation is sparse and why it can supply cattle with a diet, qualitively adequate for normal function, only for 4 to 5 months per year, even when the phosphorus deficiency is made good.

Table No. 3 gives details of the climatic and nutritional conditions which prevailed at Armoedsvlakte during January and February, 1940, i.e., during the period of the hourly observations on heifers. So that these conditions can be appreciated data are given for the whole of the 1939-1940 season, and, as a comparative background, monthly averages, for a number of years, have been added.

A study of the rainfall data reveals that the 1939-1940 season was quite abnormal. Exceptional rains fell late during winter, early during spring, and again in autumn, while the usual high rainfall period during midsummer was abnormally dry. As a result, the pasture growth season was an extended one. Temperatures too were

TABLE 2.

Number.	Date.	Hours of the Day.																						
		1	2	3	4	5	6	7	8	9	10	11	*Noon* 12	1	2	3	4	5	6	7	8	9	10	11	*Mid-night* 12
6964	17/1/40	.	.	.	.	○	⊕	+	⊕	⊕	⊕	✧	.	.	.	.	.	.	.	.	.	.	.	.	.
8012	20/1/40	.	○	.	.	.	○	○	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	✧	.	✧	✧	✧	✧	✧	.
6925	17/1/40	.	.	.	.	.	.	.	.	○	.	○	.	.	.	○	○	.	○	.	.	.	.	.	.
	18/1/40	○	.	.	.	○	○	○	○	○	○	.	○	○	○	○	○	.	.	○	.	.	.	○	○
	19/1/40	○	.	.	.	○	○	○	○	○	○	○	○	○	○	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
	20/1/40	+	+	.	.	.	⊕	✧	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6883	28/1/40	−	M.	○	○	M. ○	○	M.	M.	.	.	M.	.	.	.	.	M.	M. ○	⊕	⊕	⊕	⊕	⊖	⊕	⊕
	29/1/40	⊕	✧	✧	✧	✧	✧	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8010	3/2/40	.	.	.	.	.	M. ○	○	+	.	.	✧	.	.	.	⊕	+	+	⊕	✧	✧	.	.	.	.

unusual. Throughout the season maximum temperatures were considerably lower than during average years, and minimum temperatures considerably higher. Relative humidity figures showed the same tendency as the rainfall data and like them, favoured an early and prolonged pasture growth season. Climatically therefore the Armoedsvlakte environment, although somewhat subnormal in terms of rainfall during the actual period of hourly observations, must be regarded in terms of the 1939-1940 season as a whole, as having been exceptionally favourable to both plant and animal life.

According to du Toit, Louw and Malan (1940) an 800 lb. bovine requires 16 pounds of dry matter per day and in order to obtain its normal growth requirements from its grazing, the pasture must contain (on absolute dry matter basis) at least:

7·00 per cent. Protein.
0·14 per cent. Phosphorus.
0·16 per cent. Calcium.
0·02 per cent. Sodium.
0·07 per cent. Chlorine.

The pasture analyses in Table No. 3 show that the Armoedsvlakte vegetation as eaten by the cattle, is particularly deficient in phosphorus throughout the year; it is also relatively deficient in sodium and contains insufficient protein for normal growth requirements during 7 months per year. Since all cattle on the farm, except the "controls", receive an adequate bonemeal supplement and all cattle, including "controls", have daily access to salt licks, the protein deficiency is the only one which needs comment. Table No. 3 shows that during spring and autumn of the 1939-1940 season the pasture contained considerably more protein than during average seasons, but that during January and February it contained not only a subnormal but an insufficient amount.

Notwithstanding this, it seems justified to conclude on account of the early and extended pasture growth season and temperate climatic conditions which prevailed, that the nutritional environment, during the 1939-1940 season, was better than during an average season, and that the functional reaction of the experimental heifers to the prevailing conditions was also as good as, if not better than during average seasons.

To determine the correctness of this conclusion, the body weight curves of the experimental heifers were plotted against comparable average body weight curves of all the heifers born during the 1935, 1936, and 1937 calving seasons. From Graph No. 1, it will be seen that during the first 12 months (when the heifers were from 6 to 18 months of age), the experimental group curves fit the average curves closely. From July 1939 until the end of the 1939-40 season, the curves show a general diverging tendency, indicating that due to better than average environmental conditions, the experimental heifers developed more rapidly than usual, i.e., were functionally more active. Although this statement holds good for the season as a whole, it will be noticed that the curves of the experimental groups

TABLE No 3

TABLE

Environmental conditio

Month.	Rainfall in Inches.			Average Monthly Temperatures.				Average Monthly Relative Humidity.	
				Maximum.		Minimum.			
	Average.		1940.	Average.	1940.	Average.	1940.	Average.	1940.
July	1·20	0·04	3·33 1·53	76·8	63·2	22·3	36·8	59·0	79·0
August		0·07	0·67	84·7	69·7	25·3	37·8	51·6	66·0
September		0·40	0·065	92·3	76·0	30·0	41·6	43·6	49·0
October		0·69	1·06	96·7	83·0	39·3	52·2	43·9	55·0
November	9·73	1·89	6·53 0·97	98·4	85·3	44·8	55·9	50·0	51·0
December		2·03	1·49	100·1	91·9	49·2	59·9	51·6	46·0
January		2·94	2·52	101·1	89·8	53·5	60·6	57·3	49·0
February		2·87	1·55	97·7	89·4	51·9	61·8	63·0	57·0
March	5·14	3·22	6·92 4·25	93·3	81·8	48·0	57·6	73·6	74·0
April		1·31	2·27	87·7	76·1	38·0	48·2	67·9	71·0
May		0·55	0·36	82·1	72·0	29·4	39·3	63·5	67·0
June		0·06	0·04	77·7	67·7	22·3	34·1	61·6	63·0
Totals	16·07		15·77	—	—	—	—	—	—

*Note.—The meteorological averages are for the period 1919-1936. The pasture analysis averages are for the

TABLE No. 3.*(cont.)*

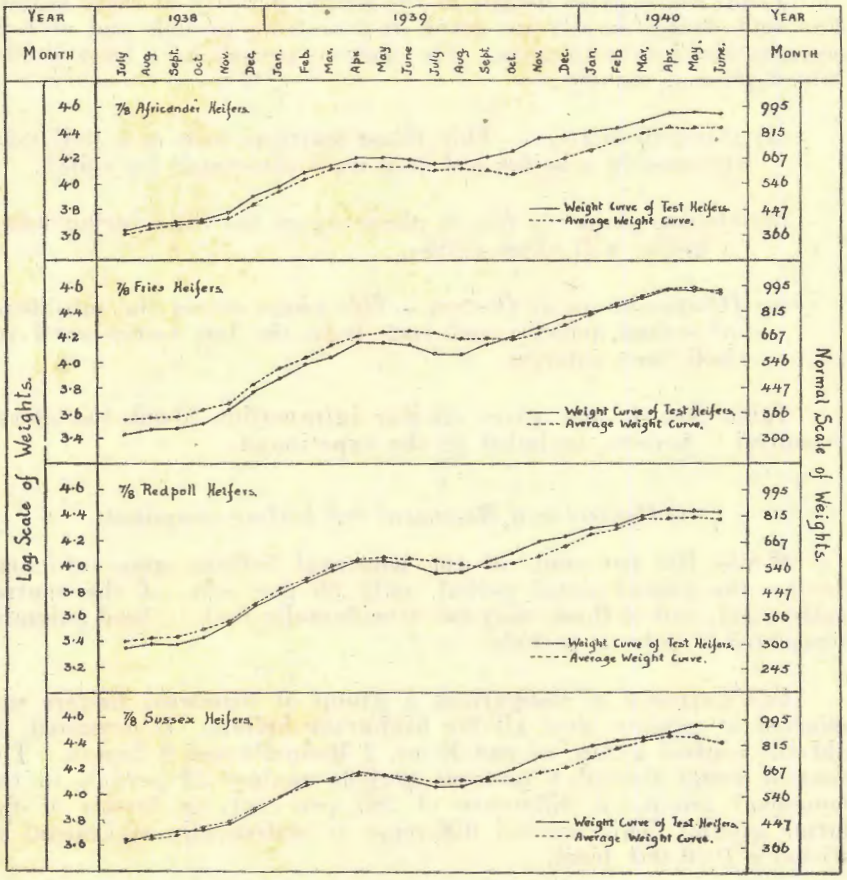
*ronmental conditions at Armoedsvlakte.**

ANALYSIS OF PASTURE AS EATEN BY CATTLE—(IN PERCENTAGES ON ABSOLUTE DRY BASIS).													
Phosphorus.		Crude Protein.		Calcium.		Sodium.		Chlorine.		Crude Fibre.		HCl, Sol. Ash.	
Average.	1940.	Average.	1940.	Average.	1940.	Average.	1940.	Average.	1940.	Average.	1940.	Average.	1940.
0·045	0·053	4·17	4·79	0·51	0·62	0·013	0·026	0·079	0·027	35·6	38·2	2·18	2·04
0·035	0·056	4·21	6·50	0·57	0·66	0·015	0·023	0·086	0·132	35·2	33·1	2·34	2·65
0·049	0·059	4·77	6·70	0·44	0·45	0·018	0·028	0·124	0·169	34·5	33·1	2·25	3·47
0·073	0·078	6·80	7·90	0·45	0·45	0·018	0·022	0·138	0·190	34·0	31·9	2·46	3·07
0·079	0·066	7·19	5·70	0·48	0·52	0·019	0·029	0·180	0·208	34·4	31·9	2·76	2·76
0·103	0·078	10·21	7·40	0·50	0·48	0·023	0·021	0·309	0·212	31·8	26·9	3·52	3·12
0·091	0·066	7·66	6·50	0·51	0·53	0·021	0·029	0·311	0·283	34·8	32·0	3·40	2·93
0·091	0·064	8·26	6·60	0·54	0·43	0·019	0·024	0·250	0·235	32·4	32·3	3·33	3·05
0·085	0·090	7·82	9·40	0·51	0·38	0·017	0·029	0·210	0·218	33·6	30·2	3·05	3·30
0·081	0·070	7·01	7·90	0·62	0·61	0·018	0·030	0·180	0·239	33·6	31·5	3·32	4·18
0·061	0·047	5·92	5·60	0·62	0·62	0·016	0·023	0·160	0·084	34·0	33·7	2·91	2·70
0·048	0·046	4·46	6·10	0·51	0·72	0·013	0·024	0·170	0·142	34·8	32·3	2·36	3·25
—	—	—	—	—	—	—	—	—	—	—	—	—	—

averages are for the period 1932-1940. The figures given under the column "1940" are for the period July, 1939, to June, 1940.

all flatten out somewhat during the actual period of hourly observations. The question therefore arises whether during this period of temporary subnormal rainfall and of crude protein deficiency, the functional activity of the experimental heifers,—including their sex activity,—diminished proportionally to their growth rate, and whether this reduction in functional intensity brought them to below average sexual activity for January and February. It is not possible to answer this question. Nevertheless it appears reasonable to assume, because of the excellence of the season as a whole, that *the heifers were functionally well within the range of normality during the experimental period*, i.e., for the months of January and February, 1940.

GRAPH I.—WEIGHTS.



VI. EXPERIMENTAL RESULTS AND DISCUSSION.

All the bonemeal fed heifers came into oestrus during the experimental period. Five of the heifers (i.e. 8·5 per cent.) completed 3 oestrous periods,—49 heifers, (72·9 per cent.) completed

2 oestrous periods, and the remaining 11 heifers (18·6 per cent.) passed through only one period of heat. For purposes of statistical analysis it was decided to use the data of only those heifers which completed 2 oestrous periods. The data of the 11 grade heifers with only one period and the last oestrus of the 5 heifers with 3 completed periods were therefore discarded. Acting on the same basis, the data of the purebred Redpoll and purebred Sussex heifers had to be excluded, since these groups were reduced respectively to 5 and 2 animals.

The comparative type and breed studies therefore became confined to groups of high grade $\frac{7}{8}$th and $^{15}/_{16}$th bred Afrikaner, Fries, Redpoll and Sussex heifers.

Table No. 4 gives details of the sexual activity of these heifers. For each heifer details are given of 2 oestrous periods and of 1 di-oestrous and 1 ovarian cycle. The oestrous periods have been divided into 3 phases, namely:—

(*a*) *Onset of Oestrus.*—This phase starts as soon as a bull takes interest in a heifer and lasts until she stands for coitus.

(*b*) *Oestrus proper.*—Which phase covers the time during which a heifer will allow coitus.

(*c*) *Disappearance of Oestrus.*—This phase covers the subsidence of sexual activity and lasts from the last coitus until the bull loses interest.

Table No. 4, also gives similar information about the eleven "control" heifers, included in the experiment.

(*a*) *Control and Bonemeal fed heifers compared.*

While 100 per cent. of the bonemeal heifers came into heat during the experimental period, only 36 per cent. of the control heifers did, and of these, only two (incidentally both $^{3}/_{4}$ bred animals) completed 2 oestrous periods.

For purposes of comparison a group of bonemeal heifers was selected at random from all the highgrade heifers. It consisted, as did the control group, of one Fries, 2 Redpolls and 8 Sussex. The control group showed 6 oestrous periods against 23 periods in the bonemeal group,—a difference of 283 per cent. in favour of the latter group. This marked difference is statistically significant to Fisher's P=0·001 level.

At Armoedsvlakte therefore, the aphosphorosis amongst the control heifers manifested itself also in subnormal oestrous activity, either by directly depressing the oestrous function, or indirectly by retarding sexual maturity. The tests now in progress seem to indicate that the latter explanation is correct.

Table No. 4.

Breed.	Numbers of Experimental Animals.	Grade.	Bonemeal or Control.	Age on 1/3/40 (in days).	Live Weight on 1/3/40.	1st Oestrus.				Duration of Di-oestrus.	Duration of Ovarian Cycle.	2nd Oestrus.			
						Date of Onset.	Duration of Onset.	Duration of Oestrus.	Duration of Disappearance.			Date of Onset.	Duration of Onset.	Duration of Oestrus.	Duration of Disappearance.
					lb.		Hours.	Hours.	Hours.	Days.	Days.		Hours.	Hours.	Hours.
Afrikaner	6881	7/8	B.M.	831	780	11/1/40	3	1	18	20·1	20·1	1/2/40	18	5	10
	6884	7/8	,,	828	931	11/1/40	12	13	10	20·0	20·6	1/2/40	10	11	8
	6885	7/8	,,	828	1,002	13/1/40	13	14	4	20·6	21·2	2/2/40	23	12	2
	6892	7/8	,,	818	980	11/1/40	2	4	7	19·6	19·8	30/1/40	21	9	6
	6964	7/8	,,	818	943	16/1/40	1	5	1	19·5	19·7	5/2/40	7	2	7
	6967	7/8	,,	816	931	22/1/40	1	11	1	19·3	19·8	11/2/40	15	3	6
	6984	7/8	,,	802	1,034	5/1/40	1	9	3	21·5	21·9	27/1/40	2	6	7
	8010	7/8	,,	782	885	13/1/40	4	10	3	20·5	20·9	3/2/40	9	4	2
	8013	7/8	,,	780	812	13/1/40	6	9	0	19·5	19·9	2/2/40	0	10	0
	8016	7/8	,,	778	799	13/1/40	4	6	10	18·9	19·1	2/2/40	2	6	9
	8024	7/8	,,	764	799	8/1/40	1	15	1	19·2	19·5	27/1/40	4	7	1
	8012	15/16	,,	780	745	18/1/40	13	9	17	20·6	21·0	9/2/40	8	3	11
	8022	15/16	,,	774	887	11/1/40	24	9	1	19·5	19·8	1/2/40	0	12	4
Averages	13			800	887						20·2				
Fries	6922	7/8	B.M.	843	897	6/1/40	10	10	7	19·9	20·3	27/1/40	12	14	11
	6923	7/8	,,	842	849	6/1/40	17	4	17	21·2	21·4	27/1/40	8	11	0
	6925	7/8	,,	840	987	17/1/40	14	16	1	17·7	18·4	6/2/40	8	15	15
	6933	7/8	,,	836	917	4/1/40	4	16	6	19·8	20·5	24/1/40	21	1	0
	6941	7/8	,,	832	964	5/1/40	17	16	2	17·8	18·4	24/1/40	11	17	3
	6968	7/8	,,	815	893	4/1/40	0	11	10	19·6	20·1	25/1/40	8	8	12
	6983	7/8	,,	804	952	6/1/40	6	14	0	17·0	17·6	24/1/40	1	15	2
	6989	7/8	,,	797	853	19/1/40	12	16	3	19·9	20·6	10/2/40	8	13	1
	6974	15/16	,,	813	818	14/1/40	0	10	7	20·2	20·6	2/2/40	1	3	10
Averages	9			825	903						19·8				

TABLE No. 4 (*continued*).

Breed.	Numbers of Experimental Animals.	Grade.	Bonemeal or Control.	Age on 1/3/40 (in days).	Live Weight on 1/3/40.	1st Oestrus.				Duration of Di-oestrus.	Duration of Ovarian Cycle.	2nd Oestrus.			
						Date of Onset.	Duration of Onset.	Duration of Oestrus.	Duration of Disappearance.			Date of Onset.	Duration of Onset.	Duration of Oestrus.	Duration of Disappearance.
					lb.		Hours.	Hours.	Hours.	Days.	Days.		Hours.	Hours.	Hours.
Red-poll	6921	7/8	B.M.	846	828	7/1/40	9	15	0	19·1	19·8	26/1/40	14	22	14
	6928	7/8	,,	838	811	7/1/40	3	10	15	19·9	20·3	28/1/40	15	10	11
	6981	7/8	,,	805	831	16/1/40	12	16	5	18·4	19·1	4/2/40	8	16	7
	6992	7/8	,,	795	872	9/1/40	13	12	12	19·6	20·1	29/1/40	15	12	9
	6996	7/8	,,	788	836	21/1/40	5	17	7	19·0	19·7	20/2/40	1	19	2
	8103	7/8	,,	781	700	4/1/40	2	13	2	19·3	14·8	23/1/40	19	19	22
	8104	7/8	,,	781	774	21/1/40	0	14	7	19·5	20·1	10/2/40	1	13	4
	8107	7/8	,,	777	715	9/1/40	10	9	12	18·8	19·1	28/1/40	9	10	8
	8114	7/8	,,	767	819	23/1/40	0	14	1	20·4	21·0	13/2/40	1	14	0
	8116	7/8	,,	767	734	3/1/40	2	11	8	18·8	19·2	21/1/40	18	14	3
Averages	10			794	792						19·8				
Sussex	6932	7/8	B.M.	836	816	21/1/40	5	11	0	20·0	20·5	11/2/40	3	11	6
	6939	7/8	,,	832	896	12/1/40	4	5	5	22·8	23·0	3/2/40	2	4	5
	6944	7/8	,,	830	731	11/1/40	10	4	14	21·5	21·7	2/2/40	9	7	6
	6950	7/8	,,	826	951	20/1/40	14	13	3	19·5	20·0	8/2/40	8	4	6
	6955	7/8	,,	823	929	23/1/40	7	9	8	21·3	21·7	13/2/40	6	12	5
	6959	7/8	,,	822	887	11/1/40	3	15	7	18·2	18·8	30/1/40	2	14	2
	6969	7/8	,,	814	978	11/1/40	10	10	2	19·2	19·7	31/1/40	0	11	2
	6879	7/8	,,	802	956	4/1/40	0	7	10	18·9	19·2	23/1/40	0	7	5
Averages	8			823	893						20·6				
Fries	6979	7/8	Control	807	536	—	—	—	—	—	—	—	—	—	—
Redpoll	6949	3/4	,,	825	522	12/1/40	21	2	6	19·7	19·7	31/1/40	15	5	11
	8119	7/8	,,	788	519	—	—	—	—	—	—	—	—	—	—
Sussex	6896	3/4	,,	811	636	17/1/40	5	11	2	20·1	20·5	6/2/40	1	6	8
	6874	7/8	,,	832	631	—	—	—	—	—	—	—	—	—	—
	6875	7/8	,,	832	486	—	—	—	—	—	—	—	—	—	—
	6878	7/8	,,	833	550	28/1/40	21	5	8	—	—	—	—	—	—
	6890	7/8	,,	818	726	—	—	—	—	—	—	—	—	—	—
	8002	7/8	,,	801	615	7/2/40	3	11	4	—	—	—	—	—	—
	8030	7/8	,,	758	554	—	—	—	—	—	—	—	—	—	—
	8026	15/16	,,	762	399	—	—	—	—	—	—	—	—	—	—
Averages	11			806	561										

(*b*) *Type and Breed comparisons.*

All data used in the comparison of types and breeds were analysed statistically. In the tables which follow, significant differences are shown in thick print, and the degree of their significance indicated (according to Fisher's, P = 0·05, = 0·01 or = 0·001) by a 5, 1, or 01 within brackets above and to the right of the figures in thick print,

(i) *Duration of the Ovarian Cycle.*—i.e., The period from the onset of one oestrous period to the commencement of the next period.

Table No. 5 supplies details, concerning the average length of the ovarian cycle for the indigenous and exogenous type groups and for each of the four breedgroups. It also gives the actual differences between the type and breedgroup averages.

TABLE NO. 5.

Duration of Ovarian Cycle.

(Average duration in days).

Types and Breeds.	Exogenous Type (Fries, Redpoll and Sussex).	Fries.	Redpoll.	Sussex.
	20·0	19·8	19·8	20·6
Afrikaner (Indigenous type).....	20·2	20·2	20·2	20·2
Differences.....	− 0·2	− 0·4	− 0·4	+ 0·4
	—	—	19·8	20·6
Fries.....	—	—	19·8	19·8
Differences.....	—	—	0·0	+ 0·8
	—	—	—	20·6
Redpoll.....	—	—	—	19·8
Difference.....	—	—	—	+ 0·8

No differences existed either between type or breedgroup averages,—in fact, the average duration of their ovarian cycles is strikingly similar. The Fries and Redpolls averaged 19·8 days; the Afrikaners 20·2 days and the Sussex 20·6 days. The average for the exogenous type group, i.e.,for the combined Fries, Redpoll and Sussex groups was 20·0 days.

Limital variations within each breedgroup (on Table 4) were:—

(*a*) Afrikaner	19·1 to 21·9 days.	17·6 to 23 days.
(*b*) Fries	17·6 to 21·4 days.	
(*c*) Redpoll	19·1 to 21·0 days.	
(*d*) Sussex	18·8 to 23·0 days.	

All these ranges fall well within the standard range of 17-24 days quoted in textbooks. Andersen (1936) found that in Kenya too, the range of ovarian cycle duration conforms to this textbook standard, and it appears therefore as if environment does not influence the duration of the ovarian cycle to any significant extent.

(ii) *Duration of Di-Oestrus.*—Because this period is very similar in duration to the ovarian cycle, i.e., ovarian cycle duration minus the duration of oestrus (in this test up to 22 hours), it was found that what applied to the one also applied to the other. Consequently no special comments are necessary.

(iii) *Duration of Oestrus proper.*—i.e., The period during which heifers allow coitus to take place.

Because of the hourly intervals between tests, the period of oestrus proper was reckoned from half an hour before the first until half an hour after the last test during which coitus occurred.

In Table No. 6, the average duration of oestrus is given for the individual type and breed groups of experimental heifers. Significant differences are shown in thick print.

TABLE No. 6.

Duration of Oestrus.

(Average in hours).

Types and Breeds.	Exogenous Type (Fries, Redpoll and Sussex).	Fries.	Redpoll.	Sussex.
	11·74	11·67	14·00	9·00
Afrikaner (Indigenous type).....	7·88	7·88	7·88	7·88
Differences.....	+ **3·86**(1)	+ **3·79**(5)	+ **6·12**(1)	+ 1·12
	—	—	14·00	9·00
Fries.....	—	—	11·67	11·67
Differences.....	—	—	+ 2·33	+ 2·67
	—	—	—	9·00
Redpoll.....	—	—	—	14·00
Difference.....	—	—	—	− **5·00**(5)

The group averages ranged from 7·88 hours in the Afrikaners, to 14·00 hours in the Redpolls. This range is much below the standard range of 18 to 24 hours, given in textbooks, in fact 81 oestrous periods, or 94 per cent. of the 86 periods included in Table No. 4, lasted less than 18 hours. On the other hand, the range at Armoedsvlakte was much higher than that established for Zebus in Kenya by Andersen (1936).

It would appear, therefore, as if the duration of oestrus proper is influenced by environmental forces. The results show, that during the summer months at Armoedsvlakte, even the highgrade heifers of European breeds, had a much shorter oestrus than has been accepted as normal for them.

Coming to a comparison of types, Table No. 6 shows an average oestrous duration for the Fries, Redpoll and Sussex groups, of 11·74 hours while that of the Afrikaner group was 7·88 hours. The difference of 3·86 hours is significant to Fisher's $P = 0·01$ level. It will be noticed, however, that although the Afrikaner group has a significantly shorter average oestrous period than the Fries and Redpoll groups, there is statistically no difference between the average duration of oestrus in Sussex and Afrikaner heifers. This fact nullifies, to a great extent, the biological significance of the difference found between indigenous and exogenous type groups.

Table No. 6, supplies no evidence of differences in the average oestrous periods between milk, dual purpose and beef types of cattle. There is no difference between Fries and Redpolls (milk and dual purpose) or between Fries and Sussex (milk and beef).

The significant differences which do occur, must be regarded as breed differences. Thus the Afrikaner heifers on the average remained in oestrus proper for a shorter period than the Redpolls. As already stated there was no difference between the Afrikaner and Sussex, Fries and Sussex, and Fries and Redpoll groups.

The results of the investigation have therefore shown up certain breed differences; they indicate a possible difference between indigenous and exogenous types, but have failed to demonstrate differences between functional types.

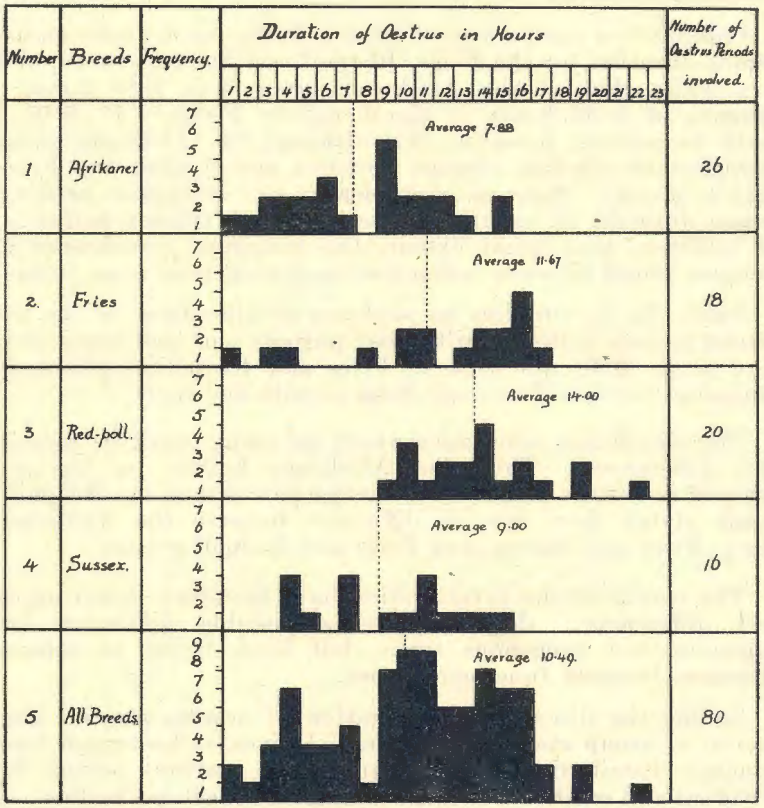
So far the discussion on duration of oestrus proper, has been in terms of group averages. Diagram 1 gives, in histogram form, the frequency distributions of the duration of oestrous periods for the individual and combined breedgroups of bonemeal fed heifers. In the histogram for the combined groups (No. 5), the "mean" and "mode" fall together, indicating for the whole of the experimental population a regularly parabolic distribution curve. In the Redpoll histogram the mean and mode also coincide, but in the Afrikaner histogram they are separated by a full hour and in the Fries by over 4 hours. In the Sussex histogram no mode shows up at all. Although it is of course possible that a tendency exists in the Afrikaner and Fries breeds to an irregular distribution of oestrous period durations, it is far more likely, in terms of histogram No. 5, that the separation of mean and mode in the present investigations, was due to the limited data available. The absence of a mode in histogram, No. 4,

must be ascribed, possibly to an even greater extent, to the same cause. In other words, the available data, although sufficient to demonstrate *some* type and breed difference, were probably not sufficient to show up all such differences. It is hoped that the hourly tests now in progress (October, 1940), upon the same experimental population, will supply the missing information.

DIAGRAM No. 1.

Frequency Distribution.

Duration of Oestrus.



It has been mentioned that, whenever the vasectomised bulls lost interest in the heifers, they were replaced by aproned bulls. While " teaser " bulls actually serve heifers, aproned bulls mount but cannot serve. The observers in charge of the hourly tests reported that with aproned bulls heifers seemed to remain on heat longer than when tested with " teasers ". This contention is being tested out in the hourly test period now in progress, and so far the indications are that the observation made is correct. The duration of oestrus appears to be shorter when coitus takes place.

The data on which our present discussion is based is of " mixed " origin, i.e., obtained from the use of both " teaser " and aproned bulls. As such the values for the duration of the oestrus lie in between those obtained with " teaser " and with aproned bulls.

(iv) *Duration of onset and of disappearance of oestrus.*—Whereas the duration of oestrus proper, is a fixed period, i.e., from the first to the last coitus, the duration of onset and of disappearance of oestrus is very indefinite, and difficult to determine.

In the present investigation, as stated, " onset " was reckoned to commence as soon as a bull began taking interest in a heifer, and " disappearance " taken to terminate when the bull finally lost interest. This criterion, however, cannot be rigidly applied. This is evident from the example of an oestrus period given in Table No. 7.

The bull first showed interest at 12 noon on January 18th, but then not again for 16 hours, until 4 a.m. on January 19th. Another interval, this time of 15 hours, followed. From 7 p.m. on the 19th of January the bull showed continuous interest and oestrus proper set in. After the last coitus at 4 p.m. on January the 20th, the bull maintained more or less continuous interest till 9 a.m. on January the 21st, and thereafter showed interest only once more, i.e., after 11 hours, at 8 p.m., on the same day.

It is very doubtful whether the two isolated cases of interest prior to service and the last case of interest after termination of oestrus proper, form part of the phases of onset and of disappearance of oestrus.

In determining therefore the duration of these phases, isolated single or double cases of interest by the bull, separated from subsequent cases during onset, and from succeeding cases of interest during the disappearance of oestrus by more than 6 hours, were discarded.

Table No. 8 gives details concerning the average duration of the onset and disappearance of oestrus in the various type and breed groups. Although the latter groups differed up to 3·59 hours (69 per cent.) in the average duration of onset and 2·45 hours (49 per cent.) in that of the disappearance of oestrus, these differences were not statistically significant, on account of the marked variation in duration within the breed groups (see Table 4).

Table No. 8 shows, that under the conditions prevailing at Armoedsvlakte during the investigation, the onset of the oestrous phase averaged from 5·19 hours in the Sussex group, to 8·78 hours in the Fries group, with an average for the combined exogenous heifer groups of 7·37 hours. This was only 5·4 minutes shorter than for the indigenous (Afrikaner) heifers.

The duration of disappearance of oestrus was in general shorter but not significantly so than the duration of onset. It varied from 5 hours in the Sussex group to 7·45 hours in the Redpoll group. The indigenous and exogenous type averages were again very similar i.e., 5·73 and 6·17 hours respectively.

Table No. 7.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
18/1/40	·	·	·	·	·	·	·	·	·	·	·	○	·	·	·	·	·	·	·	·	·	·	·	·
19/1/40	·	·	·	⊙	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊙	○	⊙	○	⊙	·
20/1/40	·	○	·	·	·	○	⊙	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	✧	·	✧	✧	✧	✧	✧	✧
21/1/40	✧	✧	·	✧	·	✧	·	·	✧	·	·	·	·	·	·	·	·	·	·	✧	·	·	·	·

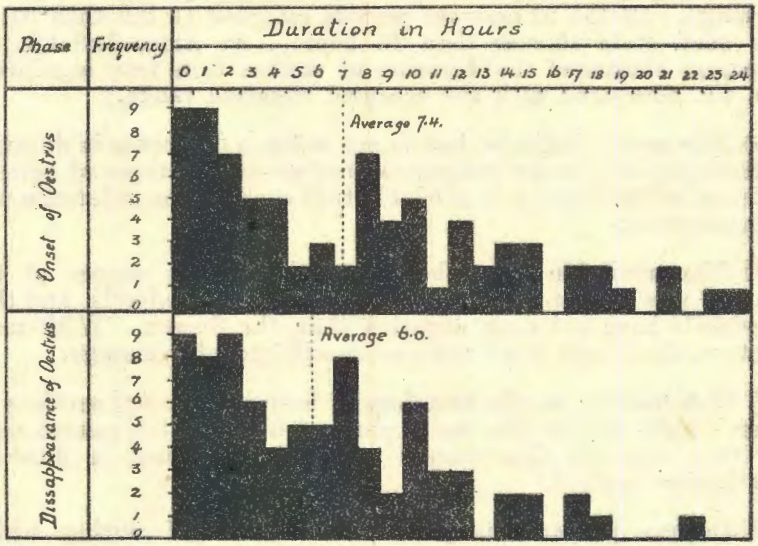
Table No. 8.

Types and Breeds.	Duration of Onset of Oestrus. (Average duration in hours).				Duration of Disappearance of Oestrus. (Average duration in hours).			
	Exogenous Type. (Fries, Redpoll and Sussex).	Fries.	Redpoll.	Sussex.	Exogenous Type.	Fries.	Redpoll.	Sussex.
Afrikaner (Indigenous type)	7·37	8·78	7·85	5·19	6·17	5·78	7·45	5·00
	7·46	7·46	7·46	7·46	5·73	5·73	5·73	5·73
Differences	−0·09	+1·32	+0·39	−2·27	+0·44	+0·05	+1·72	−0·73
	—	—	7·85	5·19	—	—	7·45	5·00
Fries	—	—	8·78	8·78	—	—	5·78	5·78
Differences	—	—	−0·93	−3·59	—	—	−0·67	−0·78
	—	—	—	5·19	—	—	—	5·00
Redpoll	—	—	—	7·85	—	—	—	7·45
Difference	—	—	—	−2·66	—	—	—	−2·45

Diagram No. 2, gives, in histogrammatic form, the frequency distribution of the duration periods of both the onset and disappearance of oestrus.

As could be expected from the fact that they constitute the commencement and termination phases of the oestrous period, their distributions are not parabolar, but linear, with a dominant tendency towards short durations of onset and disappearance. This supports the contention that isolated cases of interest in a heifer by a bull, separated by intervals of many hours from subsequent or preceding cases of interest do not form part of the onset or disappearance phenomena of oestrus.

DIAGRAM No. 2.



VI. CONCLUSIONS AND SUMMARY.

(*a*) To obtain information concerning the sexual activity of cattle under the environmental conditions prevailing in the north western, semi-arid, summer rainfall areas of the Union of South Africa, a series of sex-physiological researches are being carried out at the Veterinary Research Station, Armoedsvlakte, near the town of Vryburg, in the Cape Province.

(*b*) This article reports upon the sexual activity of groups of 2 year old, ¾th bred, Afrikaner, Fries, Redpoll and Sussex heifers, which were tested for oestrus day and night at one hourly intervals from January 3rd to February 15th, 1940, ie., during full summer conditions.

(*c*) The experimental animals, the prevailing environmental conditions and the technique employed to record sexual activity, are described.

(*d*) The results of the investigation show that the bonemeal fed heifers were sexually much more active than the heifers which received no phosphatic supplement. Nutritional deficiency therefore affected sexual activity.

(*e*) The duration of the ovarian cycle, not only of the groups, but also of the individual experimental heifers, fell within the standard range of 17 to 24 days, as found in textbooks. The Armoedsvlakte environment did not influence the duration of the ovarian cycle.

(*f*) The standard range for the duration of oestrus proper is given in textbooks as 18 to 24 hours. During the investigation, the average duration for the Afrikaner group was 7·88 hours; for the Fries 11·67 hours; for the Redpolls 14·00 hours, and for the Sussex 9·00 hours; for the exogenous breed groups together it was 11·74 hours. Of the 86 oestrous periods recorded no less than 81, or 94 per cent. were shorter than 18 hours. At Armoedsvlakte the environment shortened the duration of oestrus to a very significant degree, i.e. compared with the accepted standard range.

(*g*) The results indicate, but do not prove, a difference in duration of oestrus proper between indigenous and exogenous types of heifers. With more information it is probable that such a type difference will be demonstrated.

(*h*) The available data show that the oestrus proper of the Afrikaners was shorter than that of the Fries and Redpolls, and that the Redpolls have a longer duration than the Sussex. With more data, other significant breed differences will probably emerge.

(*j*) Observations on the reactions of heifers to actual services by " teaser " bulls and on the use of aproned bulls (which cannot serve the heifers) suggests that oestrus proper is shortened in duration by the former method.

(*k*) Oestrus proper was preceded by a period during which sexual activity waxed and was succeeded by a phase during which activity waned. The period of " onset " of oestrus varied from 5·19 to 8·78 hours in the individual breedgroups, and the average period of " disappearance " from 5·00 to 7·45 hours. No breedgroup differences were found. In both phases, the frequency distribution showed a dominant tendency to short durations.

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APPENDIX.

The following photographs show the types of heifers used for observation:—

Fig. 1.—Afrikaner Heifer.

Fig. 2.—Group of Afrikaner Heifers.

Fig. 3.—Friesland Heifer.

Fig. 4.—Group of Friesland Heifers.

Fig. 5.—Sussex Heifer.

Fig. 6.—Group of Sussex Heifers.

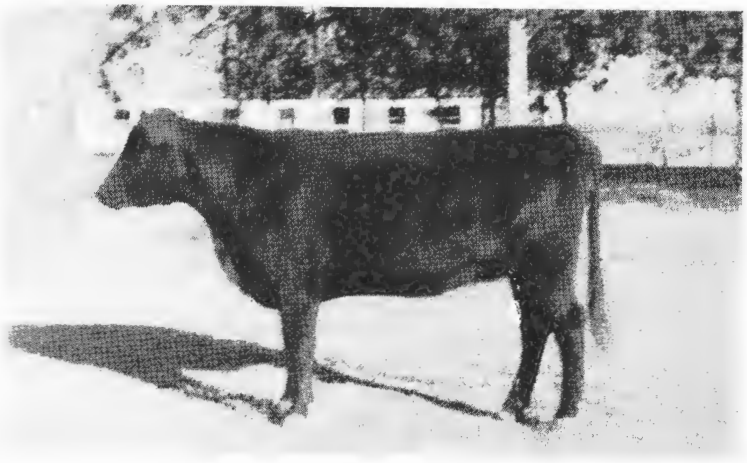

Fig. 7.—Red Poll Heifer.

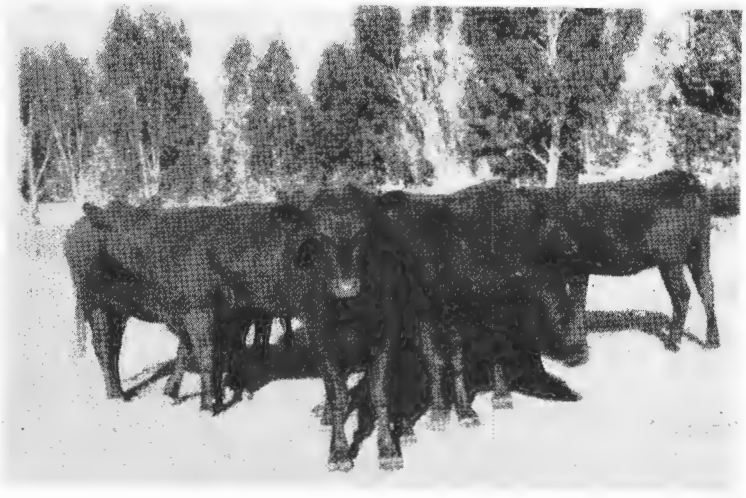

Fig. 8.—Group of Red Poll Heifers.

Fig. 9.—Pure-bred Red Poll Heifer.

Fig. 10.—Group of Pure-bred Red Poll Heifers

Fig. 11.—Red Poll Heifer—Control.

Fig. 12.—Two vasectomised teasers with heifers in teasing pan. Other heifers waiting to be tested.