FERTILITY AND INFERTILITY OF THOROUGHBRED MARES UNDER THE ENVIRONMENTAL CONDITIONS PREVAILING IN THE KARROO MIDLANDS OF SOUTH AFRICA

by

CHARLES WILLEM ALBERT BELONJE

Thesis submitted in partial fulfilment of the requirements for the degree of

D O C T O R I N V E T E R I N A R Y S C I E N C E

in the

Faculty of Veterinary Science

UNIVERSITY OF PRETORIA

P R E T O R I A

JANUARY, 1958

To my Father,

to whom this work is gratefully dedicated.

I N D E X

(3)/.....

G/.....

Thoroughbred Racing and Breeding is an established industry in South Africa. The racing centres are situated mainly in and around the cities and larger towns, but the breeding centres are isolated and confined to a few selected areas in the Union.

Such an area is the Karroo Midlands, where several Studs have firmly established themselves and gained fame for the area as a Thoroughbred breeding centre.

Before any critical analysis of the reproductive function of the thoroughbred mare is possible it is necessary to examine the background of the industry and the reasons for its commencement here. Such an examination should determine if the environmental factors operating, i.e. climatic, nutritional, etc., assist or prevent high fertility under natural circumstances. An environment adverse to high fertility is not necessarily a bar to the establishment of a successful thoroughbred stud should the area be particularly suited to the rearing of outstanding progeny.

1. INTRODUCTION.

Wyndham (1924) and Robertson (1945) in reviewing the history of the Turf in South Africa state that the first English Thoroughbred reached the Cape in 1792.

Although a certain amount of racing took place during that period it was not until Lord Charles Somerset arrived in South Africa as Governor of the Cape Colony, that the racing of Thoroughbreds was established. In 1814 he appears to have been instrumental in getting certain Rules and Regulations laid down to govern the races held under the auspices of the South African Turf Club, which exist to the present day. These 'Rules and Regulations' were the prelude to the present Jockey Club of South Africa, which, however, came into existence at a much later date.

The earliest studs were all situated in the vicinity of the Cape. Schreuder (1915) in discussing the difficulties in breeding horses in those days, states that several infectious diseases such as Glanders, Mange and Biliary were imported, but never caused great loss or serious trouble. The first recorded outbreak of Horsesickness was in 1719, or sixty-seven years after the first ordinary horses had been imported into the Cape Colony. During that year it swept away some seventeen hundred horses. The disease recurred periodically taking great toll in horse life. In 1763 an estimated 2,500 horses succumbed; during 1854-1855 some 65,000 horses and mules out of a total of 169,583 died from the disease. In 1870 another 70,000 were carried off, and during 1891-93 over 100,000 horses and mules or almost 1/5th of the total number of horses and mules given as 540,492 perished from the disease.

It was natural that when the interior of Southern Africa was opened horsebreeding soon centred in those areas comparatively free of the disease. The result was that the Thoroughbred Studs at the Cape soon disappeared and new studs started in other areas.

Lichtenstein quoted by Schreuder (1915) describes how the Karroo with its dry air and rolling plains of grass on rich soils, with a fair percentage of lime, proved very adaptable to successful commercial

horsebreeding/...

horsebreeding. He found that large troops, often consisting of over 300 mares, were quite frequently encountered. The area he describes comprises today the Districts of Calvinia, Victoria West, Richmond, Colesberg, Middelburg, Hanover, etc. and was stated to be eminently suited for the rearing of horses as it is a high plateau region, with never failing streams and rolling pastures of excellent grass. The high altitude of several of the flat-topped hills was regarded as a safeguard against Horsesickness.

There can be little doubt that the transference of Thoroughbred breeding to the interior, in particular to the Karroo Midlands, was primarily due to the usual absence of Horsesickness and to the fact that ordinary commercial horsebreeding under veld conditions proved most successful.

From small beginnings Thoroughbred Racing and Breeding has become a well established and organised industry. The Cape Times reported on 17th October, 1952, that all in all the Thoroughbred Stud Farms are worth about £4,000,000. About 4,000 Europeans and 5,000 non-Europeans are employed in racing, training and stud farming and approximately £1,000,000 paid out in stake money in South Africa each year. In 1949 there were about 4,050 Thoroughbreds, worth about £2,000,000 taking part in racing in the Union. The 450 stallions and 3,850 mares at stud in South Africa produce about 1,800 living foals each year, but it is estimated that only about three-quarters of these foals ever reach the race track.

2. OBJECT OF THIS STUDY.

The object of this study is to obtain specific information on several aspects of a well-established and specialised branch of live-stock farming of which very little is scientifically known in this country.

The origin and development of the Thoroughbred industry in South Africa as well as the factors which led to the establishment of several successful studs in the Karroo Midlands have been superficially

discussed/...

discussed and the reader is referred to the works of Schreuder (1915), Wyndham (1924) and Robertson (1945) for more detailed information.

Although the influence of the environmental conditions of this area upon the sex physiology of sheep has been discussed by Roux (1936), little or no information is available of its effects upon the fertility or otherwise of the Thoroughbred, for which this area is so justly famous.

One Thoroughbred stud was selected for the purpose of obtaining specific information on the sex physiology and psychology of Thoroughbred mares. These mares were subjected to systematic clinical examination during the breeding season of 1952, and all findings carefully recorded and compared with world literature on equine reproductive function.

During the course of these examinations it became apparent that certain mares would remain barren for that season if not assisted. Certain treatments were performed and the details recorded and discussed in the text. Although they may have disturbed what would have been the 'normal' course of the sexual cycle, they in themselves, assist in explaining reproductive function by their results.

Wherever possible the 1950 and 1951 oestrous cycles, service and foaling dates are reflected in each mare's record for comparison and analysis.

The work on this Thoroughbred Stud was authorised by the owner on condition that it would interfere as little as possible with the working arrangements and management of the farm. This explains certain inconsistencies, such as the serving of the mare WYNDSONG during an anovulatory heat.

3. THE BREEDING SEASON OF THE THOROUGHBRED IN SOUTH AFRICA.

a. The General Stud Book.

The General Stud Book (1949) issued by the Jockey Club of South Africa lays down the following procedure under Rule 120:-

"Horses shall take their ages from the undermentioned dates in the South African Racing year in which they are foaled:-

(a)/...

(a) Those sired South of the Line : from the first day of August.

(b) Those sired North of the Line : from the first day of August if born in South Africa, otherwise from the first day of January".

Note: The South African Racing Year is from 1st August to 31st July the year following.

The greatest demand by buyers in South Africa is for foals born as soon as possible after the 1st of August. Such foals are offered for sale as yearlings and are as a rule better grown than their contemporaries born later during the season. The peculiarity of this demand has created an artificial breeding season extending normally from about the 8th of September to about the middle of December. In the older and more established studs it is more usual to find the breeding season arbitrarily fixed from the 15th of September to the 15th of December. It is exceptional for Thoroughbred breeders to breed after the month of December. Such a procedure would mean that the foals dropped would be very much younger than their contemporaries and they would have little or no chance of winning any of the 2 or 3 year-old races. In addition the mare foals late in the season and if bred again would perpetuate the same mistake of producing another late foal with all its consequent drawbacks.

It is extremely rare to find a breeder retaining a late foal and allowing it to grow out on the farm and selling it as a two- or three-year-old. The general procedure is to dispose of all yearlings either by outright sale or lease, except those that may be injured at that particular time. Nevertheless they too are disposed of as soon as they have recovered. It is exceptional to encounter any 2 or 3 year-olds on the Studfarms, and any seen are as a rule those that have returned from the track for a period of rest, or a filly which has broken down and is returned for breeding.

With the demand for well-grown yearlings by buyers, who are most anxious to make a quick return on their capital outlay, it follows

that/.....

that the breeder is compelled to breed early foals. Where mares have not settled to services during December, they are allowed to skip until the next season and allowed to go barren. It follows that because of the limited breeding season, artificially created because of buyers demands, many mares are intentionally not bred, and although classed as 'barren' in the stud records of the Jockey Club, they are actually not infertile. Consequently the term 'barren', which is frequently encountered in publications dealing with equine breeding, does not imply that the mare is sterile.

b. Fertility of the Thoroughbred in South Africa.

Although accurate data on fertility of thoroughbreds are not available in South Africa certain figures have been published. So for instance Quinlan (1946) summarised the records of the various studs as follows:

TABLE 1. 1945/46.

	No. of Mares in Stud.	No. Pregnant	No. Aborted.	No. of foals born dead or alive at full term.	No. of Mares barren.
Total	3,837	2,702	221	2,481	1,135
Percentage	-	70.4	8.1	91.8	29.5

The S.A. Bloodstock Breeders Review of 1950 published the following figures obtained from the Jockey Club of S.A., in respect of the 1949 season, namely 1,630 foals registered from 2,968 mares reported as covered in 1948, i.e. 54.9 per cent.

The statistics in Table 2 are given in the same publication but refer only to stallions which covered ten or more mares in the 1948 season.

TABLE 2. 1948/49.

	No. of mares covered.	No. of foals registered.	No. of foals dead and slipped.	No. of mares barren.
Total	1,868	1,085	277	506
Percentage	-	58.1	14.8	27.1

The/...

The S.A. Bloodstock Breeders Review of 1951 reflect the following statistics published by the Jockey Club from their stud returns for the 1950 season. Out of 2,850 mares for which returns were made, there were 1,578 live foals registered, i.e. 55.4 per cent leaving 1,272 mares either 'barren' or with foals that did not survive.

The statistics in Table 3 are given in the same publication, but refer only to stallions which covered ten or more mares in the 1949 season.

TABLE 3 1949/1950.

	Mares covered	No. of foals registered.	No. of foals dead or slipped.	No. of mares barren.
Total	1,644	928	254	462
Percentage	-	56.4	15.5	28.1

Under Jockey Club Rule 353 Section (B) 8, application for registration of foals in "The Stud Book", has to be made annually between the 15th January and 31st May of the racing year (i.e. from 1st August to 31st July) in which the foal is born. The fee is 2/6 up to 31st May, £5 from the 1st June to 31st July, and £10 from 1st August to 31st December. No foal may be entered in "The Stud Book" if application for registration is received later than the 31st December of the racing year following that in which it was born.

The result of this rule is that although the foaling season starts from the 1st August and ends during December, registration of foals in "The Stud Book" is not permitted before the 15th of January of the same racing year. During the interval of birth of the foal and application for registration there is a certain percentage of foals which die or which are destroyed because of illness or accident. Such foals are therefore naturally never registered. Nevertheless the figures published by the Jockey Club are remarkably constant and details of two consecutive years are summarised in Tables 4 and 5.

TABLE/...

TABLE 4. 1948/1949.

Percentage foals registered from stallions covering 10 or more mares	58.1%
Percentage foals registered of all mares covered	54.9%

TABLE 5. 1949/1950.

Percentage foals registered from stallions covering 10 or more mares	56.4%
Percentage foals registered of all mares covered	55.4%

These figures indicate that the difference in the percentage of foals registered by stallions serving 10 mares or more, and the percentage of all foals registered in S.A., must lie with the smaller breeder. The bigger studs usually dispose of their difficult mares or 'shy' breeders, and these are as a rule bought up cheaply by the smaller breeder in preference to buying young healthy but unproven mares for whose progeny there is small demand.

The figures compiled by Quinlan in Table 1 are misleading in so far that the foaling percentage of 91.8 per cent is calculated on the number of pregnant mares instead of on the total number served. As the pregnancy percentage of 70.4 per cent was worked out on the total mares reflected, it indicates that all mares were covered. On that basis the foal-crop, i.e. 2,481 foals produced out of a total 3,837 mares will give a fertility percentage of 64.6.

Tables 4 and 5 give a total foaling percentage of 54.9 and 55.4 respectively which is appreciably lower than the 64.6 per cent recorded by Quinlan. It must be pointed out that he obtained his information direct from the Studbreeder and included foals born dead as well. The foal registration figures on the other hand, are obtained from the Studbreeder during the period 15th January to 31st May, when he applies for registration at the Jockey Club and represents the number of live foals at that time.

The/...

The difference of 9.7 and 9,2 per cent between Quinlan's figure and those of the Jockey Club published in Tables 4 and 5 is consequently the mortality and accident rate between foaling and registration time.

The assertion of many of the older breeders that it requires on an average two Thoroughbred mares to rear one foal successfully each year, is strikingly illustrated by the figures in Tables 4 and 5 which gives the foaling percentage as 54.9 and 55.4 per oent for two foaling seasons in South Africa.

These figures cannot be regarded as abnormal when compared to fertility figures published elsewhere. De Croutte (1937) estimates the rate of foaling in France at between 50-60 per cent; Mahaffey (1950) concludes that the rate in Australia is probably about 50 per cent. Day (1939) gives the fertility figures for England, heavy horses 59 per cent, light horses 52 per cent, Thoroughbreds at Stud 68 per cent. Andrews and McKenzie (1941) record a 69 per cent conception rate in their mares under observation in Montana. Jordao and others (1950) again record an average conception rate of 57.3 per cent for the period 1933 - 1948 at the Sao Paulo State Stud.

c. Incidence of Conception of the Thoroughbred in South Africa.

Andrews and McKenzie (1941) state that some breeds of horses show oestrous at regular intervals throughout the year, and others exhibit seasonal variations. Individual mares of all types kept under ordinary farm conditions in the United States, and on a reasonably high plane of nutrition exhibited reproductive phenomena throughout the year as evidenced by the fact that foals are born in all of the calendar months.

Götze (1935) found that heat periods recurred throughout the year but those in April and May were most favourable for conception. This strong seasonal influence was confirmed by Achnelt and Plas (1946) who noted that in Germany the conception figures were comparatively low in the first months of the year, but that a marked increase in conception

was/.....

was observed in May and particularly in June and July.

In England Marshall and Hammond (1949) state that the breeding season in the mare extends from about the end of February to August, although the actual time during which mares are usually served generally lies within smaller limits, this being regulated partly by the most convenient time for foaling.

Work done in South Africa confirm the above observations in that there is a seasonal period of optimum fertility. Küpfer (1928) found that mares kept at pasture with the stallion, in the Petrusburg District of the Orange Free State, showed a definite breeding season extending from the end of October to the end of March. Quinlan, van Rensburg and Steyn (1951) record that mares kept under stabled conditions at Onderstepoort failed to conceive to services during April, May, June or July. Breeding commenced in August, but they obtained the best results in November when 55.6 per cent became pregnant.

Appendix IX supplied by Pfaff (1953) Keeper of the Stud Book of South Africa, reflects the monthly incidence of conception of Thoroughbred mares for the breeding season 1950 - 1951. Tables 6 to 11 of Appendix IX, deal with this. It is clear from these figures that a progressive rise in fertility takes place in all parts of South Africa, as the season progresses from Spring to Summer.

TABLE NO. II (APPENDIX IX)

— SUMMARY OF MONTHLY CONCEPTION PERCENTAGES FOR THE 1950 BREEDING SEASON.

Areas	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
(1) CAPE	1:1	158:100	115:208	59:170	3:93	1:7	-:1
(2) EAST GRI-QUALAND	-:-	10:6	11:14	3:19	2:5	-:2	-:-
(3) O.F.S.	2:1	27:24	22:30	19:33	2:23	1:9	-:3
(4) TRANS-VAAL	4:-	43:51	36:60	17:45	1:37	-:1	-:-
(5) NATAL	-:-	25:26	22:27	11:37	2:15	-:2	-:-
TOTALS:	7:2	263:207	206:339	109:304	10:173	2:21	-:4
	9	470	545	413	183	23	4
PERCENTAGE	22.2	44.0	62.2	73.6	94.5	91.3	100

Table II/...

Table II summarises the position for the entire Union of South Africa, and the increasing tempo of conception becomes strikingly illustrated by the following figures:

August 1950	22.2	per cent conception.
September 1950	44.0	" " "
October 1950	62.2	" " "
November 1950	73.6	" " "
December 1950	94.5	" " "
January 1951	91.3	" " "
February 1951	100.0	" " "

The significance of these figures lies in the fact that under natural conditions high fertility may only be expected from November onwards. The aging rule of the Jockey Club and the demand for early foals has, however, created an artificial breeding season extending approximately from early September to the middle of December. Breeding therefore commences during a period of low conception rate and ends just when high fertility may be expected.

This arbitrary allocation of a certain time of the year as the breeding season for Thoroughbreds is responsible for a certain percentage of mares failing to conceive during that short period. Such mares would be regarded as infertile as they are left barren until the next breeding season.

This situation does not arise in those breeds of horses which have an unrestricted breeding season, and where mating takes place until autumn. There are several studs of Arabs, Palomino's, Percheron and American Saddle Horses in the Karroo Midlands where owners claim a 90 to 100 per cent conception rate each year. Mating usually starts during November and continues until April or May the next year.

E X P E R I M E N T A L P R O C E D U R E.

1. PLACE OF STUDY

(a) The Karroo Midlands.

Tidmarsh (1951) describes the Karroo Midlands generally as a region of summer rainfall. The climate is harsh, erratic and characterised by extremes. Spring rains are usually scanty and erratic, and are frequently followed by strong, desiccating winds from the west and northwest. These winds, prevalent throughout the year, are a special feature of the late winter, spring, and early summer months when desiccation is most intense. Hard frosts, and occasional sleet and snow, accompanied by chill winds from the south, characterise the usual rainless winter months, and short periods of frosty weather may occur at any time during the summer, which is usually marked by severe heat and drought.

Appendix number I reflects the monthly rainfall from 1923 to 1952, i.e. for a period of 30 years, indicating the wide variation that occurs from month to month, and year to year. The average monthly rainfall for this period is as follows:

January 1.71 inches.	May 0.78 inches.	September 0.75 inches
February 2.27 inches	June 0.28 inches	October 0.97 inches
March 2.45 inches	July 0.50 inches	November 1.50 inches
April 1.10 inches	August 0.29 inches	December 1.52 inches

As these figures are only an average taken over a 30 year period, they serve as a guide to indicate that spring usually follows a dry winter. During June, July and August there is usually very little precipitation, so that the breeding season is approached with very little green feed in the veld.

The inconsistencies and vagaries of the weather are clearly illustrated in the detailed figures reflected for the 3 years preceding this study, i.e. for the years 1950, 1951 and 1952. Appendix number II gives the daily rainfall distribution for those years, appendix number III supplies the humidity percentage/...

tage at 8 a.m. and 2 p.m. respectively, and appendix number IV gives the maximum and minimum daily temperatures in degrees Fahrenheit. These figures are obtained from the Grootfontein School of Agriculture, Middelburg, Cape, which lies approximately 12 miles from the Thoroughbred Stud under investigation, and may be taken as the climatic conditions prevailing over the area generally.

From these details it can be appreciated that land-cropping is impracticable and apart from certain irrigation settlements, the total production from cultivated lands is relatively insignificant. The natural veld constitutes the primary and major source of feed in the region, in which stockfarming is consequently the principal agricultural pursuit. Although the region boasts some of the finest dairy herds and horse studs in the country, sheep ranching, with merino sheep especially, is the chief source of income to the farming community.

In general, however, apart from the mountain ranges, which are still essentially grassveld, though seriously infested with "harpuis" (Eiryops sp.), "renosterbos" (Elytropappus sp.), and other scrub, the region is clothed at present mainly by various species of Karroo bush, among which are sparcely distributed numerous species of grasses.

The area is classified as the False Upper Karroo by Acocks (1953) in his classification of veld types of South Africa. In discussing the vegetation he regards the development of the present veld type as the most spectacular of all the changes in vegetation of South Africa, and views the conversion of this grassveld region into eroded Karroo as a national disaster.

(b) The Farm Askania Nova.

By kind permission of Mr. G.A. Kramer of Askania Nova Stud, Middelburg District, C.P., intensive clinical studies were undertaken of the mares during the breeding season of 1952 and continued for a few months afterwards.

Mr. Robertson/...

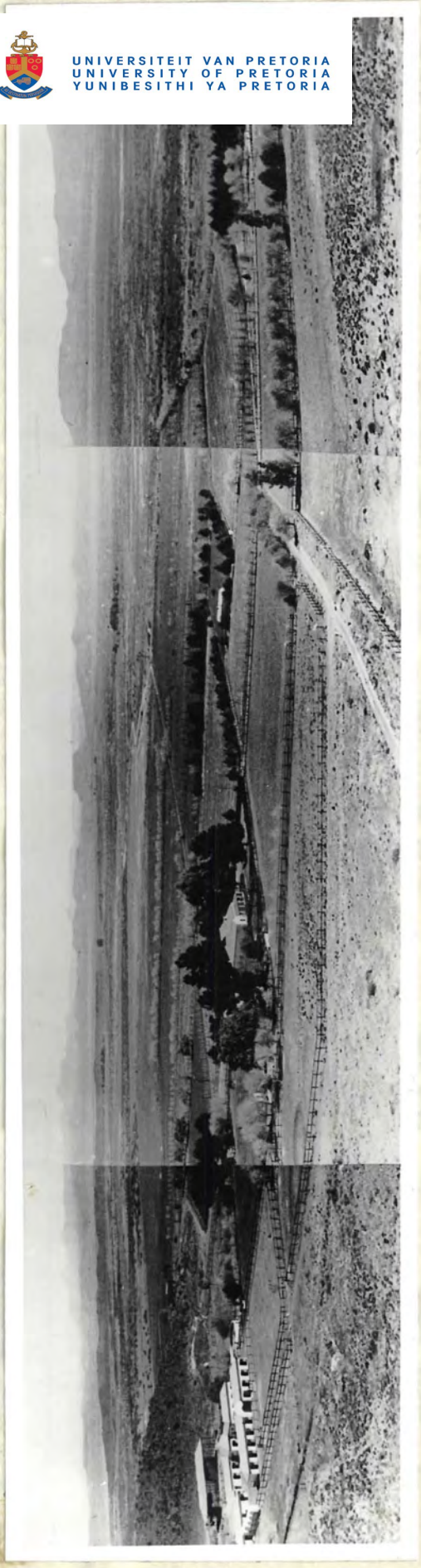


PHOTO 1. ASKARIA NOVA STUD, KLOOFBURG, CAPE.

Photo 1.

Mr. Robertson (1945) states that "among new-comers in the Middelburg district Mr. G.A. Kramer at the Askania Nova Stud has wasted no time in proving that his stud can and does produce winners. The Stud appointments at Askania Nova are second to none in the country and inspire confidence in the management of this Stud".

The choice of the farm for the purpose of this study was not fortuitous, on the contrary the author was closely connected with this Stud eversince his appointment to this area in 1945. From that time, until the undertaking of the more detailed and intensive study during the 1952 season, close observation was kept on the management and nutrition until this aspect was considered satisfactory and could be eliminated as a complicating factor in equine infertility.

Quinlan (1946) states "The uniformity in climate, management and nutrition under which Thoroughbred breeding is conducted in the British Isles, is not experienced in this country. The breeding of horses is much more difficult in South Africa than in the British Isles on account of the different conditions. In parts of the British Isles the grass, for the greater part of the year, provides a well-balanced ration. Consequently all that horses require for their potential development are good oats and bran as supplement. South African pasture for the greater part of the year does not give a ration balanced in protein, carbohydrate and minerals; neither does it provide a maintenance ration without supplementation. Consequently the nutrition of horses is far more complicated under our particular environment".

The question of functional sterility of dietetic origin is of more than ordinary interest in South Africa, where in certain localities the veldgrazing is definitely deficient in phosphates and for the greater part of the year there is a protein deficiency as well. In those areas fertility in cattle is abnormally low.

Quinlan/...

Quinlan and Roux (1936) quoting Bisschop state that from observations made at the Veterinary Research Station at Armoedsvlakte, Vryburg, it has been seen that failure to breed in cattle is due to failure to conceive during what appears to be normal oestrus and also to temporary anaphrodisia which may extend over a period of months.

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 was shown that there was a low bovine birth-rate and that abnormal calves showing weakness and congenital amaurosis were born (Theiler, Green and du Toit (1927); du Toit and Bisschop (1929); du Toit, Malan and Groenewald (1934)).

Bekker (1932) showed the detrimental influence of phosphorus deficiency on reproduction in ewes grazing on Armoedsvlakte veld. The addition of bonemeal to the diet improved fertility.

Roux (1936) states that the liberal feeding of bonemeal as opposed to its absence ensures greater sexual activity in sheep, although individual differences are not entirely eliminated; the duration of the sexual season was prolonged by an increased number of dioestrous cycles 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 were considerably lessened by such treatment.

Belonje (1949) pointed out that in the Colesberg and Middelburg areas considerable differences exist between the management and feeding of the non-pregnant and pregnant mare and that in consequence the reproductive function differs greatly. Many non-pregnant mares are run on the veld, which rapidly deteriorates as the winter months approach. Should condition be lost, additional feeding with dry lucerne hay, is resorted to.

In the/...

PHOTO 2 - 4. A STALLION OF PROVEN FE[illegible] WAS USED.

In the Karroo the non-pregnant mare shows definite ovarian activity in the summer (October to March or April) and a period of rest in the winter. He states that the first heat periods of such mares are usually prolonged lasting often from 10 to 14 days, frequently considerably longer, and that pregnancy rarely follows service during these heats. The foaling mare however receives the best of attention, obtains additional feed and invariably runs on green grazing such as lucerne, oats, barley, etc. As a rule normal heats follow foaling.

Küpfer (1928) working on ordinary horses in a different part of South Africa, observed that in horses running in the veld, puberty was delayed until the second year of life and the oestrous cycle only appeared at a certain time of the year. Outside this period and during pregnancy the oestrous cycle was absent.

Quinlan and others (1951) maintain that under the influence of domestication this seasonal appearance of the cycle tends to disappear and heat periods occur periodically throughout the year.

It is evident from the foregoing that much of the value of this study would be lost if incorrect management and malnutrition were a complicating factor.

At Askania Nova farm two turbine pumping plants provide sufficient water for the irrigation of extensive lands (exceeding 100 morgen) producing lucerne, oats, wheat and barley for green grazing or cropping. In addition the mares are fed crushed oats to which a satisfactory proprietary mineral supplement containing trace elements is added daily. If green feed is scarce good quality lucerne hay is fed in addition to the oats. Worm infestation is controlled by continuous daily low-level phenothiazine administration in the concentrate.

c. Management and Nutrition of the Stud at Askania Nova.

Since 1945 all mares that failed to conceive during the breeding season were carefully examined during the off-season, i.e.

the/....

the winter months. No gross anatomical abnormalities could be detected in the majority of cases and the cause of the failure to conceive could not be determined.

Those mares that showed an uterine discharge, or those that had aborted were treated with two intra-uterine medications dollowed by a single injection of Stilboestrol diproprionate (Belonje, 1949). The results obtained were very satisfactory and the mares settled so readily in the next breeding season that the procedure was extended to those mares which gave positive reactions to the pregnancy blood test, but which proved empty on rectal examination carried out during the winter months. Although rectal and vaginal examination of such mares failed to reveal any pathological abnormality, it was noticed that by the second treatment several mares had large pieces of yellow, stringy or gelatinous pus in the cervical canal or anterior vagina. With this discovery treatment was applied to all non-pregnant mares, (excluding maiden mares) indiscriminately, and it was surprising to find apparently normal healthy mares discharging variable amounts of inspissated pus by the time the second treatment was applied.

The role played by organisms in these cases of infertility is not known. Belonje (1949) mentions that during August 1948, oervical swabs were made from nine barren mares, incidentally all from this stud. Cultures made from these swabs only yielded growths from four mares. Quite a variety of bacteria were obtained, and it was not possible to incriminate a single organism as the specific cause of these cases of infertility. The chief organisms isolated were Staphylococci of the albus and aureus type. There were also bacilli of the subtilis type and a few organisms considered as air contaminants.

From the literature it is abundantly clear that streptococci play a considerable role in genital infection and consequent sterility in mares in the U.S.A. and England (Belonje, 1952).

This/...

This aspect will be dealt with in greater detail later, all that can be stated here is that the few bacteriological investigations carried out in this stud are insufficient to warrant an opinion of the absence of a specific organism in the causation of these cases of infertility. Many of the mares in this stud were imported from England and Normandy, where the Streptococcus has an ubiquitous distribution, and the possibility cannot be excluded of its introduction of the mare's coat or external genitalia (Burkhardt, 1948; Dimock and Bruner, 1949).

The isolation of Streptococcus equi as a causative factor of equine infertility in South Africa by Henning (1953) complicates matters considerably in a country where strangles is of very common occurrence.

The presence of pus in several mares could be taken as indicative of a low-grade endometritis with failure to conceive, but the possibility of early foetal death as a result of bacterial contamination, faulty implantation due to endometrial insufficiency or defective embryonic development cannot be excluded. It is impossible to distinguish between these possibilities clinically, and is the reason why the treatment was applied indiscriminately to all mares that failed to conceive during the previous breeding season.

The direct application of remedies to the uterine cavity fell into disuse for many years, but has received much attention lately in the case of cows by the work of Easterbrooks and Plastridge (1950); Moore (1954) and other workers, who claim excellent results of antibiotic treatment against Vibriosis and other uterine infections. Von Oettingen in 1909 recommended the use of intra-uterine irrigations after abortions in mares, and stated further that the uterus of the mare should also be washed if her foal suffered from joint-ill or if the premature birth was suspected to have been the result of joint-illness. This direct application

of/....

of remedies to the uterine cavity of mares is also supported by the work of Deubler (1952) who prefers the single application of four ounces Hexylresorcinol in oil. Those not responding were given 500 mgm. Aureomycin in oil.

In the three years preceeding this study all non-pregnant mares were treated during the winter months. During 1950 this was performed on the 11th and 14th August, 1950. During 1951 this was performed on the 28th and 30th July, 1951. During 1952 this was performed on the 9th and 11th July, 1952. The intra-uterine treatment consisted of introducing four ounces of Propamidine Intra-Uterine (May and Baker) in which 500,000 units Crystalline Penicillin G was dissolved, by means of a syringe and catheter. The second treatment was immediately followed by a single injection of 10 mgm. Stilboestrol Dipropionate subcutaneously in the vulvar region.

Robson (1947) in reviewing the recent Advances in Sex and Reproductive Physiology states:- "That in all essential respects the actions of synthetic oestrogens are similar to those of naturally occurring compounds". He says further that whatever direct function it may possess on the germinal epithelium of the ovary itself and secondary sex characteristics, it promotes growth and development of the tubular genitalia, increasing their blood supply, stimulating uterine contractions, and increasing motility of the fallopian tubes. In addition it appears to be the most important hormone factor in the control of mating. The doses of oestrogens necessary to induce mating are however much larger than those that will induce morphological changes in the secondary sex organs.

Berliner and Scales (1944) injected 20 mgm. Stilboestrol in 8 (eight) shy-breeding mares. Twenty-four hours later they came on heat, but oestrus was abnormal. Four remained on heat for 7 (seven) days, but did not become pregnant to repeated services

and/...

and the following oestrous cycles were irregular. The other four showed excessive ovarian activity and oestrus lasted up to 36 (thirty-six)-days.

Seven to ten weeks after treatment all mares started a normal oestrous rhythm and seven of the mares eventually conceived.

Burkhardt (1947) treated eleven out of 18 mares with shallow anoestrus successfully with doses of 5 - 15 mgm. Stilboestrol subcutaneously and states that the mare is extremely sensitive to oestrogens and that doses of 20 - 25 mgm. while occasionally successful, may depress ovarian function.

Harada and Nishikawa (1951) record that the experimental injection of 1 - 25 mgm. of Stilboestrol, when the diameter of the largest follicle was 2.5 - 3.0 c.m., failed to stimulate the development of the follicle in the oestrous mare.

Nishikawa, Harada and Sugu (1952) found that when mares were injected with Stilboestrol during the corpus luteum stages the following three kinds of abnormal sexual phenomena developed:-

(1) The suppression of the growth of follicles of ovaries.

(2) The appearance of male-like desire from about the 15th day after the start of injections.

(3) The activation of the ovarian function through the non-breeding season.

They claim that the phenomena observed were not specific to the synthetic hormone, but common to oestrogens and not attributable to the presence of the corpus luteum.

Robson and Adler (1940) conclude that oestrogens can act locally without absorption into the general circulation.

The recent work of Rowson, Lamming and Fry (1953) in cattle has shown that the genital tract of the cow under the influence of synthetic oestrogens is highly refractory to artificial bacterial contamination of the uterus.

That/...

That this highly defensive mechanism must also operate in the mare can be deducted from the fact that ejaculation is normally intra-uterine. Contamination of the uterus with smegma, dirt and organisms must be regarded as a normal concomitant to natural matings. Under natural conditions service appears to take place just before, at, or just after ovulation, and ovulation precedes the cessation of oestrus by 1 - 2 days in most mares. (Satoh and Hoshi (1938); (Hammond (1938); Mirskaya and Salzmann (1935); McKenzie and Andrews (1937)). The transport of the ovum through the fallopian tubes becomes slowed down and this coincides with the change over from the oestrogen to the luteal phase of the ovary. It is estimated that it takes the ovum from 95 hours. (Day, 1939; Hamilton and Day, 1945) to about 6 days (Götze, 1949; Rowlands, 1949) to reach the uterus. It is during this period that the uretrus cleanses itself of all introductions and prepares itself for the reception of the ovum.

Belonje (1949) mentioned that many barren mares are run on the veld, which rapidly deteriorates as the winter months approach. Such mares definitely go into anoestrus. With early rains and vigorous growing green vegetation it does not take long for oestrus to appear; a process analogous to flushing in ewes. It is evident that the intake of such young, vigorously growing green food supplies the necessary stimulus for the commencement of sexual activity and it must be a factor in this food that provides the trigger action for the pituitary to function.

Legg, Curnow and Simpson (1950) found that some British pasture plants possess considerable oestrogenic activity, i.e. Cocksfoot, Red Clover, Perennial and Annual Rye grass, whereas lucerne, white clover and Timothy grass are stated to be devoid of this property. They state that the early occurrences of oestrogenic activity in the leaves and, its high concentration in the chloroplast suggest that it is elaborated there. As oestrogen concentration is highest preceeding flowering its association with reproductive/...

ductive growth is also indicated.

Plant growth in the semi-arid Karroo, in which Middelburg, C.P. District is situated, is closely related to rainfall and the increase in the length and intensity of daylight. A study of the rainfall chart in Appendix No. 1 indicates that normally the rainfall is at a very low level from April to October but increases again from November to March.

Foaling commences from 1st August and the mating season from about the 8th September when the climate is still very cold. The low rainfall and the cold weather retard the growth of the grass with the result that very many barren mares do not come into season or have prolonged heat periods which prove infertile. The average rainfall of 1.50 inches during November and the increase in warmth is sufficient to cause very active and vigorous growth of grass and other vegetation. The anterior pituitary is no doubt stimulated by several factors, chief of which is the stimulus of light on the retina transmitted to the hypophysis (Hammond, 1938), (Burkhardt, 1947), to which must be added the oestrogenic content of the actively growing vegetation and the presence (i.e. sight, hearing and smell), of the stallion. It is possible that many more factors are involved in this process, (e.g. Thyroid activation) which primarily is one of ever increasing body metabolism, and that the changes that do occur cannot be ascribed to any single factor alone.

In most Studs non-pregnant and maiden mares are run on the veld and their reproductive mechanism is subjected to the influences of environment and nutrition. The summary of monthly conception percentages for the 1950 breeding season for the whole Union of South Africa, contained in Table 11, makes this position abundantly clear.

EXTRACT OF TABLE NO. 11.

U. of S.A.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
% conception	22.2	44	62.2	73.6	94.5	91.3	100

With/...

With the early realisation of all the factors involved it became the policy of the Askania Nova Stud to prepare the non-pregnant mare in such a way as to promote conception early during the breeding season.

The intra-uterine medication, administration of Stilboestrol and the placing of such treated mares and maiden mares on to young wheat, oats or barley lands, under irrigation, was instituted in 1947, and it soon became apparent that this procedure was highly successful in effecting a regular sexual rhythm of oestrus and di-oestrus with a consistent high conception rate.

The nutritional conditions under which the mares are kept at Askania Nova follow more or less a constant pattern. During June all mares, i.e. pregnant, non-pregnant and maiden mares are brought in from the horse camp on to irrigated pastures consisting of young growing oats, barley, wheat and after the winter lucerne. Each mare receives in addition 5 lbs. of rolled oats and 15 lbs. lucerne hay daily. To the oats is added a proprietary mineral compound as well as 2 grams Phenothiazine. The latter is added to the oat ration for the first twenty-one days of each month.

Appendix X reflects tables giving the origin, the date of collection, the chemical composition on a dry matter basis of individual pasture samples from areas in the Karroo Midlands.

Table I of Appendix X gives the monthly chemical composition of oats, wheat, barley and lucerne grown under irrigation at Grootfontein College, grazed each time by sheep when 6 inches high. The crude protein content remains high and remarkably constant varying from 15-20 per cent of the total dry matter, as do the other components. These high levels are maintained throughout Spring and early summer and are the result of a continuous grazing practice which keeps these plants below a certain

height/...

height. This confirms the findings of many other South African workers (du Toit, et al. 1935, Botha 1938, Louw 1938) who found that the frequency of cutting had a marked influence on the yield, persistency and chemical composition of grass species, the content of phosphorus, potassium, chlorine and crude protein decreasing with decreased frequency of cutting.

Morrison (1950) states that the nutritive ratio of cereal pastures in the U.S.A. is as follows, oats 1:2.8, wheat 1:2.6, Barley 1:2.3 and lucerne up to 10 inches high 1:2.

During the cold winter months of June to August the growth of cereal pastures is slow and erratic. Its moisture content is high and continuous grazing on such pasture tends to cause purging.

It is for this reason that rolled oats, lucerne hay and a proprietary mineral compound is supplemented in addition to the green grazing. They are fed to the mares each afternoon in small portable mangers attached to the fences enabling a careful check on the feeding habits of each mare. The additional ration is however reduced and eventually withdrawn with the advent of warmer weather when the pastures begin to grow very actively and the mares are placed almost continuously on green lucerne. By this time the moisture content of the plants is considerably lower and there is sufficient crude fibre to supply bulk which is an essential requirement of equine digestion.

High feeding at this time of the year is however required for additional purposes. Firstly it is an accepted fact that the foetus begins to draw heavily for its food requirements on the dam from the 7th month of pregnancy (Hammond, 1938) and additional nourishment is needed at this stage to meet this demand. Secondly the non-pregnant and maiden mare are being prepared for breeding in September and for this purpose require additional food to be on a rising plane of condition.

It is/....

It is however difficult to assess scientifically the nutritive value of the rations described above, as only a few digestion trials have been carried out with horses, and the digestion coefficients of most foodstuffs are not known in this species of animals. In addition Thoroughbred horses probably differ more in temperament and in individual food requirements than do other classes of stock. It is an accepted fact that cattle and sheep digest feeds high in fibre more completely than do horses and swine. In spite of the difference the digestion coefficients obtained in tests with cattle and sheep are commonly used in computing rations for equines.

The protein requirements of ruminants and horses are also much more simple than those of rats, dogs, pigs and man. This is because the bacteria and other micro-organisms, which are so important in the digestion of fibre by these animals, are able to use for their food very simple nitrogenous compounds, which the animals could not themselves use at all. The bacteria build these simple forms of nitrogen into complex proteins in making the cells of which they are composed. Then, further on in the digestive tract of the ruminant, these bacterial cells are digested, and the protein that has been made by the bacteria is thus made available to the animal. This bacterial protein may therefore provide all the essential amino-acids, even though they are lacking in the feed which the ruminant eats. Morrison (1950) claims that a similar action occurs in the caecum and colon of the horses.

The partition of the carbohydrate fraction into "crude fibre" and "nitrogen-free extract" was no doubt an attempt to divide this fraction into an indigestible part (crude fibre) and a digestible part (nitrogen-free extract). That this difference did not come up to expectation was soon realised when it became known that cellulose, the chief constituent of the crude fibre, is susceptible to attack by the micro-organisms in the digestive tract of ruminants and equines, and that the nitrogen-free extract contained

poorly/...

poorly digestible substances such as lignin. For this reason Louw (1941) was able to demonstrate that natural cellulose is the most digestible portion, and lignin the least digestible portion of the cell-wall structure of composite grass samples fed to sheep. He concludes that with regard to roughages the standard feeding stuff analysis does not divide the carbohydrates complex into substances of relatively low and substances of relatively high digestibility.

Although Groenewald (1951) estimates the approximate daily mineral requirements of farm animals, including horses, the ordinary digestion trials give little information concerning the extent to which the mineral matter is actually digested and absorbed, because calcium, magnesium, phosphorus, and iron are chiefly excreted from the body in the faeces. Therefore, in a digestion trial, these compounds would be reported as largely undigested, though they may really have been digested and absorbed, and later excreted in the faeces after being used in the body.

With all these factors involved it is considered impossible, at this stage, to work out the nutritive ratio from the foodstuffs supplied to the mares. It may however be stated that they showed continuous improvement in condition as the season progressed and at no time gave indication of suffering from deficiencies of any kind.

The breeding season commences from the first week in September and blood is collected from mares after the 40th day from the last service date. The blood is then posted to the Onderstepoort laboratories for the purpose of determining pregnancy by the biological test. Mares without foals at foot, i.e. the maiden and non-pregnant mares that come to stud, are transferred to the horse camp as soon as pregnancy is well established. This usually takes place during December-January when the veld has recovered from the winter and the natural grasses are growing well. Mares nursing foals are kept on the lands to maintain high milk production and to

supply/....

supply high nutritious green feed to the foals when they start to nibble.

During March and early April the yearlings are sent to the Yearling Sales, held at Cape Town and Johannesburg, and stable accommodation becomes available for the succeeding foal crop. Weaning of the foals can now take place and occurs on a suitable day during the latter part of April. This is performed by separating them from their dams and locking them up in loose boxes for a variable period lasting from a few days to a week. The mares are immediately moved to the horse camp which lies about a mile or more from the stables and lands. This distance is an added precaution as neither the mare not foal can see or hear each other, which prevents attempts to break through the fences to reach each other.

From April until June all mares are run in the veld in the horse camp where they are left to graze. A windmill supplies all their water requirements and no additional feeding is necessary as a rule. The camp is described by Acocks (1957) as follows. The horse camp, a long, narrow one of 1,000 morgen, lies across a shallow valley in a more or less N. and S. direction. The northern half consists of sandy flats, rising gently southwards towards dolerite hills. In the S.E. corner is a low plateau, also rising gently southwards and bounded by a low dolerite escarpment rising sharply to a high dolerite ridge on the W. side. Along the W. foot of this ridge is a belt of red sand. The soil of the small plateau is of a silty nature, as is that of a small area near the S. end of the W. boundary; while the soil of the slopes is a compact red sandy loam, rather stony, being probably the sub-soil of a former sandy soil, now denuded by erosion. The catchment is too small and the soil too sandy, to permit this valley to be regarded as a flood-plain, and its vegetation is, in fact, that of the sandy flats of this part of the False Karroo, where the plant-succession is reluctant to proceed beyond the Eragrostis lehmanniava stage.

The/...

The useful grasses of the old climax vegetation of this part are represented only by widely scattered individuals and small groups of Themeda triandra, Cymbopogon plurinodis, Digitaria agryrograpta. Sporobolus fimbriatus and, on the silty soil, of Tetrachne dregei; of the sub-climax by occasional individuals and groups of Eragrostis chloromelas and E. curvula. The bulk of the vegetation thus consists of pioneer types, which belong both to the original grassland flora and to the invading karroo flora. The large size of the camp and the position of the watering-point towards one end (the S. end), have inevitably resulted in selective grazing, with a conspicuous zoning around the watering-point. The northern half of the camp shows little sign of grazing in recent years, the vegetation consisting mainly of overgrown and moribund Eragrostis lehmanniana and Pentzia spinescens and abundance of the shorter plants Aristida congesta, Tragus koelerioides and Eragrostis obtusa. Above this zone is a zone of patchy veld, a mosaic of patches of bare sub-soil, of pure Karroo and of overgrown Eragrostis lehmanniana; and finally, around the watering-point for about half a mile, is a mosaic of patches of bare sub-soil and of Karroo.

The vegetation of the two silty patches is richer in species, including in quantity also such species as Eriocephalus spinescens, Pentzia globosa, Aster muricatus, Walafrida geniculata, Eragrostis bicolor, Nestlera conferts, Osteospermum leptolobum and, locally, Tetrachne dregei. The sandy belt along the foot of the high ridge is Kapokveld, dominated by Eriocephalus ericoides, while the dolerite outcrops and ridges are dominated by Aristida difusa var. burkii and Heteropogon contortus. These rocky parts, however, were not studied, as being unlikely to have been grazed by the horses.

It should be noted that the better grasses tend to flower in November and December, depending on the adequacy of the unreliable Spring rains; and in the late Summer, which is the main

rainy/...

rainy season, tend rather to produce foliage; so that the grazing is usually at its best during the Summer and late Summer months of January to April, at which time the horses were in this camp.

The species of plants recorded in the camp are as follows:

Grasses:

	Aristida congesta R. & S.	ab
	A. curvata (Nees) Trin. & Rupr.	lc
	A. diffusa Trin. var. burkei (Stapf) Schweick.	ff.lf
*	Cymbopogon plurinodis Stapf	lllf
*	Cynodon incompletus Nees	lvab
*	Digitaria argyrograpta (Nees) Stapf	o
	Enneapogon brachystachyus (Jaub & Spach) Stapf	o lab ↑
	Eragrostis bicolor Nees	lc
*	E. chloromelas Steud.	llf
	E. curvuva (Schrad.) Nees	O
	E. lehmanniana Nees	vab
	E. obtusa Munro ex Fic. & Hiern.	ff.lc.llab
	Heteropogon contortus (L.) Beauv.	f (hills)
	Oropetium capense Stapf	lc ↑
*	Sporobolus fimbriatus Nees	O.llf
*	Tetrachne dregei Nees	lllff
*	Themeda triandra Forsk.	vr.lllc
	Tragus koelericoides Aschers	a.b

Those marked with asterisks are likely to have been specially sought out by the horses.

Non-grasses:

Anthericum sp.	r
Aptosimum depressum (L.f.) Burch.	r
Arthroselen polycephalus C.A. Mey	↑ llf
Asparagus stipulaceus Lam.	r
Aster muricatus Less.	f ↑ lc

Berkheya/...

Berkheya annectens Harv.	lo
Chrysocoma tenuifolia Berg.	O.lc
Cyperus usitatus Burch.	r
Dimorphotheca zeyheri Sond.	vr
Ericcephalus ericoides (L.f.) Druce	r.lf
E. spinescens Burch.	lff.F
Galenia sp. cf. G. procumbens	r.llff +
Gazania oxyloba D.C.	O
Geigeria africana Gr.	r
Indigofera alternans D C.	O
Lightfootia tenella A. D C. var. rigida	r
Lycium sp. of L. pilifolium C.H. Wr.	O.lff
L. sp. cf. L. oxycladum Miers.	O.lff
Nenax microphylla (Sond.) Salter	r
Nestlera conferta D C.	r.lf.llc
N. humilis Less.	r.llo
Osteospermum leptolobum (Harv.) Norl.	O llf
Othonna pallens D C.	r
Pentzia globosa Less.	O.lfC
P. incana O. Kuntze (ankerkarroo)	lc
P. spinescens Less.	ff
Phymaspermum aciculare (DC.) Jacks.	vr
P. parvifolium (DC.) Benth.	O.lf
Plinthus karrooicus Verdoorn	r.lff.llf +
Pteronia erythrochaeta D C.	llff
P. tricephala D C.	O
Pterothrix spinescens D C.	r
Salvia clandestina L. var. angustifolia Benth.	O
Solanum supinum Dunal	r +
Sutera atropurpurea Hiern.	r
S. pinnatifida (Benth.) O.K.	r
Thesium hystrix A.W.H.	vr

Tribulus/...

Tribulus terrestris L.	0
Trichodiadema pomeridianum L. Bolus	r
Walafrida genioulata Rolfe	lf
W. saxatilis Rolfe	0

The abundance- & habitat-symbols used have the following meaning:-

vr.	:	1 per morgen	l	:	local, x 1/10
r	:	2 per morgen	ll	:	very local, x 1/100
r +	:	6 per morgen	lll	:	small patches, x 1/1000
0	:	36 per morgen	↑	:	on the slopes in the southern half of the camp.
ff -	:	225 per morgen			
ff	:	400 per morgen	↑	:	on the small plateau in the S.E. corner of the camp.
ff +	:	800 per morgen			
f	:	1 per square yard			
c	:	5½ per square yard			
ab	:	4 per square foot			
vab	:	16 per square foot			

The chemical composition of grass pastures differs in many respects considerably from that of bush pastures found in the Karroo midlands. Especially is this the case in connection with the changes to which the composition of pastures are subject with changing meterological conditions from January to December (du Toit, et al. 1932, 1934, 1935).

Bush pastures are on the whole richer in all the constituents determined than are grass pastures. Another distinguishing feature in the two veld types is the difference in chemical composition between winter and summer pasturage; whereas the former type shows only minor fluctuations in the course of the year, the difference in the percentage contents of certain constituents during winter and summer are considerable in the case of grass pastures

(van Wyk/.....

(van Wyk 1933, Botha 1938).

There is no doubt that while grasses show fair figures for phosphorus and protein during the period of active growth associated with the rainy season, these values drop to extremely low levels after the cessation of the rains into the cold winter months (Henrici 1928, 1932, du Toit, et al. 1940). On the other hand, while they are undoubtedly influenced by the rainfall, trees, shrubs and other edible herbaceous plants do not only appear to be on the whole richer in phosphorus and protein than the grasses, but they retain these nutritive constituents to a greater extent, even in the absence of rain (Henrici 1935, 1940, 1945; du Toit et al. 1940).

Du Toit et al. (1940) expressed as percentages of the dry matter the phosphorus content of grass pastures as 0.12 - 0.17 during summer and 0.05 - 0.07 during winter. They state that in pastures composed mainly of bushes this constituent varies between 0.11 and 0.20 per cent. Crude protein values of the grass pastures fall from 7.0 to 9.0 per cent in summer to 3.3 - 4.0 per cent in winter, while the percentage of this constituents in those pastures composed mainly or wholly of bushes varies between 7.0 and 10.0 in the course of the year.

The detailed analysis of certain veld grasses, such as Eragrostis lehmanniana, Eragrostis curvula, Themeda triandra, Tetrachne dregei, Aristida congesta and Digitaria argyrograpta are reflected in Table 2 of Appendix X. They were collected during the late summer months from January to April, i.e. during the rainy season and serve as a guide to the nutritive value of grasses during that period of the year.

The composite sample of grass collected in the Middelburg District during January 1934, by du Toit et al. (1940) indicates that they contain sufficient nourishment to maintain adult horses in good health. Their calcium and phosphorus content is low but this is of no practical importance as it is an established

fact/...

fact that the calcium and phosphorus reserves in the animal's body may tide it over a long period of inadequate intake without appreciably affecting its productive perfomrance.

Furthermore Thoroughbreds bred and reared in the Karroo Midlands do not confine their grazing habits to grasses only but feed freely on Karroo bushes of various kinds. Table 2 of Appendix X gives the chemical analysis of the common Karroo bush, Pentzia incana, collected during the month of April and it will be noted that not only is its crude protein content high but so is its mineral content, particularly in calcium and phosphorus.

The analysis of composite samples of herbage representative of what sheep actually ate on the day when the sample was collected, is reflected in Appendix X for the Middelburg District. As the feeding habits of sheep and horses correspond fairly closely, both being fastidious and selective feeders, these details are of particular interest as they give an indication of the nutritional value of composite pastures in the Karroo Midlands. These details extracted from Table 2 of Appendix X are reflected herewith.

APPENDIX X : TABLE NO. 2

CHEMICAL COMPOSITION ON A DRY MATTER BASIS OF COMPOSITE SAMPLES COLLECTED IN THE MIDDELBURG CAPE DISTRICT (du Toit et al. 1940)

Description of Sample	Crude Prot.	Crude Fibre	Ash	Ca	P	K	Na	Cl	Mg
Composite Sample Grass - mainly green. Farm - Landsdowne, Middelburg, Cape January 1934.	9.5	33.2	4.67	.39	.26	2.00	.04	.33	.19
Composite Sample Grass - mainly green, leafy and bush. Mostly grass: Farm - Onbekend, Middelburg Cape. April 1934.	13.2	30.6	7.45	1.13	.27	2.80	.03	.60	.30

The nutritional management of the mares is therefore sharply divided into two periods i.e. the period of high feeding

extending/...

extending from June to December-January for the dry mares and from June to April the next year for mares suckling foals. After this period the mares are run in the veld on natural pastures. The nutritional level of the veld during this period is not high but sufficient to maintain good condition. Pregnancy tends to make mares gain in weight and fatten more rapidly because it makes them more quiet and also increases their appetite. A highly nutritious pasture is consequently considered undesirable at this stage and it is preferred to maintain them in a good healthy condition only.

Those mares which failed to conceive during the breeding season usually lose some weight and reach a thrifty condition on the veld grazing and the abundant excercise they have in the camp.

2. DETAILS OF THE SELECTED MARES.

The following mares were selected for intensive clinical observation during the 1952 breeding season:-

a. Foaling Mares:

1.	Armorial	born	1940	aged	12	years.
2.	Audition IInd	"	1942	"	10	"
3.	Bacarolla	"	1945	"	7	"
4.	Blue Vision	"	1943	"	9	"
5.	Calamity Jane	"	1937	"	15	"
6.	Daror	"	1935	"	17	"
7.	Fata Morgana	"	1945	"	7	"
8.	Flaming River	"	1936	"	16	"
9.	Flora Sandes	"	1940	"	12	"
10.	Fresco	"	1948	"	4	"
11.	Hats Off IInd	"	1936	"	16	"
12.	Hattie Hart	"	1944	"	8	"
13.	Jinnipet	"	1936	"	16	"
14.	Kings Flame	"	1946	"	6	"
15.	Olive Grove	"	1938	"	14	"

16/...

16.	Ornament IInd	born	1948	aged	4	Years
17.	Protect	"	1943	"	9	"
18.	Unconcern	"	1944	"	9	"
19.	Wyndsong	"	1940	"	12	"

b. Non-pregnant Mares:

1.	Castania	"	1944	"	8	"
2.	Cara Nostra	"	1945	"	7	"
3.	Distance	"	1943	"	10	"
4.	Heliotrope II	"	1944	"	9	"
5.	Holy Grail	"	1936	"	16	"
6.	Pavane	"	1940	"	12	"

c. Visiting Mares:

1.	Contrast	"	1945	"	7	"
2.	Terai	"	1948	"	4	"

It was unfortunate that no maiden mare was present for examination in the group of mares selected for intensive study. Nevertheless it will not be out of place to make certain remarks in this connection.

Puberty, or the onset of sexual maturity, in the filly is given variously as from 12 - 24 months. Although symptoms of oestrus are frequently seen in very young fillies from approximately 9 months of age, it is doubtful whether pregnancy will result if service is permitted. Usually the external genitalia in the very young filly is too small to allow intromission, but even if that were possible it is unlikely that the uterus will have developed sufficiently for the acceptance of the fertilized ovum.

In reviewing the fertility in thoroughbred horses Robertson (1912) gives the following results of mating two-year old Thoroughbred fillies:-

69.2 per cent became pregnant.

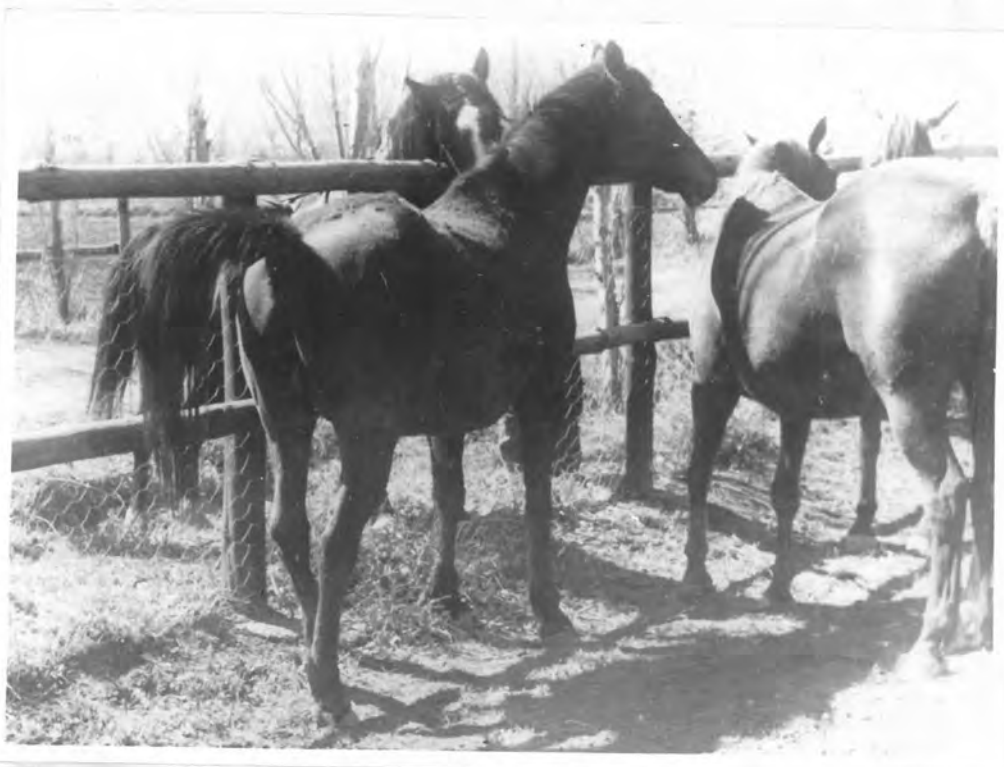
11.5 per cent had dead foals.

1.5 per cent slipped their foals.

30.8 per cent failed to conceive.

Experience/...

PHOTO No. 5-7. HOLY GRAIL HEREFORD BADGY.



Experience in this respect was limited to two fillies of two-years old. The one was served repeatedly during apparently normal heats, but failed to conceive during the season. The other was examined rectally and vaginally, and the ovaries and uteri massaged daily for three consecutive days. She came into season, was served only once, conceived but slipped her foal five months later.

This condition, regarded as one of sexual immaturity, does not appear to be confined to the very young filly. It has been repeatedly encountered in mares four years old and older, and is associated by Studbreeders with a hard racing career.

Burkhardt (1948) is also of the opinion that this sexual immaturity is responsible for more cases of infertility then is generally recognized.

3. METHODS OF EXAMINATION.

a. Note was taken of the external appearance and condition of the mares.

b. The vaginal speculum was used to determine the changes of the vaginal tract and cervix.

c. An attempt was made to correlate the changes in the vestibule (vulva) with the ovarian cycle.

d. Rectal examination was performed at short intervals and palpable changes of the genital tract recorded.

Details of the Methods of Examination.

a. External examination.

The external appearance and conditions of the non-pregnant mare was recorded as a reflection of her having wintered well or not. As the food supplied to these mares was identical it served as an indication if the mare was a bad 'doer' or whether she was a strong 'constitutional' mare that made the best utilisation of her food. The early shedding of the coat in spring has long

been/...

been accepted as a pre-requisite to successful breeding and indicates that the mare's metabolism is increasing and reproductive function awakening.

b. Speculum examination.

The mare is twitched, hobbled, a tailbandage applied, and the perineal region thoroughly washed with soap and warm water and dried. The vulvar lips are cleaned with absolute alcohol on cotton wool, and the vestibule swabbed with a mild disinfectant in boiled water. The sterile speculum is introduced without lubricant in mares on heat, but where the introduction is difficult a little sterile liquid paraffin was used.

The speculum used in these investigations was the standard Polyansky model manufactured by Arnold and Sons, London. It was found eminently suitable as it opened the passage to such an extend that it was unnecessary to use artificial light to examine the interior.

The walls of the vagina, the cervix and anterior vagina were carefully scrutinised. It was found that examination had to be performed gently and quickly as handling of the genitalia soon caused hyperaemia of the vaginal passage. For this reason vaginal examination is performed before rectal examination. Thorough rectal examination, i.e. rectal palpation of the genital passage, frequently caused hyperaemia of the vagina and may result in an incorrect clinical observation if the vaginal speculum is applied afterwards.

CLINICAL OBSERVATION.

The speculum was used mainly for examination of the os cervix and the observations were recorded as follows for the sake of brevity.

1. SHAPE.

(a) Narrow, contracted, projecting like a finger.

(b) Round rosette shaped, fleshy.

(c)/...

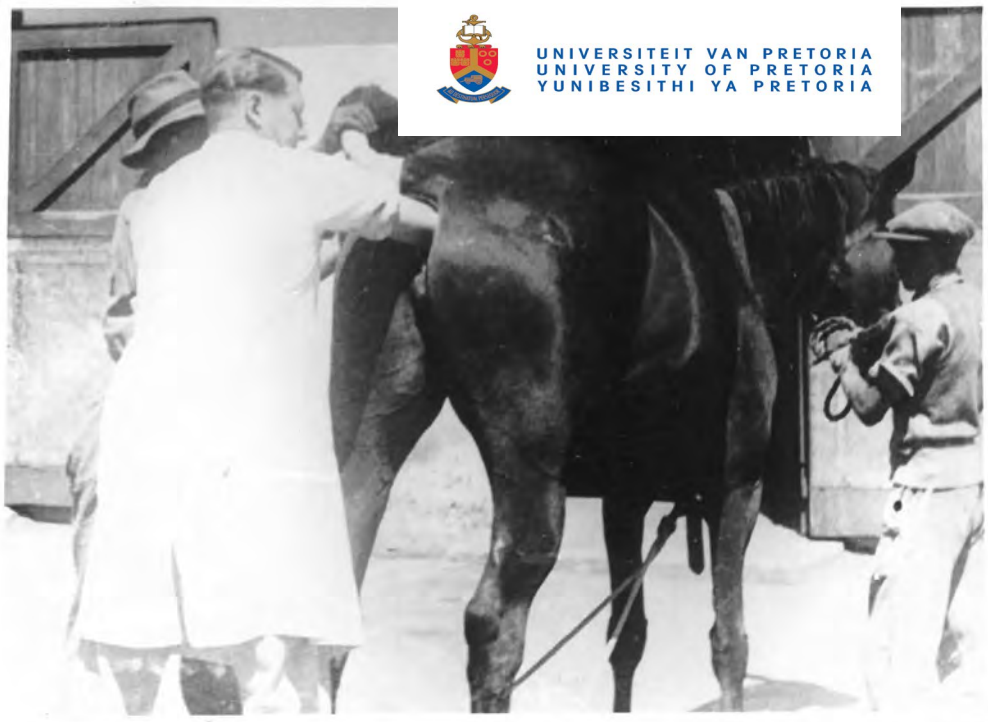


PHOTO 9 - 10. RECTAL EXAMINATION.

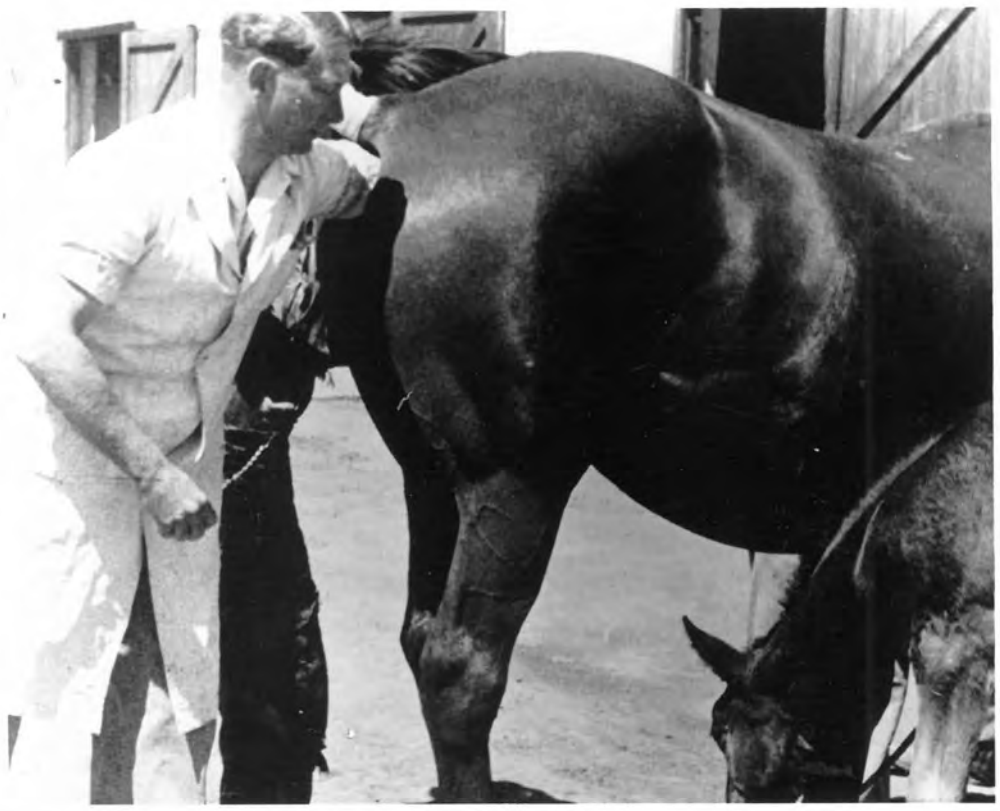


PHOTO 8. VAGINAL EXAMINATION BY MEANS OF A SPECULUM.

(c) Flaccid, collapsed.

2. OPENING.

(0) Completely closed and gummed up.

(1) Cervical canal funnel-shaped, passes pencil.

(2) Cervical canal open and passes 1-2 fingers.

(3) Cervical canal wide open and passes 2-5 fingers.

3. COLOUR. This applies to the cervix and the area of the anterior vagina adjoining.

(A) Pale.

(B) Pink.

(C) Hyperaemic. Red.

4. MOISTURE CONTENT. This applies to the anterior vagina and cervix.

(I) Dry and sticky like glue.

(II) Small amount of moisture.

(III) Fair amount of moisture of a glary, tenacious, glistening type.

(IV) Excessive amount of liquid.

5. POSITION.

The position is described as centre, sideways, upwards or downwards deflected.

c. Vestibule examination.

The vestibulum or vulva is described by Sisson (1938) as that portion of the vagina caudal to the urethra. The hymen feminus, which is usually a pronounced ring-like construction, marks the junction between this and the vagina proper.

In mares, particularly old mares, this section of the genital tract is clearly visible when the vulvar lips are parted. The term 'vestibule' is preferred, and is used in this study to denote this section of the genitalia, rather than the use of the word 'vulva' which in the other domestic animals refers only to

the/...

the external genital structures.

The changes that occur in this portion of the genital tract were carefully recorded, so that they could be correlated with ovarian development, in an endeavour to dispense with the use of the vaginal speculum by the studgroom as a means of determining the optimum time for service by the stallion.

d. Rectal examination.

The mare was twitched, hobbled and a tailbandage applied. At first the examinations were carried out in the teasing chute, but the mares soon became accustomed to handling and eventually it was carried out in the paddocks without difficulty or objection by the mares concerned. The only exception was the mare PROTECT who violently objected to ovarian palpation.

Fingernails were kept paired as short as possible to avoid injuries to the rectal mucosa. At first a patent obstetrical lubricant was used, but this was later dispensed with and the following procedure adopted.

A two-gallon bucket was half-filled with warm water during the cold weather, but with ordinary tapwater in summer, to which was added 2-3 ounces of Hygienol (a proprietary disinfectant consisting of a pinetar-oil emulsion), 2-3 ounces liquid paraffin and a cake of carbolic soap. The arms and hands were thoroughly soaped with this mixture which, after a few examinations, forms a thick emulsion and a satisfactory lubricant.

One or two fingers were inserted and gently rotated to lubricate the anal passage and to relax the sphinoter muscle. The hand was inserted and the rectum gently emptied. Where severe peristalsis and straining occurs the hand was withdrawn until this had passed over.

The simplest method was to insert the hand and arm as far forward as possible, press down with the hand and fingers and when sliding back push the bowels into the abdominal cavity and

attempt/....

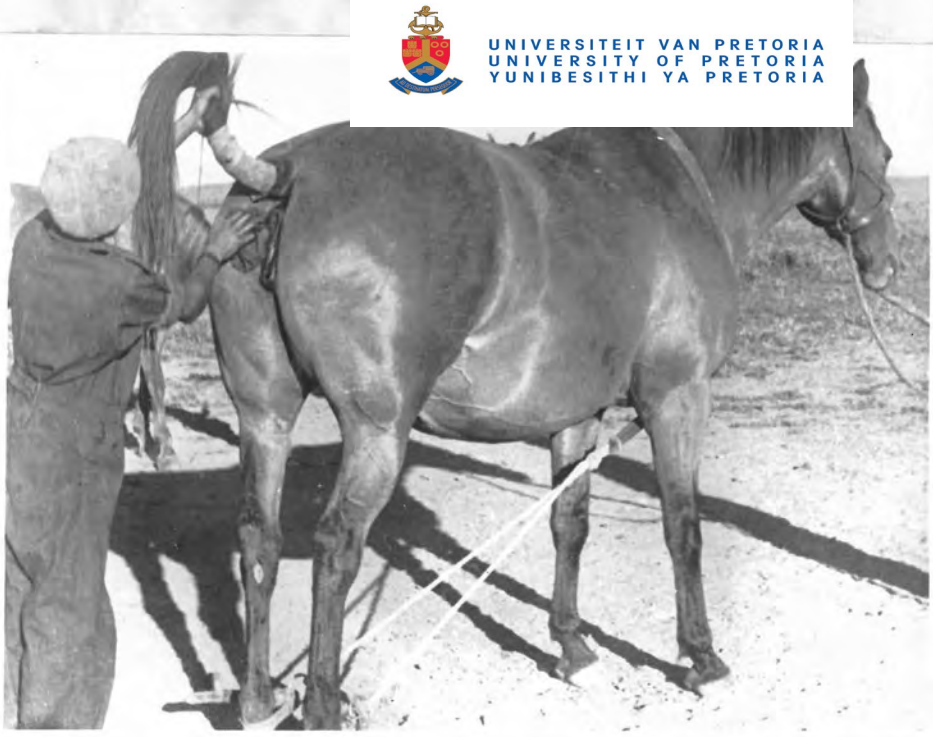


FOTO 11 - 11

3. RECTAL EXAMINATION IN THE PADDOCK.

Photo 11 - 13.

attempt to reach the pelvic brim i.e. the pubic symphysis. The uterine bifurcation was located, in this manner the fingers curved over it and if necessary the organ drawn up into the pelvic cavity.

The hand was run along the body of the uterus to the horns and the position, size, shape, consistency and content recorded. The fallopian tube was palpated, its uterine opening traced and the ovaries located.

Where the ovaries were out of reach it became necessary to excercise gently traction on the body of the uterus and to slide the curved hand over it along the horns in a lateral and upward movement in search of the ovaries. After the ovaries had been carefully palpated as to position, size, shape, and consistency, the number of Graafian follicles or Corpora lutea were examined, and their size, shape, location and consistency recorded.

The hand was again passed along the uterus and a note made of its contractibility or rather erectibility and consequent consistency after the genital manipulations. The hand was then passed back along the body to the Cervix and the consistency and shape of the latter noted. The fingers were then run gently over the vagina and withdrawn from the rectum. Any alterations or discharge from the vulva were noted.

The mares soon became accustomed to handling and internal examination was easier, upon subsequent examinations, because of earlier relaxation of the anal sphincter and the absence of rectal peristalsis. This was a fact worthy of note and one which makes regular rectal examinations in Thoroughbred Studs a practical undertaking. It may be mentioned that on several occasions it was necessary in other Studs to apply severe restraint in the form of two twitches, one to the ear, the other to the lip, apart from the hobbling and the assistance of a considerable staff to perform the first few examinations. Even such mares subsequently submitted to routine examination, with

normal/...

normal methods of control.

CLINICAL OBSERVATION.

1. OVARIES:

Size, shape, position and consistency were noted as well as the presence of Graafian follicles or corpora lutea and their respective sizes, shapes, position and consistency recorded.

2. FALLOPIAN TUBES were traced to their uterine ends and any abnormality noted.

3. UTERUS was palpated for:-

(a) SIZE.

1. Small.
2. Medium.
3. Large.

(b) CONSISTENCY.

1. Flabby: non-contractile.
2. Medium: slowly contractile.
3. Firm : quickly contractile.

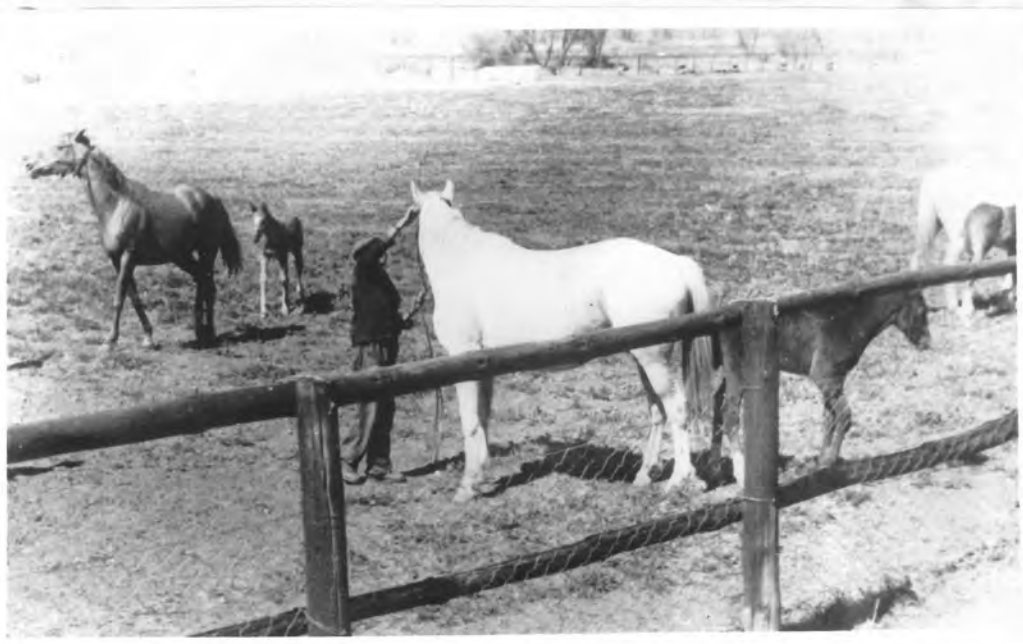
(c) SHAPE.

1. Symmetrical.
2. As-symmetrical.

e. Oestrus Observations.

Belonje (1949) observed that in the Karroo the non-pregnant Thoroughbred mare showed a definite cycle of ovarian activity followed by ovarian rest. Usually mares come in season from October until March or April which is followed by the inactive season during which oestrus ceases completely. The period of sexual activity corresponded to the summer months and the inactive period to the winter months. Many of these barren mares are run on the veld which rapidly deteriorated as the winter months progresses.

Oestrus/...



COLLECTING MARES WITH FOALS IN PADDOCK FOR TEASING

PHOTO 14 - 16.

Photo 14-16.

Oestrus in the barren mare is detected by the presence of the stallion and it is extremely rare to find mares giving oestrous indications on their own. In Thoroughbred Studs after the breeding season is over and the mares are no longer teased it is extremely rare to detect a mare on heat.

This is a basic fact. Further, it is possible to force a mare into a heat period. An old method employed by Studgrooms is to place the stallion in a loose box and put the mare into an adjoining box so that both can see each other over or through the partition and for the Studgroom to insert his arm into the vagina and gently massage the cervix. The more modern method is to apply a nose twitch and if necessary hobble the mare in a padded crush and to allow the teaser stallion to approach and nuzzle her and even mount, but not serve her. In both methods symptoms of heat will appear in the majority of cases within a short period, depending on the time of the season, but the oestrus so provoked may be completely dissociated from any ovarian development.

Von Oettingen (1909) remarks that there certainly exists the danger of provoking oestrus by too many and too intensive trials, and of producing false heat without ovulation.

The external manifestation of heat is now called "Psychological Heat" as it appears to be the outcome of a mental stimulus, whereas the phenomena which take place in the ovario-genital tract are called "Physiological Heat".

The distinction exists and has been observed and commented upon by many workers. It makes critical analysis of many publications dealing with oestrus in the mare very difficult as the 'psychological heat' may be artificially induced by excessive teasing and is essentially an artefact.

The varying degrees of receptivity and resistance of mares in their reactions in oestrus and dioestrus to the stallion

have/...

have been described by McKenzie and Andrews (1937, 1938, 1939, 1941) and the methods they described have been employed, in part, to classify the psychological behaviour of the Thoroughbred mares under observation. These reactions have been recorded and reflected in the form of a graph.

An ordinary Basuto type horse was used as a teaser stallion. Teasing of all mares was performed once daily during the early morning. The teaser stallion was ridden to the paddocks by the studgroom and teasing conducted over the rails. The mares were collected and brought to a corner of the paddock where they were caught and individually brought up to the teaser stallion.

Rectal examination was performed on the spot and those considered right for breeding brought to the stables for service. Here they would be teased again to accustom them to their surroundings before being twitched, hobbled and the perineal region cleansed prior to service.

The criteria on which it was decided whether the mare was right for breeding will be discussed in detail later, but was based mainly on the degree of receptivity to the attentions of the stallion, the degree of hyperaemia of the vestibule and os uteri, the extent of relaxation of the cervix, and the presence of a Graafian follicle in the ovary.

The external manifestations of heat i.e. the psychological response of the mare to the teaser stallion are recorded, classified and reflected in the form of a graph in the following manner:

XXX VERY RECEPTIVE: The mare approaches the stallion on her own. She is very persistent and refuses to go away. The mare straddles, raises tail, urinates, ejects mucus and exposes the clitoris by raising and lowering it i.e. she "shows".

XX/...

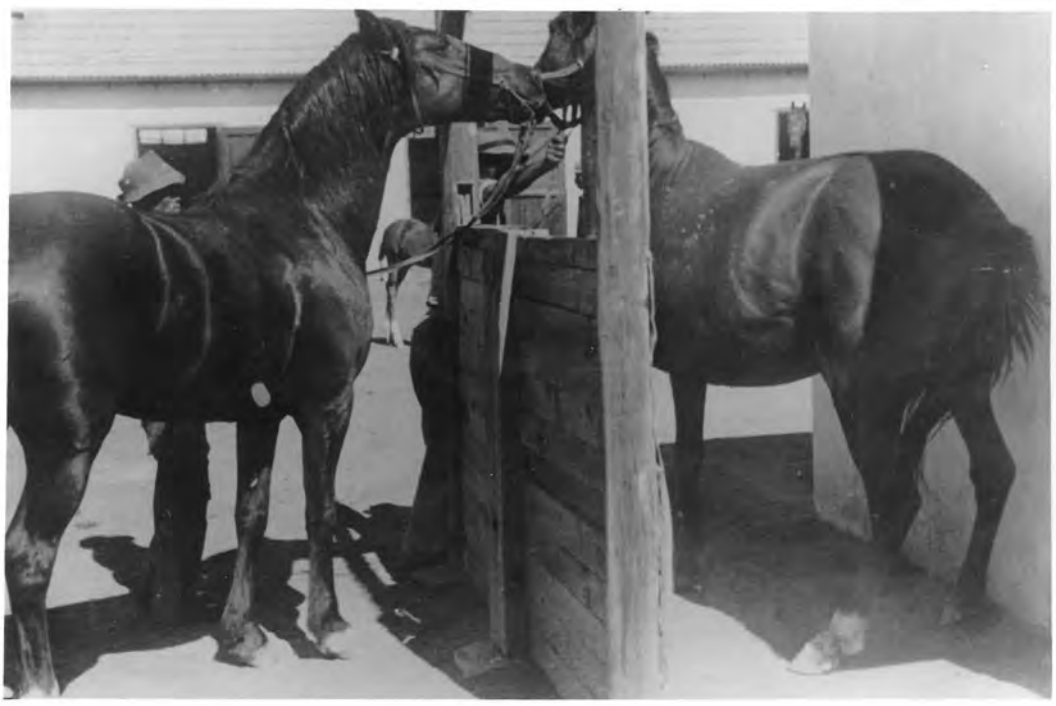


FIGURE 19. TEASING IN CRUSH PRIOR TO SERVICE. PHOTO 17 - 18. TEASING OF DRY MARES IN PADDOCKS.

XX MODERATELY RECEPTIVE: The mare may approach the stallion on her own free will or when confined the mare stands. She may or may not urinate. She permits the teaser to smell her, exposes the clitoris and raises tail, but is soon distracted and loses interest.

X MILDLY RECEPTIVE: After some initial objection the mare allows the stallion to nuzzle her, exposes the clitoris and raises tail slightly but then loses interest.

---

0 PASSIVE: The mare stands, allows the stallion to approach and nuzzle her. Does not urinate, 'show' or urinate and appears completely indifferent.

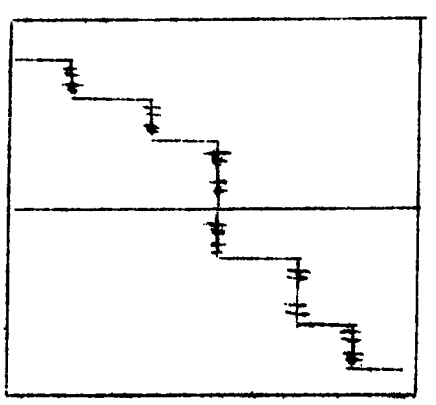
\- MILDLY RESISTANT: The mare stands, allows the stallion to approach her, but on nuzzling moves away. She does not urinate, but may raise the tail and 'show' slightly. She does however object to his attentions.

-- ACTIVELY RESISTANT: The mare objects to the stallion's approach and furiously resents his attentions. Does not urinate or 'show', clamps down the tail and keeps moving away from him.

--- VIOLENTLY RESISTANT: The mare resents the stallion vigorously and often viciously. Bites, chops, and lashes out at him. She refuses to stand, does not urinate or 'show' and clamps down her tail. She frequently screams and ejects small amounts of urine in temper and is in a furious rage.

PSYCHOLOGICAL REACTION.

Each square represents one day.



3. XXX Very receptive.
2. XX Moderately receptive
1. X Mildly receptive
0 Passive - Indifferent
1 - Mildly resistant
2 -- Actively resistant
3 --- Violently resistant

O B S E R V A T I O N S.

1. ANATOMY AND PHYSIOLOGY OF THE GENITALIA OF THE THOROUGHBRED MARE.

A. THE OVARIES.

(I) The normal Ovaries.

A detailed description of the anatomy and topography of the genital organs of the mare is given by Schmaltz, (1911, 1921); Ellenberger and Baum, (1932); Sisson, (1938) and Williams, (1943), so that it will only be necessary to make a few general statements.

a. Position of the Ovaries.

Review of the Literature. Sisson (1938) states that normally the abdominal viscera deflect the ovaries transversely in each direction to the full limit of the broad ligament, but as a rule, except during pregnancy, they remain in contact with the lumbar wall of the abdomen and do not hang among the adjacent viscera. He states furthermore that they may be 5 cm. (ca 2") from the extremity of the corresponding arm of the uterus or in contact with it. The average distance from the ovaries to the vulvar orifice is about 50-55 cm. (ca 20 - 22") in a mare of moderate size. Small ovaries are usually located more dorsally on each side of the vertebral column, and medium sized ovaries on a level with the tips of the uterine horns.

Clinical observations. The position of the ovaries in the non-pregnant mare was found to be extremely variable and depended to a large extent on the amount of food present in the bowels and the distention of the bladder. In many mares it was necessary to empty the rectum before palpation could be performed, and in others it was necessary to push the viscera away from the pelvic cavity to allow palpation of the uterine body. These manipulations altered the existing topographical relationship to such an extent that no significance could be attached to the findings.

During/...

During pregnancy, as will be discussed later, the gradual increasing weight of the developing foetus, exercises continuous traction on the broad ligaments, drawing the ovaries downwards and forwards until they were out of reach. Grasping the broad ligament and drawing the ovaries within reach could not be performed in these Thoroughbred mares, because of their high degree of sensitivity and their violent reactions to this method of examination. This difficulty was experienced in the mares PROTECT and DISTANCE. Both were small and highly strung and resented rectal palpation of the genital organs. In both these mares the one ovary could not be drawn within reach during early pregnancy.

Ovarian palpation was not carried out throughout pregnancy as it fell outside the scope of this study.

The following observations are recorded:-

TABLE 12.

Name of Mare	Date last service	Date both ovaries out of reach	Length of Gestation
Audition	10/ 9/52	14/1/53	126 days
Barcarolla	4/12/52	21/3/53	107 days
Kings Flame	21/11/52	26/2/53	98 days
Pavane	25/ 9/52	15/1/53	112 days

In several mares the ovary of the pregnant uterine horn disappeared before the other ovary. These particulars are given as follows:-

TABLE 13/...

TABLE 13

Name of Mare	Date last service	Date ovary of pregnant horn out of reach	Length of Gestation
Calamity Jane	24/11/52	27/2/53	96 days
Castania	10/10/52	15/1/53	97 days
Distance	29/12/52	27/2/53	60 days
Fata Morgana	7/11/52	27/2/53	113 days
Protect	13/12/52	18/2/53	67 days

After foaling, involution of the uterus occurred rapidly and the broad ligament contracted correspondingly. On about the 4th day after foaling the uterine horns were as a rule conical in shape, with a base measuring about 4 inches in diameter (Hattie Hart, Flora Sandes, Blue Vision, Kings Flame, etc.) on which summit the ovary was found perched, more or less level with the brim of the pelvic inlet. With further involution of the uterus, the horns were drawn into the pelvic cavity and the ovaries slowly reached an antero-dorsal position from the extremity of the corresponding horn of the uterus.

The uterus shrank until it reached the normal stage of the non-pregnant mare and in this manner allowed the gradual return of the ovary to its usual sublumbar position. This was found to be the case in all non-pregnant mares at the beginning of the breeding season.

Because of the restricted breeding season mating was frequently performed before return to the normal postion had taken place. Where for instance conception followed service during foalheat, it was observed that there was only a partial return of the ovary to the normal position before the increasing weight of the developing uterus and foetus drew it once more downwards and forwards. This was the case in Hats Off 2nd, Blue Vision and Kings Flame.

In/...

In other cases there appeared to be a marked reluctance on the part of the uterus to contract and this prevented the ovaries from returning to their normal resting postion. This delayed involution has been advanced as a possible cause of infertility. The mares Protect and Barcarolla showed this delay in involution to a marked degree. In both mares the ovaries did not return to a dorsal lumbar position, but both conceived and carried the foetus to full term.

Götze (1949) mentions that large ovaries usually sink down because of continued traction of their weight and are found ventrally in the abdominal cavity. This condition has not been encountered in Thoroughbreds and was not observed in these studies. At no time were ovaries found ventrally in the abdominal cavity except during pregnancy.

Furthermore, Götze states that this condition may occur where prolonged pathological enlargements have taken place. No such case was observed in the mares under observation, but one case was seen in the Newmarket area in Suffolk, England. This Thoroughbred mare had one cystic ovary, the size of a small football which was removed through the flank. This ovary was suspended from a long mesovarium, and was situated ventrally in the abdominal cavity.

Conclusion. The position of the ovary was found to be extremely variable and dependent upon many intrinsic factors, e.g. cystic degeneration, and extrinsic factors such as bowel or bladder distention suring various stages of pregnancy, and displacement during the actual process of rectal examination.

b. Shape of the Ovary.

Review of the literature. In the new-born foal the ovaries are large, soft and oval, but as growth proceeds the ovary gradually becomes bent until it assumes its definite curved bean- or kidney-shape. This is explained by Küpfer (1928) as being the result of a

deforming/....

deforming process, caused by a local growth of ovarian tissue starting at the poles with a consequent protrusion of the polar ends beyond the middle portion bending the ovary in the middle.

Clinical observations. The alterations in the shape of the ovaries have been diagrametically represented in the examination records of each mare. These changes were found to be dependent upon the activity of the organ, and showed wide variations within a comparatively short time. Where the ovary was not functioning and became completely retracted, small and hard it resembled as a rule the kidney-shape described in the literature.

Such retracted, non-functional ovaries are referred to as "static ovaries of deep anoestrus" by Burkhardt (1947, 1948) and other workers, when accompanied by anoestrus. This term was found unsatisfactory during this study because the condition may be encountered in one ovary, while the other one is functioning normally, e.g. Ornament. It was also encountered in a Thoroughbred mare where the one ovary had been removed. She was left with one small, hard, non-functioning ovary but has remained in heat for the past two years.

It is proposed that the term 'involuted ovary' be introduced to indicate the ovary which has shrunk completely to a solid, hard, organ, in which no sign of activity, such as the formation of a follicle or follicles, can be detected and which seems to have its function completely suspended. This condition is encountered after a certain period of gestation has been reached and details of this are given under the discussion on the size of the ovaries. The return of the functional ovary to the non-functional 'involuted' form is found in many non-pregnant mares, which are subjected to the rigours of a harsh winter and which run out on the veld.

Mares/...

Mares stabled during the winter months and which receive some additional feed usually have a partially developed ovary which can be regarded as 'static' or as being in an arrested state of development. This condition has been referred to as the 'static ovary of shallow anoestrus' by Burkhardt and others, because they were able to induce oestrus by a variety of stimuli. Experience with this type of ovary revealed that they contain follicles, heat periods may even occur, but ovarian development does not progress and the follicles do not mature. Quinlan and others (1951) found that service during the winter months proved sterile. It is proposed that the term 'static ovaries' be reserved to indicate those that have reached a certain stage of development and in which palpable follicles are present irrespective of the presence or absence of oestrus. The main characteristic of such ovaries is that they fail to shrink or grow in size and that the follicles fail to mature, viz. the organ remains in a state of arrested development. Such 'static' ovaries were observed in the mare Frescoe, which was brought into oestrus with Pregnant Mare Serum. In the mare Contrast, uterine distention failed to have the desired effect and the ovaries remained static. The mare Wyndsong showed half-hearted ovarian development which then became static and eventually regressed until the ovaries were completely involuted. All three mares had foaled during the 1952 breeding season and it is considered that maternal instinct and the suckling reflex were the reasons for the partial to total, suppression of ovarian function.

Ovarian shape was found to be dependent upon functional activity. Where only one tertiary follicle developed and did not reach an excessive size, the shape was not altered to any large extent e.g. Flora Sandes on 22/12/52. Where only one follicle formed it was usually found on the anterior pole of the ovary and if it became large in size the ovary became pear-shaped, as was

the/...

the case with Blue Vision on 30/10/52 and Fata Morgana on 6/11/52. An ovary under intense hormone stimulation alters considerably in shape. Such an ovary was observed in the case of Calamity Jane where repeated injections of Pregnant Mare Serum caused the formation of multiple follicles and in this manner distortion of the ovary.

As a rule multiple tertiary follicles formed in one or both ovaries during the breeding season, and the ovary became swollen, gorged, and variable in shape. Several follicles distended the surface and were recognised as palpable protuberances, but the number so distinguished is no indication of the actual number developed within the ovarian stroma itself.

The writer, while working at the Equine Researoh Station, Newmarket, England, during the 1950 season, had occasion to make repeated visits to the horse abattoir at Cambridge. Rectal examinations performed prior to slaughter made it clear that when only one or more superficial follicles were palpable, there were considerable numbers, up to 12, within the ovary itself in various stages of development. This was found to be the case as well in Thoroughbred mares post-mortemed subsequently in this country.

The rupture of a small follicle did not alter the total shape of the ovary to any appreciable extent. Where the follicle had reached a very large size and in all probability compressed all other follicular development, its rupture caused a dramatic change in shape. This was well illustrated in the case of the mare Olive Grove. On 12/2/53 she had a large watery follicle of 10 cm. size, which burst after handling. The ovary measured $5\frac{1}{2}$" x $4\frac{1}{2}$" x 3" before the rupture, after which only a strip of ovarian tissue, measuring 1" x $\frac{1}{2}$" x $\frac{1}{2}$" could be felt on which could be felt the soft and flabby walls of the previous follicle.

Conclusion/...

Conclusion. The shape of the ovary was found to be dependent upon its functional activity. Where the ovary had returned to its resting state by maximal contraction it assumed the kidney-shape described in the literature. The term 'involuted ovary' is introduced to describe this state.

In other cases follicular development had occurred to a certain extent. The ovary is soft and swollen, and the shape variable, but further development had been arrested. The term 'static ovary' is applied to this development.

The rhythmic functioning of the normal ovary, with its alternating formation of follicles and corpora lutea, results in an ever changing pattern of size and shape, which can be strikingly seen in the individual records of each mare. These records show clearly that the ovaries of these Thoroughbred mares are highly elastic organs, capable of great distention and contraction and that the shape is dependent upon the stage of its functional activity.

The figures of measurements encountered in anatomical and other textbooks, are misleading in so far as they create the impression of a standard of normality in size, shape and consistency which can not be supported by these observations.

c. Consistency of the Ovary.

Review of the literature. Williams (1943) states that the ovary in the young mare is rounded and fleshy, becoming smaller and firmer as age advances.

They are described as small, flat and very firm in consistency during complete anoestrus as in the case of racing mares, mares suckling foals (Burkhardt, 1948), late pregnancy (Cole et al. 1931), and age (Williams, 1943).

Samodelkin (1939) states that the consistency of the ovary is firm during the resting stages, and during oestrus it

enlarges/...

enlarges and becomes wholly or partially elastic. The next stage is the softening of the elastic parts, and fluctuations on pressure indicate impending ovulation. The softness persists for 24 hours after ovulation and subsequently the ovary becomes firm again.

Day (1940) describes that after ovulation the collapsed walls of the follicle felt soft and flabby, and an indentation could be felt on the surface of the ovary. Within about 8 hours after ovulation the collapsed walls of the follicle were redistended by blood which accumulated in the cavity of the follicle and at this stage the ovary felt soft and spongy.

Clinical observations. From the previous observations it is clear that considerable differences exist in the consistency of ovaries of even the same mare within a very short period of time and that the organ does distend and contract with great facility.

During its maximum contraction the organ was found to be firm, and contained no soft points of any description. The term 'involuted' is preferred to the description of the 'hard ovary of deep anoestrus' given by other workers. That this so-called deep anoestral ovary can spring into productive life within an amazingly short period, is well illustrated in table No. 14 dealing with the alterations in size.

When the ovary became active, infiltration and softening of its texture took place without the formation of any palpable follicles. Sooner or later the tertiary bladder-like follicles appeared, but further development may through various factors, become arrested. This condition is preferably called the 'static' ovary as it had functioned, but, at this stage remains between retrogression and further development. Ovaries at this stage felt fairly soft and elastic.

When maturation of the follicles took place the consistency altered. If multiple follicular development had occurred the ovary felt nodular and the follicles tense and non-

fluctuating/...

fluctuating. Sooner or later one follicle progressed and as it grew it most probably compressed the others into regression until it stood out distinctly above the surface of the ovary, or reached such a size that it occupied one entire pole of the ovary. In the latter case it invariably softened and became fluctuating like a flabby, watery blister.

After rupture of the normal sized follicle a distinct crater was felt. Where however, the follicle was of a large size and occupied an entire pole of the ovary the change in shape and consistency was considerable and startling. For instance - OLIVE GROVE's left ovary on the 12/2/53 measured 5½" x 4½" x 3" (14.0 x 11.4 x 7.6 cm.) with a 10 cm. follicle on the anterior pole which burst on handling. The remaining ovarian tissue measured 1" x ½" x ½" (2.5 x 1.3 x 1.3) and consisted mainly of a small core of ovarian tissue with the collapsed walls of the follicle feeling soft, loose and flabby. After formation of the blood clot it felt soft and crunched slightly on palpation. As the blood clot luteinised so it became spongy and elastic.

Conclusion. The consistency of the ovaries in these mares showed wide variations, which again were dependent upon the stage of their functional development. The concept is advanced that the ovary of the Thoroughbred is a highly elastic organ, capable of contraction to a small, solid structure in all probability without functional significance. When it becomes functional the first noticeable sign is swelling of the gland and softer consistency through fluid infiltration of its stroma. The next stage of development is fluid accumulation in the cavities of the tertiary follicles and their appearance on the surface of the ovary, where they become palpable.

The description found in the literature of the 'small, flat, hard ovaries of complete anoestrus' is misleading in several respects as such an ovary is associated firstly, with anoestrus,

secondly/...

secondly, only with racing, pregnancy, age and suckling anaphrodisia, and thirdly, that it only occurs as a bilateral ovarian condition.

These studies reveal that this complete retraction, or 'involution' as it is preferred to be called, often occurred in one ovary only, i.e. unilateral, with the other ovary functioning normally. It was also observed that such an involuted ovary could alter into an actively functioning organ in an amazingly short time.

It must be repeated that a Thoroughbred mare which had one ovary removed, has continuously been on heat for the past two years. The remaining ovary is in the involuted state, which proves that oestrus can be present in such cases.

In these studies the mare Wyndsong had the typical suckling anaphrodisia accompanied by bilateral ovarian involution. Yet she was brought into an apparently normal oestrus by hormone administration, proving that heat can be provoked in the absence of any ovarian development.

d. The Size of the Ovaries.

Review of the literature. Their size varies much in different subjects and they are normally relatively larger in young animals than in adult ones. The gland attains its maximum size when the animal has reached the age of 3 or 4 years (Sisson, 1938; Ellenberger and Baum, 1932, and Williams, 1943).

At this age it is usually fleshy in consistency and about 7 - 8 cm. (ca. 3") long and 3 - 4 cm. (ca 1 - 1½") thick and weigh about 70 - 80 grams (ca 2½ - 3 ounces) (Sisson, 1938).

Williams (1943) gives the average weight about 90 - 120 grams (3 - 4 ounces) and states that they begin to atrophy at 10 - 15 years to become very small and fibrous as age advances. They may shrink to 4 cm. (ca 1½") in the greatest diameter and in weight to 15 grams (ca ½ ounce).

The/...

The functional activity of the ovaries modifies their size and form and Seaborn (1925) notes that the size of the ovaries varies greatly with the oestrous cycle, being much increased during heat. This he found was caused mostly by the development of follicles but partly by a gorging of the lymphatics with a liquid like that in the follicles. This is confirmed by Aitken (1927), Satch and Hoshi (1933), Topp (1937) and others.

Clinical observations. Considerable variation in the size of functional ovaries was encountered at different times in the same mare during the 1952 breeding season. One cannot escape the conclusion that the ovary, when completely involuted, is a firm and solid organ, but, that under specific stimulation it becomes infiltrated with fluids, distends and becomes soft and elastic to the touch. From one to many tertiary follicles form either by specific absorption of fluids into their cavities or by active secretion from certain of their component cells. Examples of this observation are reflected in table No. 14. The ovaries were carefully examined and the length, width (thickness), and height measured by rectal palpation. The length, width and height of the ovaries were recorded in these studies in that sequence. The drawings represent the approximate shape of the ovaries.

Conclusions The size of the ovary was found to be in direct relationship to its functional activity. When completely involuted, whether uni- or bi-lateral, it reached its minimum size, which remained constant for a variable period.

When the ovary became active its shape altered from cycle to cycle, depending upon the number of tertiary follicles formed.

The statement that they have an 'average' weight cannot be reconciled with these findings. The variability is so great that an average weight would merely be misleading. Nor can it be accepted

that/...

that they begin to atrophy at 10 - 15 years, to become very small and fibrous as age advances. No such noticeable decrease in ovarian size was observed in these mares, 13 of whom were 10 years and older. It is possible that with senility of advanced age, ovarian function ceases and the ovary involutes to its minimum size, but such ovaries remain completely functionless. The involution encountered in these mares was of a temporary nature and merely represented a period of dormancy of variable duration after which the ovary became fully functional again.

Table/...

TABLE NO. 14.

	NAME	DATE	OVARY	SIZE	DATE	OVARY	SIZE
1.	CALAMITY JANE	21/11/52	Functional. R.O. Multiple follicles	3" x 3" x 3" 7.6 x 7.6 x 7.6 cm.	22/1/53	R.O. Involuted	R.O. 1½" x 1" x 1" 3.8 x 2.5 x 2.5 cm.
2.	CASTANIA	10/10/52	L.O. functional 1 palpable follicle 5 cm.	L.O. 4½" x 3½" x 3" 11.4 x 8.9 x 7.6 cm.	5/11/52	L.O. Involuted	L.O. 1½ x 1" x 1" 3.8 x 2.5 x 2.5 cm.
3.	FATA MORGANA	6/11/52	R.O. Functional 1 follicle 4.5 cm. 1 follicle 1 cm.	R.O. 4½" x 4" x 3" 11.4 x 7.6 x 7.6 cm.	27/2/53	R.O. Involuted	R.O. 1" x ½" x ½" 2.5 x 1.3 x 1.3 cm.
4.	FLORA SANDES	20/11/52	R.O. Involuted	R.O. 1" x ½" x ½"	9/12/52	R.O. Functional C.F. 3 cm.	R.O. 3" x 2" x 2" 7.5 x 5.1 x 5.1 cm.
5.	FRESCOE	16/10/52	L.O. Functional 1 follicle 4 cm.	L.O. 4½" x 3" x 2" 11.4 x 7.6 x 5.1 cm.	14/1/53	L.O. Involuted	L.O. 1½" x 1½" x 1" 3.8 x 3.8 x 2.5 cm.
6.	HOLY GRAIL	19/11/52	R.O. Involuted	1½" x 1" x 1" 3.8 x 2.5 x 2.5 cm.	19/12/52	R.O. Functional 1 follicle 8 cm.	R.O. 5" x 4" x 4" 12.7 x 10.2 x 10.2 cm
7.	KINGS FLAME	18/11/52	L.O. Functional Multiple follicles	L.O. 3½" x 2" x 2" 8.9 x 5.1 x 5.1 cm.	23/1/53	L.O. Involuted	L.O. 1½" x 1" x 1" 3.8 x 2.5 x 2.5 cm.
8.	OLIVE GROVE	7/10/52	L.O. Involuted	L.O. 2" x ½" x ½" 5.1 c 1.3 x 1.3 cm.	12/2/53	L.O. Functional 1 Follicle cm.	L.O. 5½" x 4½" x 3" 14 x 11.4 x 7.6 cm.
9.	ORNAMENT II	9/10/52	L.O. Involuted	L.O. 1½" x 1½" x 1" 3.8 x 3.8 x 2.5 cm.	16/10/52	L.O. Functional Multiple follicl-es	L.O. 4" x 3½" x 3" 10.2 x 8.9 x 7.6 cm.
		20/9/52	R.O. Functional 10.2 x 7.6 x 6.4 cm.	R.O. 4" x 3" x 2.5"	23/10/52	R.O. Involuted	R.O. 1½" x ¾" x ½" 3.8 x 2 x 1.3 cm.
10.	WYNDSONG	14/10/52	L.O. Functional 1 palpable follicle 3 cm.	L.O. 3½" x 2" x 1½" 8.9 x 5.1 x 3.8 cm.	22/1/53	L.O. Involuted	L.O. 1½" x 1" x ½" 3.5 x 2.5 x 1.3 cm.

e. Structure and Function of the Ovaries.

Review of the literature. The ovary has two smooth rounded surfaces, lateral and medial, two borders and two extremities or poles. The attached border is convex and enclosed in the mesovarial region of the broad ligament; the free border is characterised by a depression known as the ovulation fossa which deepens with age. The anterior pole is rounded and related to the fimbriated end of the Fallopian tube, whereas the posterior pole is rounded and attached to the horns of the uterus by the ovarian ligament.

The structure of the ovary in the mare is peculiar and differs from that of other species, in that it does not consist of a cortex (ZONA PARENCHYMATOSA) in which the follicles are situated and a medulla (ZONA VASCULOSA) which contains the vessels and nerves.

This arrangement is present in the foetus but later the follicles become distributed throughout the interior of the gland and the vascular zone is superficial.

Küpfer (1928) states that in the young adult mare germinal epithelium covers the ovary except at the hilum and that ovulation takes place over any part of the surface, the same as in other domestic animals, but as the animal grows older the poles of the ovary grow out and are covered by peritoneum. The only part of the ovary then covered by germinal epithelium is the ovulation fossa. From this time on ovulation takes place from the ovulation fossa.

Beneath the covering peritoneum is a heavy membrane the TUNICA ALBUGINEA. This is extremely heavy and according to Dukes (1947) makes rectal palpation difficult and expulsion of ovarian follicles, cysts or corpora lutea by digital pressure practically impossible.

It is now generally accepted that the ovary has a dual purpose, the production of the egg or ovum (Ovogenesis) and an endocrine function. Although it possesses a great number of eggs

only/...

only a few reach complete ripening and are liberated. The others shrink (atresia) or degenerate.

The endocrine function consists of the production of important hormones, but the fact should not be overlooked that the ovary itself is the recipient and becomes the re-acting organ to the internal secretions originating elsewhere (anterior pituitary, thyroid adrenals, endometrium).

The production of ova starts early in the prenatal period and commences even during the embryonal period. The superficial germinal epithelium sinks into the deeper tissues of the ovary and forms strings or clumps of germinal cells.

The primary follicle develops from these and contains one ovum (seldom two or more) surrounded by a single layer of follicle epithelial cells. Shortly after birth a further debelopment takes place by the formation of secondary follicles, consisting of the ovum surrounded by a multiple layer of follicle epithelium.

When puberty is reached (12-18 months according to Götze; 2 years to Küpfer) the tertiary follicle (Graafian follicle, ovarian follicle or vesicle) develops by multiplication of the epithelial cells surrounding the ovum and by a special formation of the surrounding connective tissue stroma, known as the Theca folliculi.

The theca is divided into an outer zone of typical stroma cells (theca externa) and an inner zone of epithelioid cells (theca interna). After a certain stage of growth the epithelial cells begin to separate producing a cavity filled with a light brown or yellowish alkaline, albuminous fluid, the liquor folliculi.

In this stage of development the ovum remains in a small hillock of epithelial cells, which project into the cavity and is known as the discus proligerus. The ovum and its surrounding epithelium together are known as the cumulus cophorus or cumulus

ovigerous/...

ovigerous. The epithelial cells around the circumference of the follicle form the membrana granulosa. As the ovarian follicle matures the cumulus cophorus becomes nearly or completely separated from the membrana granulosa.

There is a surprisingly small variation in the size of the ovum which, according to Dukes (1947), is about 0.13 m.m. in diameter, and according to Götze (1949) it may vary from 0.1 to 0.2 m.m.

The great majority of follicles do not reach complete ripening, but undergo a process of degeneration or atresia. Hetzel, quoted by Götze (1949), found that one ovary of a yearling filly possessed 33,000 follicles and a 15 year old broodmare still had 23,000.

Small follicles develop and then become atretic and disappear throughout the later part of prenatal life. From birth to puberty this process is continuous, but the follicles progressively enlarge before regression sets in. Its purpose according to Götze (1949) lies in the influence it exerts on the development of the internal and external genitalia and the formation of the secondary sexual characteristics. The developing and regressing Graafian follicles are the source of the follicular hormone (oestrogens) and in all probability other substances which are essential to the growth and functional activity of the developing mare.

The attainment of sexual maturity is a gradual process. As the ovary increases in size as a whole and the Graafian follicles in particular enlarge, more of the follicular hormone oestradiol is produced. This causes the growth of the tubular genitalia and the mammary gland until the stage of full sexual maturity is reached. Puberty may be defined as the time at which reproduction may occur for the first time but it is not associated with full reproductive function. This occurs later. The age

of/...

of puberty varies with the state of nutrition and climatic factors and is reached much earlier in animals kept in a high state of nutrition (Dukes, 1947).

Küpfer (1928) found in horses, running in the veld in South Africa, that puberty may be delayed until the second year of life and that the oestrous cycle appears only at a certain time of the year. Outside this period and during pregnancy the oestrous cycle is absent.

Quinlan and others (1951) again, found that under the influence of domestication this seasonal appearance of the cycle tends to disappear and heat periods occur periodically thoughout the year.

It is now generally accepted that ovulation in the mare takes place by a spontaneous rupture of the follicle (Küpfer, (1928); Day (1939); Götze, (1949)).

Aitken (1927) states that ovulation always occurs through the ovulation fossa and that the wall of the follicle and capsule of the ovary are left intact.

Küpfer (1928) studied the anatomy of large numbers of ovaries at various stages of the oestral cycle and found that young sexually mature donkeys and horses ovulated on the free surface of the ovary as do cattle, sheep, goats and pigs. He found that the follicles were arranged in rows in the ovaries and particularly active follicular development was observed at the poles. The ovulation fossa according to him, is the result of unequal growth at the poles. These secondary growth processes result in a bending and deformation of the ovary, and that portion of the ovary where ovulation takes place by preference is then found in a depression, surrounded by a wall of ovarian tissue with a thick covering of connective tissue. He claims that the embryological structure and organogenesis of the horse ovary is such, that ripe follicles may appear over the entire surface.

Mirskaya/...

Mirskaya and Salzmann (1935) reported that follicles might start their development in any region of the ovary and after reaching a certain size they stand out markedly above the surface of the ovary and then migrated towards the ovulation groove where complete maturation and ovulation takes place.

(A) Development of the Grafian Follicle.

Review of the literature.

The Graafian follicle within the ovary grows principally by the increased secretion of follicular fluid. This process takes place gradually during the quiescent interval until it suddenly receives an impulse to ripen. This impulse is produced by the follicle stimulating hormone (FSH) secreted by the anterior pituitary and can only take place after the regression of the corpus luteum of the previous ovulation. Ripening or maturation occurs a few days prior to the onset of the external symptoms of heat and usually takes from 2 - 6 days or even longer. (Götze, 1949).

Aitken (1927) found that as many as 15 new follicles might appear during one cycle and that 8 to 9 was the average. This observation is supported by the findings of Küpfer (1928), Satch and Hoshi (1933), Hoshi (1939), and Hancock (1948), who record that a large number of follicles might mature in one or both ovaries at the same time, but that usually one and rarely two ruptured, the others remaining in arrested development or degenerating.

Much divergence as to the size of the follicle at, or just before, ovulation is found in the literature. So for instance Aitken (1927) states it to vary between 4 - 7 cm. in diameter before ovulation; Satch and Hoshi (1933) give a minimum measurement of 3 cm., a maximum of 6.5 cm. and an average of 4.38 cm. on the 6 - 7th day of oestrus; Mirskaya and Salzmann (1935) found the greatest frequency in size between 4.5 and 5 cm. in diameter on the day preceding ovulation, and Day (1940) from 3.0 to 5.0 cm. usually 4.0 cm. at ovulation.

McKenzie/...

McKenzie and Andrews (1937) observed that the average size of the follicle on the first day of heat was 2.7 cm., and 3.2 to 3.8 cm. on the day of ovulation. They found that mares with heat periods longer than the average (5.54 days) tended to develop larger follicles, the average on the 7th day being 4.0 cm. and on the 8th day 5 cm. Hamilton and Day (1945) state that as a rule one follicle gradually increased in size during oestrus and that it reached an estimated diameter of 3.5 to 5 cm. just prior to ovulation. Hancock (1948) records that although one follicle may be found more prominent than the rest it was frequently noted that the former were not invariably destined to reach maturity, regression taking place as oestrus progressed and ovulation resulting from the growth of an initially smaller follicle.

Trum (1950) does not regard the relative size of a follicle as a good indication of maturity as follicles as small as 2 cm. in diameter can rupture as well as a follicle roughly the size of a tennis ball, and which can produce an ovum that will be fertilised and produce a foal. Mature follicles varied in size from 2 to 10 cm. in diameter.

The physical condition of the follicle has also been regarded of diagnostic value in determining maturity and predicting the time of ovulation. Aitken (1927) observed that some mature follicles were very tense as the time of ovulation approached, but that others were decidedly slack, and he states that internal follicular pressure can have very little to do with causing ovulation. Mirskaya and Salzmann (1935), Salzmann (1936) and Day (1940) found that at the beginning of heat the follicular capsule was very tight and became softer towards the time of ovulation, and they conclude that the physical state of the follicle was a better indication of the approach of ovulation than the size of the follicle itself.

Andrews/...

Andrews and McKenzie (1941) conclude that practically all follicles, regardless of size, were taut and firm on the 1st day of oestrus. Those follicles which remained tense throughout the period of examination often became taut as the time of ovulation approached and became of a drumhead firmness. The internal pressure was greatly reduced in some follicles before rupture and they were quite flaccid as in the nature of a partly filled bladder. They explain the difference in the physical condition of various follicles on the day preceding ovulation, in part at least by the fact that examinations were made at 24 hours intervals and some might have been several hours closer to rupture than others and yet have been described as of the day prior to ovulation.

Clinical observations:

(1) The Anoestral Mare.

The appearance, development and ultimate fate of the superficial Graafian follicle was followed in several anoestral Thoroughbred mares. The details are reflected in Table number 15.

TABLE NO. 15

Development of the Graafian follicle in the Pregnant and non-pregnant Mare.

ANOESTRUS: (In the Non-pregnant and Pregnant Mare).

Mare	Ovary	Maximum size G.F. and its consistency	Ultimate fate of Graafian follicle.
Armorial	R.O. L.O.	3.5 cm. Tense 3 cm. Tense	Unknown Regressed and disappeared
Audition II.	L.O.	2.5 cm. Tense	Regressed and disappeared.
Barcarolla	R.O. L.O. R.O.	4 cm. Soft and fluctuating 4.5 cm. Soft and fluctuating Several follicles during early pregnancy in both ovaries. The largest being 5 cm. very soft and watery.	Ruptured and formed a C.L, Regressed and disappeared. Luteinised and formed C.L.

Table Cont/...

Mare	Ovary	Maximum size G.F. and its consistency	Ultimate fate of Graafian follicle.
Blue Vision	L.O.	During early pregnancy 2.5 cm. Tense	Regressed and disappeared.
Calamity Jane	L.O.	2.5 cm. Several follicles tense	Became 4 cm. soft and fluctuating during early pregnancy and formed a C.L.
Castania	L.O.	Both ovaries contained a follicle of 3 cm. Soft.	Both ruptured during the following heat.
Cara Nostra	R.O.	3.5 cm. Soft.	Regressed and disappeared.
Distance	L.O. L.O.	5 cm. Soft and fluctuating. During early pregnancy 6 cm. Soft and fluctuating.	Ovulation without heat suspected and formation C.L. Luteinised and formed C.L.
Flaming River	L.O.	3 cm. Tense	Luteinised and formed C.L. without oestrus.
Flora Sandes	R.O. L.O.	3 cm. Soft During early pregnancy 4 cm. Soft and fluctuating.	Ruptured just prior to coming on heat Luteinised and formed a C.L.
Frescoe	L.O.	4 cm. Soft and fluctuating. Became 4.5 cm. during early pregnancy. Soft and fluctuating.	Regressed and disappeared.
Hats Off II	R.O.	1.5 cm. Tense	Regressed during pregnancy and disappeared.
Hattie Hart	L.O.	Several follicles during early pregnancy in both ovaries. The largest being 4 cm. Tense and thick skinned.	Luteinised and formed a C.L.
Holy Grail " " " "	R.O. R.O. L.O.	3.5 cm. soft but not fluctuating. 1.5 cm. Tense During early pregnancy 3 cm. soft.	Regressed and disappeared. Became 8 cm. during early pregnancy. Soft and fluctuating and formed a C.L. Luteinised and formed a C.L.

Table Cont. /

Mare	Ovary	Maximum size G.F. and its consistency	Ultimate date of Graafian follicle
Kings Flame	L.O.	3 cm. Soft.	Luteinised during early pregnancy and formed C.L.
Olive Grove	L.O. L.O.	During early pregnancy 3 cm. Soft. 10 cm. Soft and watery.	Ovulated and formed C.L. Ruptured on handling.
Ornament II	R.O.	3.5 cm. Soft and fluctuating.	Regressed and then increased in size and ruptured suddenly during following heat without C.L. formation.
Protect	L.O.	During early pregnancy 2.5 cm. Tense.	Regressed and disappeared.
Terai	L.O.	During early pregnancy 3 cm. Soft but firm.	Regressed and disappeared.

Abbreviation: L.O. - Left Ovary
R.O. - Right Ovary
C.L. - Corpus luteum.

Conclusions: From these observations it was noticed that in the non-oestral non-pregnant mare follicles developed which either:-

a. remained tense, regressed and eventually disappeared;

b. became soft, ovulated and formed a corpus luteum;

c. became soft, failed to ovulate, regressed and disappeared;

d. became soft, ovulated and formed a corpus luteum during the following heat.

In the non-oestral pregnant mare it was found that during early pregnancy follicles developed which became large, soft and watery, which either:-

a. regressed completely;

b. ovulated to form a corpus luteum;

c. luteinised without rupturing.

The/...

The luteinisation of follicles under (c) was a very distinct phenomenon. The first indication of failure to ovulate was the gradual thickening of the wall of the Graafian follicle, accompanied by wrinkling as the luteinisation of its internal wall took place. The centre remained soft and fluctuating until the cavity became obliterated by luteal tissue.

(2) The Oestral Mare.

Observations on the size and consistency of the Graafian follicle at the commencement of heat and at the approximate time of ovulation are reflected in Table No. 16.

TABLE NO. 16.

Development of the Graafian follicle during oestrus in the non-pregnant mare.

Mare	Ovary	Size and consistency G.F. during early heat	Size and consistency G.F. approximate ovulation.	Result
Armorial	L.O.	3.5 cm. Tense	No ovulation but luteinised into C.L.	Returned.
Audition II	R.O.	Unknown	3.5 cm. Soft and fluctuating	Conceived
Barcarolla	R.O.	3.5 cm. Soft but does not fluctuate.	4 cm. Soft and watery no ovulation regressed ultimately disappeared.	Returned.
"	R.O.	4 cm. Soft and fluctuating.	4 cm. Soft and watery.	Conceived.
Blue Vision	R.O.	3 cm. Tense	4 cm. Soft and fluctuating.	Conceived.
Calamity Jane	R.O.	3 cm. Tense	3 cm. Tense	Conceived.
Castania	L.O.	4 cm. Soft	5 cm. Soft and fluctuating.	Double ovulation same heat conceived.
"	R.O.	3 cm. Soft.	4.5 cm. Soft and fluctuating	Double ovulation same heat.
Cara Nostra	L.O.	3.5 cm. Tense	3.5 cm. Tense	Not served.
" "	R.O.	3.5 cm. Tense	4 cm. Soft and fluctuating.	Returned.
Distance	L.O.	3 cm. Tense	3.5 cm. Soft, watery and very fluctuating.	Returned.
	R.O.	2.5 cm. Tense	3.5 cm. Soft & fluctuating.	Conceived.

Table Cont./...

Mare	Ovary	Size and consistency G.F. During early heat.	Size and consistency G.F. approximate ovulation.	Result.
Fata Morgana	R.O.	2.5 cm. Tense	3 cm. Soft and fluctuating.	Returned.
	R.O.	3.5 cm. Soft but firm.	4.5 cm. very soft and fluctuating.	Conceived.
Flaming River	R.O.	3.5 cm. Tense	3.5 cm. Soft.	Returned.
Flora Sandes	R.O.	2 cm. Tense	2.5 cm. Soft and water.	Conceived.
Frescoe	R.O.	5 cm. Soft but firm.	5 cm. Soft and fluctuating	Conceived.
Hats Off 2nd	L.O.	3.5 cm. Tense	3.5 cm. Soft and watery.	Conceived.
Hattie Hart	L.O.	3.5 cm. Soft.	Unknown.	Not served.
	L.O.	3 cm. Tense	3 cm. Soft and fluctuating.	Conceived.
Heliotrope II	L.O.	2.5 cm. Tense	4 cm. Soft and fluctuating.	Conceived.
Holy Grail	R.O.	3 cm. Tense	3.5 cm. Soft and fluctuating.	Returned.
" "	L.O.	1.5 cm. Tense	2.5 cm. Soft and fluctuating.	Conceived.
Kings Flame	R.O.	3.5 cm. Soft.	4 cm. Soft and watery.	Conceived.
Olive Grove	R.O.	4 cm. Soft.	4 cm. Flabby.	Returned.
" "	R.O.	4 cm. Tense	4 cm. Soft and watery.	Conceived.
Ornament II	L.O.	2.5 cm. Tense	3.5 cm. Soft & fluctuating.	Conceived.
Pavane	L.O.	4 cm. Fairly tense.	4.5 cm. Soft and watery.	Conceived.
Protect	L.O.	3.5 cm. Soft	3.5 cm. Soft.	Returned.
	L.O.	2.5 cm. Tense	4 cm. Softer	Conceived

L.O. - Left Ovary.

R.O. - Right Ovary.

C.L. - Corpus luteum.

Although several follicles reached the heat period in a soft and fluctuating state, the great majority were firm and tense at the beginning of oestrus becoming softer as time of ovulation approached. The wall of the follicle in particular became very thin and pliable and there was a noticeable drop in intra-follicular pressure at or near the time of ovulation.

The intra-follicular pressure of the Graafian follicle could be distinguished as tense, soft but firm, soft, and soft and fluctuating. The mare Barcarolla had a soft and fluctuating follicle at the commencement of heat; Hattie hart, Castania,

Olive/...

Olive Grove, King's Flame and Protect a soft Graafian follicle; Barcarolla, Frescoe and Fata Morgana a soft but firm follicle and the great majority a tense one.

The size of the follicle at commencement of oestrus varied from 1.5 cm. in diameter, with an average of 3.2 cm. At or just before ovulation it varied from 2.5 cm. to 5 cm. in diameter with an average of 3.8 cm.

At the commencement of oestrus:-

1 mare	had a follicle of 1.5 cm. i.e.	3.3%
1 mare	had a follicle of 2 cm. i.e.	3.3%
6 mares	had a follicle of 2.5 cm. i.e.	20.0%
6 mares	had a follicle of 3 cm. i.e.	20.0%
10 mares	had a follicle of 3.5 cm. i.e.	33.3%
5 mares	had a follicle of 4 cm. i.e.	16.8%
1 mare	had a follicle of 5 cm. i.e.	3.3%
30		100.0%

At or just preceding ovulation:-

2 mares	had a follicle of 2.5 cm. i.e.	6.9%
3 mares	had a follicle of 3 cm. i.e.	10.3%
9 mares	had a follicle of 3.5 cm. i.e.	31.0%
10 mares	had a follicle of 4 cm. i.e.	34.5%
3 mares	had a follicle of 4.5 cm. i.e.	10.4%
2 mares	had a follicle of 5 cm. i.e.	6.9%
29		100.0%

Figure number I is the frequency graph showing follicular size at the commencement of heat and at or just preceding ovulation. It will be observed that the follicle grows larger as ovulation approaches but that this enlargement is by no means very great, or marked. The size of the follicle was found to be extremely variable. No definite relationship could be detected between the occurrence of oestrus and the size of the follicle, and furthermore

it/...

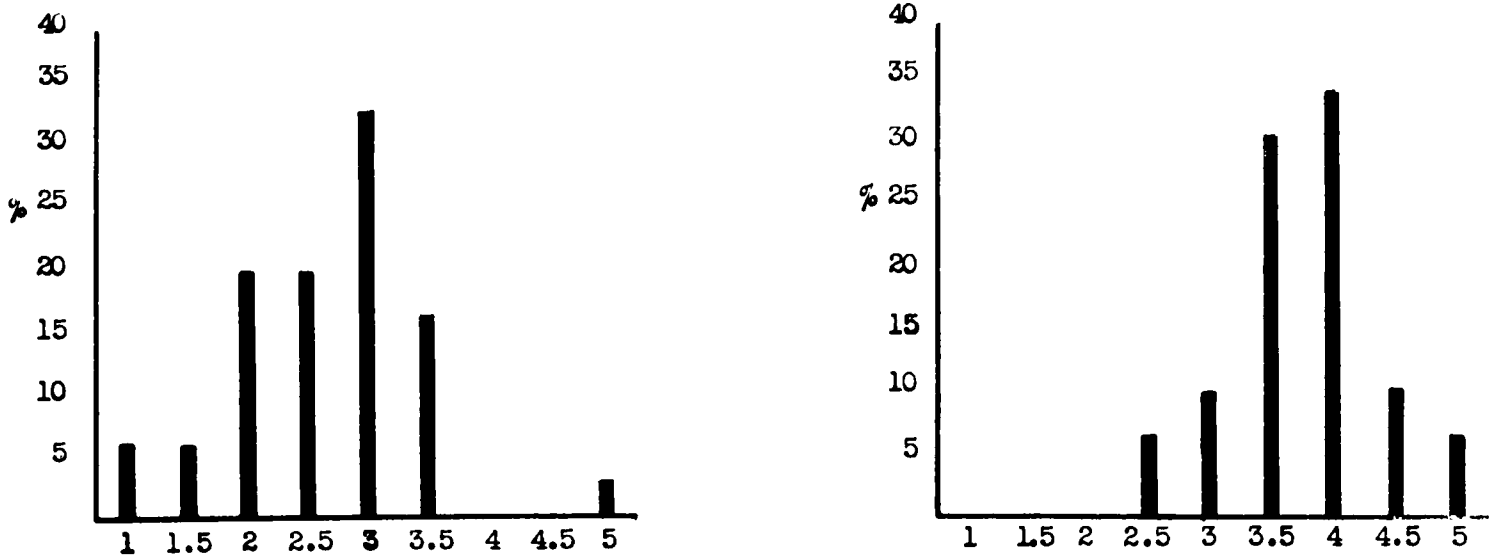


Fig.1. Frequency Graph showing Follicular Size.

it appeared as if the oestrous-producing hormone was not always produced proportionally with the enlargement of the follicle.

(3) Rupture of the Graafian follicle during oestrus. Review of the literature.

A considerable amount of work has been performed to establish the time of ovulation in relation to the length of oestrus in the mare.

Seaborn (1925) states that this may take place during the 5th or 6th day after the onset of heat; Satch and Hoshi (1933) on the 6th or 7th day; Mirskaya and Salzmann (1935) on an average on the 3.84 days; Zivotkov and others (1936) on the 3rd to 6th day, in the majority of adult animals (39 per cent) on the 5th and of young ones on the 6th day; McKenzie and Andrews (1937) found ovulation to occur on an average 4.86 days after onset of heat. Ganz (1939) summarised his findings by stating that the follicle ruptures, in 50 per cent of cases, at the end of 3/5th; and 33.1/3rd. per cent of cases at the end of 4/5th part of a heat period lasting up to 10 days.

Aitken (1927) observed that with heat lasting from 4 to 11 days, there was a possibility of wide variation in the time of ovulation but that it usually occurred during the last or next to the last day of heat. This observation was confirmed by Satch and Hoshi (1933) who found all oestrus indications disappearing 1.6 days after ovulation, and they state that at the earliest it disappears on the day of ovulation and at the latest 5 days afterwards. Zivotkov and others (1936), Day (1940), Hammond and Wodzichi (1941) confirmed previous findings and agree that ovulation occurs mainly at some time during the last days of heat.

Trum (1950) found that 40 per cent of mares ovulated one day prior to the termination of oestrus and 77 per cent ovulated during the last three days of oestrus. He poihts out

the/...

the extreme variation in the time of ovulation in the mare by an observation that one mare ovulated 11 days prior to the termination of oestrus and another as having become pregnant to a service 27 days prior to cessation of oestrus. Crowhurst and Caslick (1946) observed one instance of a mare becoming pregnant to a service 15 days before termination of heat.

Krampe (1936) draws attention to the fact that young, mainly 3 year old, mares often exhibit false heat in early spring and fail to conceive after 3 services. McKenzie and Andrews (1937) and Day (1940) found some mares ovulating after oestrus had ceased.

Observations. Under this group were placed those mares whose ovaries showed follicular maturation and rupture within the period of oestrus. The foal-heat period with its associated ovarian activity is discussed elsewhere and will not be dealt with here.

It will be noted from Table No. 17 that all mares, with the exception of Heliotrope and Terai, ovulated on the last day of heat or the day preceding it, and that all external manifestations of oestrus had disappeared within 24-48 hours after follicular rupture. Both Heliotrope and Terai showed a mild heat for two days after the estimated time of ovulation, and both went off heat on the third day.

Table No. 17/...

TABLE NO. 17

Name of Mare	Date of heat period	Length of heat in days	Normal or induced heat	Estimated day of ovulation	Date of Service	Result
Armorial	5-13/12	9	normal	12/12	7&9/12	Barren
Audition 2nd	8-10/9	3	"	10/9	10/9	Pregnant
Barcarolla	4-5/12	2	"	4/12	4/12	"
Calamity Jane	21-24/11	4	induced	23/11	22&24/11	"
Castania	4-12/10	9	normal	11/10	6&10/10	"
Cara Nostra	10-22/9	13	LH.used	21/9	nil	Returned
	10-14/10	5	normal	13/10	12/10	"
	27-30/12	4	induced	29/12	28&30/12	Barren
Distance	2 - 9/10	8	normal	8/10	4&8/10	Returned
	27-31/12	5	induced	29/12	27&29/12	Pregnant
Fata Morgana	22-26/9	5	normal	25/9	24/9	Returned
	2-8/11	7	"	7/11	4&7/11	Pregnant
Flaming River	20-23/11	4	" l	22/11	22/11	Barren
Flora Sandes	19-23/12	5	induced	22/12	20&22/12	Pregnant
Frescoe	23-24/10	2	" and LH.used	24/10	24/10	"
Hattie Hart	22-26/11	5	normal	25/11	23&25/11	"
Heliotrope 2nd	9-15/9	7	"	13/9	12/9	"
Holy Grail	15-22/9	8	LH.used	21/9	20/9	Returned
	27-11-3/12	7	normal	2/12	29/11 & 2/12	Pregnant
Olive Grove	26-29/10	4	"	29/10	28/10	"
Ornament 2nd	16-22/10	7	LH.used	17/10 & 21/10	17&21/10	"
Pavane	20-26/9	7	normal	26/9	22&25/9	"
Protect	8-15/12	8	"	14/12	10&13/12	"
Terai	12-17/9	6	"	15/9	14/9	"
Unconcern	14-19/11	6	"	18/11	15&18/11	"
Wyndsong	27-28/9	2	"	28/9	nil	Anoestrus

luteinising hormone

These observations confirm the work of Aitken (1927) and others that in the majority of cases heat ceases within two days after rupture of the Graafian follicle. The extreme variability in the length of oestrus makes it impossible to arrange mating in such a manner that ovulation and service are to coincide to

obtain/...

obtain the highest fertility. As has been discussed previously, the size and physical consistency of the follicle was found to have no direct relationship on its maturity, so that rectal palpation is unable to assit in predicting with any degree of accuracy the time when ovulation will take place. For practical purposes it is generally accepted that when a mare remains on heat 48 to 72 hours after service, the follicle could not have ruptured. It forms one of the reasons why breeding is performed every second or third day to ensure the presence of a fresh supply of semen in the genital tract when liberation of the ovum takes place.

(4) Failure to ovulate during oestrus.

Review of the literature. The fact that ovulation may not occur during oestrus was known for some considerable time (von Oettingen, 1909), but its significance as a major cause of equine infertility has only been appreciated by the observations of Day (1940), Hancock (1948), and others,

Observations. Failure to ovulate during the heat period was noticed on several occasions, details of which are tabulated in table number 18.

TABLE NO. 18

Name	Heat period	Length	Induced normal	Fate of follicle	Service Date	Result
1. Barcarolla	4-8/10	5 days	normal	Regressed	Nil	Not pregnant
"	15-19/11	5 "	"	"	17/11	"
2. Flora Sandes	23-24/11	2 "	"	"	Nil	"
3. Ornament 2nd	11/9-4/10	24 "	"	Ruptured during next heat	13/9	"
4. Unconcern	Although exact details of examination are not available for this mare, it is believed that she failed to ovulate during her heat periods of 27/9-6/10 and 21/10 - 27/10.					

In /...

In these cases the mares FLORA SANDES and ORNAMENT 2nd failed to ovulate during one heat, and the mares BARCAROLLA UNCONCERN failed to do so during two consecutive heats. In all four mares heats, with ovulation, followed and each mare conceived. During the 1952 breeding season 22 mares had 39 heat periods (Table 35) of which 6 were anovulatory or 15.4 per cent. The number of heats do not include foal-heats which are regarded by Horse-breeders' as different from the ordinary oestrous periods. The subject of foal-heats will be discussed later but, it may be mentioned here that in 22.2 per cent of foal-heats no ovulation occurred.

Failure of the Graafian follicle to rupture during heat is explained by insufficiency, or absence, of the luteinising hormone of the anterior pituitary, and this aspect will be dealt with later. Sufficient data and indications are, however, available to accept as a fact that failure to settle early in the season, or failure to conceive in very young mares is mainly due to inability of the follicle to ovulate. It is also known that as the season progresses the position improves by the mares conceiving more readily.

There can be little doubt that this form of ovarian dysfunction is of considerable importance in Thoroughbred breeding where aging rules, and the peculiar demands of the racetrack, have created an aritificial and restricted breeding season, during which short period the highest fertility must be obtained. Whether this condition is equally important in other breeds of horses is doubtful. In the Percheron, Arab, and other Saddlehorse studs in this area, breeding usually commences during November and is carried on to February or March with a consistent high fertility of over 90 per cent. I have observed that in these breeds conception eventually takes place although repeated services during several heats may be required in some mares before pregnancy is finally established.

(5)/...

(5) Ovulation in the absence of oestrus.

Review of the literature.

Failure to show heat is usually associated with the shy breeder and is frequently referred to as "silent heat" amongst horse-breeders. The condition is described by Sharpe (1930), McKenzie (1937, 1938), Day (1940) and Hancock (1948).

Day (1940) describes such mares as a trouble-some group which ovulate regulary showing all the physiological changes of oestrus in the vagina and cervix, but, which will not show the psychological manifestation of oestrus when tried with a teaser. He states that mares like this will behave the same way in successive years, either when barren, or as foaling mares, and remarks that the only way they are bred at all is by the studgroom seeing them 'show' to other mares in the paddock, and by the fact that they relax and are quiet in the serving yard when he handles them behind.

Observations.

1. The mare BARCAROLLA ovulated suddenly on the 7/11/52 in the absence of any symptom of heat. She had been on heat on 4 to 8/10/52 and came back into season on 15 -19/11/52 after an interoestral period of 37 days. At the time of ovulation there were no vestibular, vaginal or cervical changes indicative of heat present, so that this condition cannot be regarded as one of 'silent heat'.

2. The mare CASTANIA had a heat period from 4 - 12/10/52, during which she ovulated in the right ovary. She went off completely but ovulated again in the left ovary in the absence of any external signs of oestrus on 13/10/52.

3. Whereas ovulation in 1 above occurred spontaneously and unrelated to any development of the tubular genitalia, the mare FLORA SANDES ovulated on 9/12/52 and came on heat

10 -/...

10 - 11/12/52, i.e. one day after the actual ovulation. In her case it may be regarded as 'silent heat' as psychological heat was scarcely detectable, but vaginal inspection revealed maximum development of the tubular genitalia. Service was performed on 10/12/52, but proved unsatisfactory and the mare subsequently returned.

4. Ovulation occurring during early pregnancy, and in the absence of any manifestations of heat, will be discussed under pregnancy. Its incidence is recorded in Table No. 15 and it will be noticed that the mare OLIVE GROVE ovulated after pregnancy had been established.

(6) Multiple ovulation during oestrus.

Review of the literature.

If the incidence of twinning is taken as evidence of multiple follicular development with double ovulation, Uppenborn (1933) considers twinning to occur in about 1.5 per cent of cases, and remarks that the viability of the foals born is so low that only 13.8 per cent reach the yearling stage. Mauch (1937) supports these findings and found twins to occur in 1.23 per cent of cases, but states that 65 per cent are born dead.

Hancock (1948) observed multiple ovulation in normal cycles in 15 per cent of cases, which is much higher than the 3.8 per cent reported by Andrews and McKenzie (1941), but is only about one half that recorded by Burkhardt (1948) who found evidence of its occurrence in 27 per cent of approximately 80 mares examined at autopsy.

Koroljkov (1951) found that of 8252 mares which conceived to one service, multifoetation occurred in 266 (3%), 16 mares produced 2 viable foals, 199 mares aborted both foetuses, 21 mares produced 2 stillborn foals, 17 mares had 2 weakly foals,

and/...

and 13 mares had only 1 viable foal.

It is generally agreed that in the mare a twin pregnancy most frequently terminates in abortion long before the end of the gestational period (Peck, 1952; Blakeslee and Hudson, 1942, etc.) and that the incidence of twin conception, the result of multiple ovulation, may be considerably higher than has been previously reported.

Observations.

1. The mare ORNAMENT ovulated during the early morning of 17/10/52 in the right ovary in a heat which extended from 16 - 22/10/52 i.e. 7 days. On that day she carried another three follicles in the left ovary which by 20/10/52 had changed considerably, two smaller ones regressing, and the larger one reaching a size of 3.5 cm. on the anterior pole. As the mare had a very prolonged oestrus at the previous heat she was served again during the early morning of 21/10/52 and luteinising hormone (2,000 I.U. Physostab) injected intra-muscularly. She must have ovulated that same day, for by 23/10/52 a corpus luteum had formed which was distinct in outline and consistency. It was noted that the previous ovulation in the right ovary was not accompanied by any luteinisation, the ovary steadily continued to involute until it reached a very small size.

2. The mare CASTANIA ovulated once during her heat period of 4 - 12/10/52 and again ovulated the day after she went out of heat.

3. The mare ARMORIAL in her heat period of 5 - 13/12/52, i.e. during an oestrus of 9 days failed to ovulate in her left ovary. The Graafian follicle luteinised instead, forming a corpus luteum. In the right ovary a follicle matured and ruptured during the same heat on 12/12/52.

4/...

4. The mare DAROR was served once on 12/11/51 during a 4 day heat extending from 10 - 13/11/51 and foaled stillborn twins, a colt and filly on 7/10/52 after 330 days gestation.

5. The mare JINIPET was served once on 30/10/51 during a 4 day heat extending from 28 - 31/10/51 and foaled twins, a colt and filly on 19/9/52 after 325 days gestation. The mare attempted to abort very easily in her pregnancy, but this was prevented by repeated injections of progesterone. The colt was stillborn, the filly died 4 days later from generalised septicaemia, and the mare had a retained afterbirth with purulent metritis.

Discussion. During 1951 twenty-eight mares were served on this Stud of which two (DAROR and JINIPET) foaled twins or 7.1 per cent. Both DAROR and JINIPET had double ovulation in a heat period of 4 day duration, with the production of dissimilar twins, i.e. a colt and filly each. Voloskov (1936) records that in 25-30 per cent of cases during the heat period, ovulation in mares takes place in both ovaries at an interval of 2 -3 days and that the heat period is consequently prolonged. Although no twins resulted from the matings of the 1952 season, the cases of DAROR and JINIPET, as well as experience gained in other studs indicate that double ovulations with result male and female twins are by no means the result of prolonged heats so that the statement of Voloskov cannot be accepted without reservation. There is every reason to accept Burkhardt's (1948) suggestion that a high incidence of twin ovulation represents a seasonal variation in ovarian activity. This may be further qualified by stating that in the Karroo Midlands ovarian activity is subject to the climatic and environmental conditions of the mare, and that a high incidence of twinning can be expected to follow a good season.

The mare ORNAMENT ovulated on the day of service, but a twin pregnancy did not follow. It was noticed that the follicle which ruptured on 17/10/52 failed to develop a corpus luteum.

This/.....

This follicle was the one which failed to rupture during her previous heat of 24 duration, (11/9 - 4/10/52) and it is supposed that when it eventually ruptured on 17/10/52 its content had degenerated and fertilisation could not occur.

The mare CASTANIA was served early during the mornings of the 6th and 10/10/52. She ovulated on 11/10/52 and late during the afternoon or evening of the 13/10/52. She failed to produce twins and it is possible that fertilisation of the second ovulation did not take place as this occurred about 3½ days after the last service, and the spermatozoa had most probably perished by this time.

The mare ARMORIAL is of interest as she had two fully developed follicles present in the ovaries during her heat period. One failed to rupture and luteinised on 9/12/52. The other follicle increased in size and ruptured on 12/12/52.

To avoid twinning in the mare Day (1940) advocates the draining of one follicle by means of a special trocar introduced through the vagina. It is difficult to support this recommendation in view of the fact that both follicles need not rupture simultaneously, but that this may occur at a considerable interval and fertilisation of the second ovulation would not occur if repeated matings are avoided. Spontaneous luteinisation of one follicle may occur; one follicle although rupturing may not contain a viable ovum, and in addition various other intrinsic factors of the genital tract may exist which prohibit fertilisation, or implantation, of the liberated ova, or which may cause the death of the supernumerary ova with the survival of only one.

Perusal of the literature indicates that multiple ovulation during a single heat is by no means uncommon and that its incidence, as determined by rectal palpation or post-mortem examination, may often be considerable. The percentage twins recorded is remarkably constant, ranging well below 3 per cent, 1.5 per cent being/...

being the usual figure, (Uppenborn, 1933; Wagner, 1934), and being very much lower than the occurrence of multiple ovulation.

In Thoroughbred breeding in South Africa all visible abortions, slipping or twinnings are reported to the Jockey Club, and these facts are published in the service records of the stallions for the purpose of estimating his fertility percentage. The first supplement to volume 16 of the General Stud Book of S.A., records 20 twins born out of 2,293 mares bred during the 1952 season or 0.8 per cent. The second supplement to the same volume records 17 twins out of 2,409 mares served during the 1953 season or 0.7 per cent.

The difference between the incidence of multiple ovulation and twinning is ascribed by other workers as due to early abortions, but this assumption is by no means satisfactory or conclusive in Thoroughbred breeding where accurate records exist. The high incidence of multiple ovulation, recorded by Burkhardt and Hancock, was observed by the writer when examining mares slaughtered at the Equine Abattoir at Cambridge, England, during the breeding season of 1950. There can be little doubt that several factors are responsible in preventing multiple pregnancy after multiple ovulation, as no cases of triplets or more can be traced in the literature. This may be due to only one ovum being viable; ovulation may occur at such long intervals that the sperms have lost their fertilising capacity for all the ova subsequently released; one twin or more may perish during early pregnancy through placental encroachment without causing expulsion of the one and only surviving foetus (Errington, 1942); or death of all but one ovum through unknown intrinsic factors which control implantation in the uterus. In multiparous animals, such as sows and bitches, considerably more ova are normally produced than young. The factors which control, or limit the number of fertilised ova for implantation, as well as their regular spacing in the uterine

cavity/....

cavity, are still puzzling investigators in this field of study, and no adequate explanations are as yet available of the intrinsic. and maternal factors governing the intra-uterine survival of mammalian young.

(7) Activity of the right and left ovary.

Review of the literature.

The fact that ovulation does not necessarily alternate between the ovaries was observed by Aitken (1927) who records that out of 19 successive cycles, including 28 ovulations (20 single and 4 double) in 5 mares, ovulation alternated 9 times, repeating in the same ovary 6 times and twin ovulations 4 times.

Andrews and McKenzie (1939) observed in their group of mares that not only were more follicles produced in the left ovary (61.6 per cent in light mares) but that there was a tendency for those on the left to be of greater diameter than those on the right ovary. They conclude that with other species there was no rigid pattern for the order of ovulation.

Hancock (1948) agrees with the observations of Andrews and McKenzie and of Kedrov (1939) and statesthat particular evidence of the superior activity of the left ovary is suggested by the findings with regard to multiple ovulation: simultaneous ovulation of two follicles in the left ovary was noted on 4 occasions, while no multiple ovulation was observed in the right ovary. Amoroso, Hancock and Rowlands (1948) confirm these views and state that ovulation was observed more frequently in the left ovary during early pregnancy, and that their findings are in close agreement with the extensive data of Kedrov.

Observations.

Table number 19 records only cases of successful ripening and rupture of Graafian follicles in non-pregnant Thoroughbred mares. Ovulations occurring during early pregnancy are not included in this record.

Table/...

TABLE NO. 19.

Incidence of ovulation in the right and left ovary.

Name of Mare	Left Ovary	Right Ovary.
1. ARMORIAL	1	1
2. AUDITION 2nd	-	1
3. BARCAROLLA	-	2
4. BLUE VISION	-	1
5. CALAMITY JANE	-	1
6. CASTANIA	2	1
7. CARA NOSTRA	2	1
8. DISTANCE	1	1
9. FATA MORGANA	-	2
10. FLAMING RIVER	2	1
11. FLORA SANDES	-	2
12. FRESCOE	-	1
13. HATS OFF 2nd	1	-
14. HATTIE HART	2	-
15. HELIOTROPE 2nd	1	-
16. HOLY GRAIL	1	1
17. KINGS FLAME	-	1
18. OLIVE GROVE	-	2
19. ORNAMENT 2nd	1	-
20. PAVANE	1	-
21. PROTECT	2	-
22. TERAI	-	1
23. UNCONCERN	1	-
24. WYNDSONG	2	-
TOTALS:	20	20

The/...

The peculiar ovulation that took place in the right ovary of ORNAMENT on 17/10/52 is not included in the table. Although rupture took place there was no formation of a corpus luteum, which indicated that this could not have been a successful maturation of a fillicle. This ovulation was regarded as abnormal and omitted for that reason. The frequency of ovulation between the right and left ovary was found identical in 40 ovulations of 24 Thoroughbred mares. These mares were selected at random and the period of investigation was limited to a single breeding season and confined to non-pregnant mares. Ovulation was found not to occur alternately in the left and right ovary; in addition both had the same power to produce follicles. These observations confirm the findings of Satch and Hoshi (1933) and Day (1940), who arrived at the same conclusions.

(B) Development of the Corpus Luteum.

Review of the literature.

(1) The non-pregnant mare.

Aitken (1927) observed that from external examination it was sometimes difficult to distinguish between corpora lutea and follicles. The character of the corpora lutea changed as they became older. Fresh corpora lutea were often found to fluctuate because of fluid in the cavities, becoming elastic as the fluid coagulated, and rough like "a mass of angle worms under a membrane" as the luteal tissue became folded. He found that corpora lutea were usually one-half to three-fourths of the maximum dimensions of the follicles they replaced. They became noticeably reduced in size from the 6th to 18th day, until during the first part of the following heat period they could no longer be distinguished.

Hamilton and Day (1945) found that at first the follicle is quite tense but within 12-24 hours of ovulation becomes somewhat softened. As the time of ovulation the follicle bursts through the ovulation fossa and leaves a soft depression

in the/...

in the ovary. Within about 8 hours the follicular cavity fills with a blood clot and for the next 10 hours or so is soft and pliable to the touch until by the 24-30 hours after ovulation it is plum-like in consistency. It then becomes firmer and less conspicuous per rectum until by the 4th or 5th day it is no longer palpable except that the ovary with the corpus luteum is normally about twice the size of the in-active ovary.

Rowlands (1949) described the fresh corpus luteum as a blood-tinged fibrinous clot in a spongy matrix. The membrana granulosa is prominent as a thickened lining of 1-2 m.m. in depth and deep red in colour. Luteinisation commences from this membrane. The fully developed corpus luteum is 3 cm. in diameter, dark red or mauve in colour and after section can easily be enucleated from its fibrous theca. They state that the aging corpus luteum can be recognized by its fibrous trabeculæ.

Götze (1949) describes that within 6 hours after rupture of the follicle its cavity becomes partly occupied by a blood clot. The cells of the theca interna rapidly multiply and grow inwards carrying with them the blood vessels. The granulosa cells which have not all been expelled with the ovum hypertrophy, and become laden with fine lipoid droplets. The new structure, the corpus luteum, is a temporary endoctrine structure with important functions. During its functional life it is a highly vascular organ secreting the hormone PROGESTERONE which inhibits the maturation of further Graafian follicles, thus preventing the occurrence of further heat periods for a time. It is essential for the implantation of the fertilised egg and for its nourishment during early pregnancy. When fertilisation does not occur the corpus luteum periodicum regresses after about 10-12 days, although its function ceases before it shrinks anatomically.

(2) The pregnant mare.

Cole, Howell and Hart (1931) report that from conception until the 40th day the corpus luteum of pregnancy persis-

ted/...

ted, and follicles of variable sizes were present in each of the ovaries. From the 40th to the 150th day of pregnancy there was continuous follicular development, and marked luteinisation, and several corpora lutea were present. They conclude that ovulation must occur frequently prior to luteinisation. From the end of the 5th month until late pregnancy large follicles were completely absent with a marked regression of the corpora lutea. At the end of pregnancy the ovaries were entirely lacking incorpora lutea, although minute vestiges of old corpora lutea were observed in most cases. Follicles larger than 1 cm. in diameter were seldom detected at that time.

Amoroso, Hancock and Rowlands (1948) recovered one or more ova from the Fallopian tubes of 9 of 14 mares which were examined when 47-73 days in foal. In all 15 ova were recorded, 9 from the right and 6 from the left Fallopian tubes; three of the latter were found in one tube. The corpora lutea of the whole series were distributed in a proportion of 22-18 between the left and right ovaries. They conclude that there is no reason to suppose that the frequency of ovulation between the ovaries is dissimilar during pregnancy.

Observations.

(1) Formation of the Corpus luteum in the Non-pregnant Mare.

It was found that the alterations which occurred in the ovary subsequent to ovulation, depended to a large extent upon the size and position of the Graafian follicle prior to rupture. If it was an average sized one in a well developed ovary, only a depression was left surrounded by a loose flabby wall. If the follicle was very large and the rest of the ovarian tissue small, ovulation resulted in a flabby mass which was difficult to palpate and differentiate.

The/...

The mare ORNAMENT had a long heat period of 24 days, from 11/9/52 to 4/10/52, during which a Graafian follicle reached a maximum size of 3.5 cm. on the anterior pole of the right ovary, and which eventually subsided. During her next heat of 7 days duration (16/10/52 - 22/10/52) a follicle developed to 3 cm., again on the anterior pole of the right ovary and burst on 17/10/52, but formed no corpus luteum. One is inclined to believe that this was the same follicle of the previous heat, which might have degenerated and failed to luteinise. It may offer an explanation why matings during a prolonged heat are frequently sterile.

Normally the cavity of the ruptured Graafian follicle filled with blood which could be distinctly felt from 8-12 hours after ovulation. At this stage it was soft and spongy and on digital pressure crunched between the fingers. Organisation of the blood clot took place rapidly. Within the next 24 hours it had contracted firmly and felt soft, firm, elastic and doughy to the touch. Althoug it could be easily located and recognised, rectal estimation of its size proved most difficult at this because of its indistinct outline and the softness of the infiltrated ovary.

Luteinisation occurred fairly rapidly and the corpus luteum soon differentiated itself from the surrounding ovary. This was partly due to the growth and formation of the corpus luteum as a distinct entity, as well as to retrogression of the other tertiary follicles, when present, and the consequent shrinking and hardening of the ovary itself.

An estimation of the life of the corpus luteum was difficult to make because its anatomical presence may have no significance if its physiological function has ceased. Nevertheless its presence was recorded in order to make a note of its duration, a matter complicated by the fact that certain corpora lutea sank into the substance of the ovary itself and in this way

could/...

could only be detected as doughy centres without any indication whatsoever of their size. The period during which the corpus luteum could be detected in the non-pregnant mare is given in table number 20. (From Appendix V).

TABLE NO. 20.

Length of period during which the corpus luteum spurium could be detected in the non-pregnant mare. (From Appendix V)

NAME OF MARE.	PALPABLE LIFE OF THE CORPUS LUTEUM
1. ARMORIAL	9 + 10 days
2. CARA NOSTRA	19 + 16 days
3. FLORA SANDES	10 days
4. HATTIE HART	13 days
5. HOLY GRAIL	19 days
6. OLIVE GROVE	8 days
7. PROTECT	16 days

Although the functional life of the corpus luteum is known to be considerably shorter than the anatomical one, it is clear from the above table that its presence can be detected for some period after ovulation. The range in the above-mentioned mares was from 8-19 days with an average of 13.3 days.

(2) Formation of the Corpus luteum in the Pregnant mare.

Götze (1949) does not regard the corpus luteum as being completely autonomous, but definitely under the influence of the inner secretions of the uterine mucosa. Where fertilisation has taken place the rapidly growing egg stimulates the endometrium which in turn prolongs the life of the corpus luteum, and changes it into the corpus luteum graviditatis. This body in the mare he regards as temporary, existing only for about 5 months in the mare, its function being then taken over by the co-operation of the foetal placenta (trophoblasts) and the endometrium (placenta materna).

In/...

In Table number 21 (from Appendix V) the corpus luteum formed from the Graafian follicle which produced the fertilised ovum was traced for some time afterwards. This corpus luteum was designated the persistent primary corpus luteum of pregnancy.

TABLE NO. 21.

The Duration of the Persistent Primary Corpus Luteum of Pregnancy

1.	AUDITION II	The	primary	C.L.	of	pregnancy	exceeded	57 days
2.	BLUE VISION	"	"	"	"	"	lasted	76 "
3.	FATA MORGANA	"	"	"	"	"	"	68 "
4.	FRESCOE	"	"	"	"	"	"	82 "
5.	HATS OFF II	"	"	"	"	"	"	72 "
6.	HELIOTROPE II	"	"	"	"	"	exceeded	83 "
7.	ORNAMENT II	"	"	"	"	"	lasted	86 "
8.	PAVANE	"	"	"	"	"	exceeded	49 "
9.	PROTECT	"	"	"	"	"	"	60 "
10.	TERAI	"	"	"	"	"	lasted	73 "

From the table it is clear that several mares developed and maintained only one corpus luteum after conception, and that its presence could be detected with some degree of certainty for a period varying from 49 to 85 days. The ovary after that period commenced to involute and the presence of the corpus luteum could no longer be detected by rectal examination.

In several mares it was however noticed that this primary corpus luteum regressed slowly and that its place was taken by another corpus luteum, which was formed, either in the same ovary, or more usually in the opposite one. This second corpus luteum was formed either by spontaneous ovulation with subsequent luteinisation or by luteinisation of an unruptured follicle. This second corpus luteum was called the Secondary Corpus Luteum of

Pregnancy/...

Pregnancy and the duration during which its presence could accurately be estimated is reflected in Table number 22 (from Appendix V).

TABLE NO. 22.

Length of period during which the primary and secondary corpora lutea could be detected in the pregnant mare.

Mare.	Duration Primary C.L.	Duration Secondary C.L.	Total
1. BARCAROLLA	20 days	lasted 21-28 days	41-48
2. CALAMITY JANE	15 "	exceeding 57 "	72
3. FLORA SANDES	66 "	" 35 "	101
4. HATTIE HART	43 "	lasted 73-80 "	116-123
5. KINGS FLAME	20 "	" 56-61 "	76-81
6. OLIVE GROVE	46 "	" 73 "	119

The formation of the new corpus luteum corresponded in every respect to the usual course following ovulation, i.e. there was at first a change in the shape, consistency and size of the ovary, the ruptured Graafian follicle formed a fresh corpus luteum which could be detected as such because it was soft at first, crunching on pressure and later becoming organised into a larger, firmer body.

Luteinisation of an unruptured follicle was detected by the gradual thickening of the wall of the Graafian follicle, accompanied by distinct wrinkling as the luteal tissue developed inside. The centre remained soft until filled with luteal tissue when it turned into a firm, doughy body.

The mares Hattie Hart and Barcarolla developed the secondary corpus luteum in the same ovary that produced the primary one.

Calamity Jane, Olive Grove, Flora Sandes and Kings Flame formed the new corpus luteum in the opposite ovary. The

duration/...

duration during which the primary corpus luteum could be detected in the ovary varied from 15-66 days, and the secondary corpus luteum from 21-80 days. The total period during which a corpus luteum was detectable varied from 41-123 days.

In two mares definite indications existed that the secondary corpus luteum of pregnancy receded and that its place was taken by a third body. This is reflected in Table number 23. (From Appendix V).

TABLE NO. 23.

MARE	DURATION PRIMARY C.L.	DURATION SECONDARY C.L.	DURATION TERTIARY C.L.
1. CASTANIA	9 days	23 days	unknown
2. HOLY GRAIL	17 days	52-67 days	unknown

The duration of the primary corpus luteum was from 9-17 days, the second from 23-67 days. The ovary by this time was slowly involuting and the formation of the tertiary follicle was difficult to detect as the outlines were indistinct in an ovary which was slowly becoming firmer. Nevertheless, the presence of such a corpus luteum could be ascertained by careful palpation, being characterised by its firm and doughy consistency.

It was mentioned that the secondary corpora lutea were formed, in the majority of cases, in the ovary opposite to the one that ovulated. This was also found to be the case in the formation of the tertiary follicles and the findings are reflected in Table number 24.

TABLE/...

TABLE NO. 24.

MARE	OVULATION AND FORMATION OF PRIMARY CORPUS LUTEUM	SECONDARY C.L.	TERTIARY C.L.
1. BARCAROLLA	Right	Right	-
2. CALAMITY JANE	Left	Right	-
3. CASTANIA	Right	Left	Left
4. FLORA SANDES	"	"	-
5. HATTIE HART	Left	"	-
6. HOLY GRAIL	"	Right	Left
7. KINGS FLAME	Right	Left	-
8. OLIVE GROVE	"	"	-

It was not clear whether the tertiary corpus luteum was formed by ovulation or merely by luteinisation of a follicle. No conclusion could be drawn from these two cases.

In these studies it was possible to compare the sizes of the Graafian follicles and their subsequent corpora lutea. In the great majority of cases the corpus luteum was found to be either as large as, or smaller than, the follicle which preceded it. Certain exceptions were noted and are tabulated below in Table number 25.

TABLE NO. 25.

NAME	MAXIMUM SIZE OF FOLLICLE	MAXIMUM SIZE OF C.L.
1. BLUE VISION	4 cm.	5 cm.
2. CALAMITY JANE	3 cm.	3.5 cm.
3. CARA NOSTRA	3 cm.	5.0 cm.
4. DISTANCE	3.5 cm.	4.5 cm.
5. FATA MORGANA	3 cm.	5 cm.
6. FLORA SANDES	2.5 cm.	3 cm.
7. ORNAMENT	3.5 cm.	4 cm.

Although/...

Although the presence of a freshly formed corpus luteum could easily be ascertained, it was difficult to estimate its size. Day (1939) found that after 72 hours it could no longer be distinguished from the rest of the ovary. Andrews and McKenzie (1941) found that they were able to distinguish it with ease during the dirst 5 days following ovulation, but after that time it was difficult to locate with any degree of certainty. This was confirmed by Hamilton and Day (1945) who state that the newly formed corpus luteum becomes firmer and less conspicuous per rectum until by the 4th or 5th day it is no longer palpable, except that the ovary with the corpus luteum is normally about twice the size of the inactive ovary.

In these studies periodic examinations following ovulation in non-pregnant mares yielded results which are reflected in Table number 26. In 7 mares, with 9 ovulations, the presence of the corpus luteum could be followed for a period of 8-19 days after its formation. Closer examination of the records revealed however, that, with the exception of Flora Sandes and Protect, the corpus luteum never organised sufficiently to permit of an estimation of its size.

Where pregnancy took place the presence of the newly formed corpus luteum could be detected with ease, but the same difficulty was encountered when attempting to estimate its size. It was further noticed that there was a decided tendency for the corpus luteum to shrink progressively, until it could be detected only as a doughy centre within the ovarian tissue, before gradually making its re-appearance as a structure with well-defined dimensions. To illustrate this point the date of ovulation and date when the corpus luteum first became a measurable entity are reflected in Table number 26. (Appendix V). This table deals with mares that had the persistent corpus luteum of pregnancy.

TABLE/...

TABLE NO. 26.

Interval between formation of corpus luteum of pregnancy and the period it could be measured.

MARE	DATE OVULATION	DATE CORPUS LUTEUM MEASURED	INTERVAL
1. AUDITION II	10/9/52	22/10/52	42 days
2. BLUE VISION	31/10/52	18/11/52	18 days
3. FATA MORGANA	7/11/52	28/11/52	21 days
4. FRESCOE	24/10/52	19/11/52	26 days
5. HATS OFF II	30/9/52	12/10/52	12 days
6. HELIOTROPE II	13/9/52	22/10/52	29 days
7., ORNAMENT II	21/10/52	30/10/52	9 days
8. PAVANE	26/9/52	9/10/52	13 days
9. PROTECT	14/12/52	23/12/52	9 days
10. TERAI	15/9/52	26/9/52	11 days

The interval of 42 and 29 days in the case of Audition and Heliotrope would most probably have been shorter if those mares had been examined at shorter intervals.

The reason for the disappearance and re-appearance of the corpus luteum is most probably explained by the findings of Kipfer (1928) who, on post-mortem examinations, found the centre of a fresh corpus luteum filled with coagulated blood which was later transformed into a gelatinous mass. Absorption of the fluid no doubt contributed to the reduction and withdrawal of the corpus luteum from the surface of the ovary, although it was felt that shrinkages of the ovary itself might play a part.

In the case of pregnancy this reduction and withdrawal was also observed and continued, no doubt, until arrested by the proliferating luteal cells. These cells grow until they slowly fill the available space within the fibrous theca, and in this manner form a distinct, firm, entity which becomes differentiated from the

rest/...

rest of the ovarian tissue and is measurable. As shrinkage of the ovary is accompanied, as a rule, by a reduction of the corpus luteum, it follows that the previous follicular space will become smaller as well, with the result that the luteal cells have a smaller space to fill. Aitken (1927) observed that corpora lutea were usually one-half to three-fourths of the maximal dimensions of the follicles they replace. Hammond and Wodzicki (1941) record that the maximum diameter of the corpus luteum was always less than that of the Graafian follicle. In the group of Thoroughbred mares detailed in Table number 25 seven proved to be exceptions to the above statements. In them the corpora lutea definitively became larger than the follicles they replaced.

The mares, Blue Visions and Distance, received no treatment. Fata Morgana was treated on 13/10/52, 15/10/52 and 31/10/52 for a most persisten discharge. Treatment consisted of 4 ounces Propamidine Intra-uterine (M & B), to which 0.5 M.U. Crystalline penicillin had been added, introduced into the uterus. Calamity Jane was injected with 1,500 units P.M.S. and 1,000 units luteinising hormone on 16/10/52. As she failed to come into season she was given a further 3,000 units P.M.S. plus 25 mgm. Progesterone on 16/11/52. Cara Nostra, on 20/9/52, was injected with 500 units luteinising hormone and another 1,000 units luteinising hormone the next day. Flora Sandes was injected with 2,500 units luteinising hormone on 19/12/52, which dose was repeated on 22/12/52. Ornament was injected with 2,000 units luteinising hormone on 21/10/52.

Of the seven mares, two received no treatment of any description, one received intra-uterine medication, and four were subjected to hormone stimulation of various kinds. There was, however, no evidence that the enlargement of the corpus luteum over and above the size of the follicle it replaced was in any way due to the treatment. The findings of other workers could not

be/...

be supported in this respect, but it must be pointed out that in these Thoroughbred mares the primary corpus luteum of pregnancy only reached its maximum size some considerable time after ovulation. In no instance was a corpus luteum larger than its preceding follicle found during the normal oestral cycles of the non-pregnant Thoroughbred mare.

(2) The Abnormal Ovary.

Review of the literature.

Day (1939) divides cystic ovaries in mares into two groups according to the oestrous cycle: mares which do not come into oestrus, and mares continually in oestrus, or having long irregular oestrous periods. He points out that cysts cannot be distinguished from follicles by rectal palpation, unless the exact time of the oestrous cycle at which the examination was made, is known. In several mares with cystic ovaries, observed by him, through the winter, about half went into anoestrus, and the cysts disappeared, whereas in the others they perished. He comes to the conclusion that cystic ovaries are usually the result of abnormal pituitary stimulation, although in a few cases cystic ovaries appear to occur as a primary condition when the presence of old luteal tissue prevents ovulation.

Burkhardt (1948) points out that many normal non-pregnant mares push up an outsize follicle in autumn. This is often diagnosed as a cyst and is punctured. These follicles regress and subside when anoestrus develops and the blood flow through the ovary diminishes. They do not recur in the following spring. He emphasises that true cystic ovaries are much more difficult to recognise in autumn and winter, and such mares generally enter into a prolonged oestrus in mid-February or early March, and continue to show heat periods of varying durations until the end of the breeding season. True cystic ovaries, on rectal examination, are abnormal both in size and consistency.

The/...

The glands are enlarged and feel like a bunch of unripe grapes. The surface is studded with a mass of small cysts from 1 to 2 cm. in diameter. They may number 30 to 40 in each ovary. They are generally found in mares 15 years old and upwards.

Götze (1949) classifies cystic ovaries as follows:

A. (1) Multiple, small cysts in the ovaries in young mares he regards as primarily the result of faults in feeding and management; in particular insufficient green feed and lack of adequate pasturage. The condition is transitory, i.e. reversible and disappears on pasture.

(2) He quotes Aehnelt and Plas (1946) who regard multiple small cysts in older mares as being the result of faulty feeding and management. They state that the condition may occur at all ages, but most frequently in cold-blooded horses from 10 to 11, and in warm-blooded horses from 13 to 14 years old. These multiple cysts which failed to respond to any treatment, are regarded as irreversible and remained unchanged in the ovaries.

B. (1) Large cysts in the ovaries may occur at all ages. These, he states, may be brought to ovulation and luteinisation by the use of appropriate hormones. There is little doubt that in this condition there is one or more outsize follicle in a static ovary. He draws attention to the fact that large watery follicles are normally present during early pregnancy.

(2) Large cysts in the ovaries which fail to respond to any hormone treatment, and which remain uncahnged in the ovary for years. Götze mentions the incidence of excessive haemorrhage into the follicular cavity following ovulation. Such follicle haematomata or bloodcysts may reach the size of a child's head and retract within a few weeks. Others remain for months and even years.

It is/...

It is evident that the diagnosis of cystic degeneration of the ovary is no easy task. Cystic degeneration may be classified as reversible or irreversible, i.e. those that return to normal function and those that do not: Reversible cystic ovaries are in all probability normal ovaries examined at a certain stage of development.

The question arises whether cystic ovaries exist as a primary condition per se, or whether the condition is invariably secondary, the result of hormonal imbalance or disease.

Hetzel (1938) considers nymphomania to be a neuro-hormonic disease, based upon a constitutional hypersensitivity of the nervous system. He ascribes cysts in the ovary to bacteria, plant poisons or the toxic effects of too rich a protein diet, as well as ovarian inflammation. He thinks these cysts cause an over-production of follicular hormone, which influence the nervous system, with a consequnet change in the behaviour of the animal.

Hesse (1939) examined the fluid found in ovarian cysts of nymphomaniac mares and failed to reveal increased hormone production. He concluded that nymphomania is more likely to be due to cophoritis and neurasthenia.

Hancock (1948) quotes Hignett as stating that nymphomania may be encountered in mares showing no obvious ovarian dysfunction and that ovariectomy frequently failed to terminate this type of oestrous behaviour. Hancock further mentions the possibility that oestrogens may be produced at some other site than the ovary.

Observations.

No cases of nymphomania or cystic ovaries were encountered in these studies. This was no doubt due to the fact that ovarian development was under constant examination and thus the errors of judgment described above were thus avoided. It is evident that many reports in veterinary literature describing

cystic/...

cystic ovaries in the mare, are describing nothing more than normal, functioning organs. To what extent cystic ovaries occur as a pathological condition in the mare is not known, but experience indicates that it is rare in the Karroo Midlands, and mainly confined to mares 15 years old or older.

Nevertheless it was quite clear from these investigations that certain mares failed to show the rhythmic ovarian changes considered normal. These are detailed and discussed below.

a. The Involuted Ovary.

The only case of bilateral ovarian involution occurred in the mare WYNDSONG. She foaled on 20/8/52 and came on heat during 27-28/9/52 for 2 days, during which period she was mildly receptive and was not served. During 12-16/10/52 she came into heat again and was moderately receptive to the teaser. A Graafian follicle of 3 cm. was present in the anterior pole of the ovary and the uterine horns felt flabby and unresponsive. She was served on 14/10/52. Ovulation was estimated to have occurred on 16/10/52 and the corpus luteum was distinct by 17/10/52. She failed to conceive to this service.

By 16/11/52 both ovaries had become very small and firm, showing no activity whatsoever, representing the so-called typical hard flat ovaries of 'deep anoestrus'. It was decided to test out the responsiveness of these organs to hormone administration and the following treatment was applied on that date.

1. 1,000 ml. sterile, warm, normal saline was introduced under pressure into the uterine cavity.
2. 1,500 I.U. pregnant mare serum injected subcutaneously.

3/...

3. 25 mgm. progesterone injected intramuscularly. On 22/11/52 the mare had not come into heat and it was decided to give very small doses of Stilboestrol diproprionate to initiate response. She was given 5 mgm. subcutaneously, and the intention was to give 2.5 mgm. every third day. This proved unnecessary as the mare came into a perfectly normal heat on 24-29/11/52, the tubular genitalia being indicative of oestrus. The mare was so receptive that she was served on the 25th and 28th November. She went off heat and did not return to the stallion that season. The blood test on 7/1/53 proved negative for pregnancy.

During this entire period the ovaries failed to indicate any activity. The refractiveness of an ovary in this condition is well known and has been mentioned by other workers (Day, 1940; Burkhardt, 1948). This case is of interest in that typical oestrous indications, and full tubular genital development, was provoked independently of ovarian development. The condition encountered is the typical deep anoestrus following suckling anaphrodisia. The subsequent breeding record of this mare indicates that the condition could not be regarded as patholological since she bred again. According to the fourth Supplement to the General Stud Book of S.A., Wyndsong foaled twins on 2/8/55. Such mares frequently breed only once every other year.

Unilateral involution of the ovary is of common occurrence. It is usually transient and the ovary recovers full activity within a short time, or remains dormant while the opposite ovary remains functional. Where pregnancy takes place the involuted ovary may not become functional at all for that season.

Unilateral/...

Unilateral involution was observed in the mare ORNAMENT during the period 11/9/52 to 9/10/52, but by 16/10/52 the ovary had become fully functional. In the case of PAVANE one ovary remained functionless until pregnancy was well established. Then under the influence of serum gonadotrophin it became active and produced a follicle. In the case of HELIOTROPE the one ovary remained inactive before and after conception and remained involuted.

b. The Static Ovary.

By this term is meant the ovary which contains a degree of follicular development as distinct from the involuted and firmly contracted ovary discussed under (a). Here one or more follicles are present, but the ovary remains static, i.e. there is no tendency to maturation or regression. The mare may or may not be in heat. The condition is discussed in detail below.

(A) The Static Ovary and Anoestrus.

There were three examples of this type.

1. FRESCOE. This mare foaled on 21/8/52 and came on heat half heartedly during 28-29/9/52. The vulva was firm, puckered up, the vestibule pale and dry and it was consequently decided not to mate her. As she was not intended for observation no rectal examinations were made during this period. It soon became apparent that the mare was not behaving normally. Rectal examination carried out during 8-21/10/52 revealed the presence of follicles but no particular tendency towards maturation and ovulation. The uterus, however, behave normally and was very receptive to handling, contracting readily and firmly. To assist the process 1,500 units pregnant mare serum was injected subcutaneously on 21/10/52. She came on heat during 23-24/10/52, was served on 24/10/52 and 1,000 I.U. Luteinising hormone injected intravenously after service. Follicular rupture occurred during 25/10/52 and

the/...

the mare conceived from this service. Attention must be drawn to the fact that on 21/10/52 one Graafian follicle of 4 cm. diameter was present in the ovary at the time of injection of the pregnant mare serum. This follicle was soft, thin walled and fluctuating. It slowly receded and an initially smaller, firmer and tense follicle in the other ovary matured to 5 cm. in diameter and ruptured.

2. CONTRAST. This mare had foaled on 14/10/52 and was sent as a visiting mare to the Askania Nova Stud. She arrived on 3/11/52 but by 27/11/52 had failed to show any heat notwithstanding daily teasing. The owner had definite objections to hormone treatment and would not give his permission to use them. Only 900 ml. sterile, warm, normal saline was introduced under pressure into the uterine cavity. The mare failed to come into season and on 31/12/52 she was returned without being served. During this period the mare had prominent tertiary follicles in both ovaries and the uterine horns were responsive to handling. The case is of particular interest as all cases of anoestrus treated by intra-uterine dilatation, and hormone therapy, were successful in bringing mares into season. The application of the intra-uterine distension without hormone supplementation failed to bring this mare into heat, although ovarian development and uterine responsiveness were present.

3. CALAMITY JANE. This mare foaled on 6/8/52 and by 16/10/52 had failed to come into season. The uterine horns had completely involuted, were firm, round and symmetrical. A tertiary follicle was present in both ovaries.

A mixture of follicle stimulating hormone and luteinising hormone were injected as suggested by Götze (1949), i.e. 1,500 I.U. pregnant mare serum and 1,000 units luteinising hormone were injected subcutaneously. Intense follicular development/...

ment followed, the ovaries becoming studded with small tense follicles, but there was no tendency for maturation or ovulation to take place. The mare remained violently opposed to any attention of the teaser stallion. (Photo 25).

On 16/11/52 she was given 3,000 I.U. pregnant mare serum, subcutaneously, 25 mgm. progesterone intramuscularly, and 1,000 ml. sterile, warm, normal saline introduced under pressure into the uterus.

The mare came into season on 21-24/11/52 and was served on 22/11/52 as an early ovulation and termination of oestrus was expected. She ovulated on 23/11/52 and was served again on 24/11/52 as she was still well on heat, and in accordance with the usual practice of breeding every second day towards the end of the season. On 7/1/53 the blood test proved positive for pregnancy and the mare foaled on 18/10/53.

(B) The Static Ovary and Persistent or Prolonged Oestrus.

The imported mare ORNAMENT foaled on 21/4/52 and came into season on 11/9/52 until 4/10/52, i.e. for a period of 24 days. She was served on 13/9/52 in accordance with the policy of this stud, i.e. one service on the third day of heat during the first heat period of the breeding season. On 11/9/52 the left ovary was completely involuted and hard, but the right ovary was normal in size, felt soft and infiltrated, and contained a Graafian follicle on the anterior pole. The mare and foal ran by themselves in a small paddock, but oestrus was so intense that she indicated responsiveness by herself.

She abruptly went out of heat on 5/10/52 and the follicle slowly decreased in size from 3.5 cm. to 2 cm. in diameter by 9/10/52 and is believed to have completely retrogressed by the time the next heat period commenced on 16/10/52.

The/...

The interest in this case lies in the fact that heat was present for a prolonged period without any particular ovarian alteration, and that the Graafian follicle failed to rupture.

(C) The Static Ovary and Short Oestrus.

The mare FLORA SANDES foaled on 12/11/52 and came on heat for two days, 23-24/11/52, during which period only one follicle was present on the anterior pole of the left ovary. The follicle was small, 1 cm. in diameter, tense, never developed any further and had disappeared by 19/12/52.

B. THE FALLOPIAN TUBES.

Review of the literature.

According to Sisson (1938) the Fallopian tubes in the mare are 8-12 inches long (ca 20-30 cm). and consist of two flexuous tubes which extend from the uterine horns to the ovaries. The tube is very small at its uterine end (2-3 m.m. in diameter), but towards the ovary it widens considerably (4-8 m.m.), forming the ampulla.

Götze (1949) states that the changes which occur in the mucosa of the genital tract of the mare (Fallopian tube, uterus, cervix and vagina) are entirely dependent upon the ovarian cycle. During maturation of the follicle as well as just prior to and subsequent to ovulation, the entire tubular genitalia, from fimbrial to vulva, undergo a change. They become hyperaemic, soften, swell, and secrete mucus. During this period the Fallopian tubes and uterus contract readily, but the cervical canal and os dilate.

The histological findings of Hammond and Wodzicki (1941) support this statement, but they are of the opinion that the changes which occur in the fallopian tubes during the heat period are less pronounced than those found by Courrier (1930)

in/...

in dogs, bats, swine and guinea-pigs. There is a slight enlargement, both of the sub-epithelial blood vessels and of the epithelial cells. The secretion stage of the latter is not pronounced.

Götze (1949) is of the opinion that the frimbiated ends of the Fallopian tubes approximate the ovulation fossa prior to ovulation and he states furthermore, that in animals with uterine insemination, the cervical function of storage, encountered in ruminants falls away. Because of the great bulk of the ejaculate of the stallion, and the sucking action of the uterus, a portion of the semen is flushed into the uterine horns. This negative pressure, within the uterus during coitus, was recently demonstrated by Millar (1952). The active movements of the spermatozoa are not considered of great importance and only partly assist the entrance of sperms into the Fallopian tubes.

Haard (1946) is of the opinion that the uterine end of the Fallopian tube relaxes and opens during heat until the fertilised egg reaches the uterus. He thinks that the anterior part of the horn of the uterus and the entrance of the fallopian tubes may act as a receptaculum seminis. Sperm progression in the fallopian tubes is believed to take place by active movement, assisted by ciliary action of the epithelium and contraction of the tube itself, as well as being aided by respiratory and bowel movements.

Observations.

Palpation of the Thoroughbred mares under observation failed to reveal any abnormalities. Particular attention was paid to the anterior parts of the horns of the uterus and to the papilla uterina in the non-pregnant mare, but no alteration in size or consistency could be detected during the various phases of the oestrous cycle. In mares that foaled during the 1952 breeding season, the anterior horns of the uterus were very large and

massive/...

massive, and the uterine ends of the fallopian tubes could not be ascertained with any degree of accuracy.

Para-ovarian cysts have often been encountered in Thoroughbred mares. Rectally they feel smooth, firm, elastic, and free from the ovary. On post-mortem they have always been found located in the fimbriated ends of the Fallopian bursa. They have never been found to be a cause of infertility.

Conclusion.

No abnormalities of the Fallopian tubes were detected in these Thoroughbred mares. Para-ovarian cysts, encountered in other Thoroughbred mares, have been found as fluid containing cysts of variable size, located in the fimbriae of the Fallopian bursa. They have never been found to be a cause of infertility. Rectal palpation of the papilla Uterine, i.e. the uterine ending of the Fallopian tube, failed to reveal any alterations in size, shape and consistency during the various phases of the sexual cycle in the non-pregnant or recently foaled mare.

C. THE UTERUS.

Review of the literature.

Sisson (1938) describes the uterus of the mare as consisting of two separate horns, joining posteriorly to form the body of the uterus. It constitutes a somewhat cruciform organ, the horns leaving the body laterally at right angles or slightly recurved. The horns are situated entirely in the abdomen and vary considerably in position. The two horns are commonly unsymmetrical in length and diameter in mares which have borne young. They are about 10" (25 cm.) in length and the anterior extremity of each forms a blunt point which receives the Fallopian tube. The body of the uterus is situated partly in the abdomen, partly in the pelvic cavity, is elliptical in shape, about 7-8" (18-20 cm.) long and about 4" (10 cm.) broad.

Detailed/...

Detailed histological examination of the uterus is given by Schmaltz (1911), but unfortunately he makes no mention during which period of the oestrous cycle the examination was conducted.

Hammond and Wodzicki (1941) performed detailed anatomical and histological studies on several mares destroyed during various stages of the œstrous cycle and in early pregnancy. They found that two days before heat, there are fewer layers of cells in the epithelium than two days after heat, when the epithelial cells are taller and lymphocytes can be seen passing through them. The changes in the size of the lumen of the superficial glands are small but two days after the end of heat they are wide. The become smaller again eight days later. The stages of proper oestrus, which are marked by a widening of the lumen of the uterine glands, are rather like the third month of pregnancy, although not so pronounced. Taken as a whole, Hammond and Wodzicki are of the opinion that the cyclic changes in the uterine mucosa of the mare and sow are not nearly so marked as in those which have a more specialised placentation, e.g. the cow, sheep, rabbit and ferret.

These findings have been confirmed by the observations made by Andrews and McKenzie (1941). They described the histological alterations, occurring in the uterine mucosa during the various phases of the oestrous cycle in mares, from material obtained by the process of curetting small pieces from the endometrium in the living animal.

Compared to the considerable amount of detail available in the literature on equine ovarian function it is surprising to find so little on uterine function and dysfunction. Day (1940) records the relative sizes of developing foetuses and membranes at different stages during early pregnancy, but this work was performed on pony mares. No details of any kind are available for Thoroughbreds.

Observations/...

Observations. Great variation in the size of the uterus was found in the non-pregnant mare and during early pregnancy. For a basis of discussion however, it is preferable to start with the mare that has just foaled.

(1) The Foaling Mare.

1. The mare DAROR foaled on 7/10/52 and whilst giving birth to twins tore badly in the perineal region. As she was 17 years old the owner had her destroyed the same day. Autopsy that evening revealed a strongly contracted uterus lying over the pelvic brim in the abdominal cavity; the walls were wrinkled and fleshy, but the horns measured only about 6" in diameter at the base. Both horns were symmetrical in size and the ovaries were situated between the extremities of the uterine horns and the dorsal abdominal wall, about 8" below the latter.

2. The mare JINIPET foaled twins on 19/9/52 and was destroyed on 2/10/52, i.e. 13 days later, because of old age and purulent metritis. She had a period of foalheat during 26-30/9/52. At autopsy the uterus had contracted further and felt fleshy and firm. The diameter of the base of the uterine horn was about 4", and most of the body of that organ was contained within the pelvic cavity. The uterine extremities faced antero-dorsally and were conically in shape with the ovaries just above their tips. The mesovarium had contracted considerably as the ovaries were about 5" from the sublumbar surface.

3. The mares BARCAROLLA and HATS OFF 2nd were examined rectally seven days after foaling. In both cases the uterus were very big, heavy and doughy. The horns were conical on the body and very firm in consistency. The base of the uterine horns in both instances measured 4" in diameter.

4. Eight days after foaling the following mares were examined rectally:- HATTIE HAT and BLUE VISION both had a

large/...

large symmetrical uterus firmly contracted, the horns being conical in shape and 4" in diameter at the base. OLIVE GROVE had a large symmetrical uterus, but the horns were pendulous although contracting firmly on handling. The diameter of their base was 4". FLORA SANDES had a large unsymmetrical uterus, the left horn being larger than the right. The left horn measured 6" in diameter at its base and the right horn 4". FLAMING RIVER also had a large unsymmetrical uterus, the left base of the horn measuring 5" in diameter and the right base of the horn 4" in diameter.

5. Nine days after foaling KINGS FLAME still had a large unsymmetrical uterus which contracted slowly on handling. The base of the right horn was 4" in diameter and that of the left horn 3" in diameter.

Contractions of the uterine horns continued steadily until the organ reached a comparative small size. In the Thoroughbred where the breeding season is artificially limited to a certain period, complete involution does not always take place by the time early succeeding pregnancy supervenes. Nevertheless the interval between the time of foaling and the time when involution of the uterus appeared to be complete is given in Table number 27.

Involution of the uterine horns took place rapidly in the case of BLUE VISION, HATS OFF 2nd, KINGS FLAME and PROTECT, and was completed within 3 to 5 weeks. The first three mares all conceived during foalheat. The mare PROTECT ovulated 4 days after service during foalheat and failure to conceive during that period was undoubtedly due to inability of the spermatozoa to survive this interval.

ARMORIAL, FLORA SANDES, HATTIE HART and OLIVE GROVE required 6-8 weeks; AUDITION 2nd, BARCAROLLA, FLAMING RIVER, and FRESCOE 9-12 weeks; and FATA MORGANA 17 weeks for both uterine horns to reach minimum size. The minimum size was not always

reached/...

reached by both horns simultaneously, e.g. in the case of AUDITION 2nd and KINGS FLAME the left horn base continued to contract although the opposite horn was already being distended by the developing foetus.

In the case of FATA MORGANA the uterus was so atonic that on 31/10/52 air was aspirated into the uterine cavity during rectal examination. She conceived to a service 75 days after foaling, although the uterus continued to contract for another 41 days.

From the forgoing it is evident that a certain relationship appears to exist between the rate of uterine involution, its tonus and consequent fertility. This aspect has been pointed out before in another publication (Belonje, 1949) where it was claimed that beneficial results were obtained by accelerating uterine involution by administering pituitrin intramuscularly after foaling.

(2) The Non-Pregnant Mare.

No maiden mares were available for observation during these studies and the examinations were confined to foaling mares and non-pregnant mares.

In the recently foaled mare the uterus was found to be heavy, fleshy or doughy to the touch, the body extending over the pubic symphysis and the horns conical in shape directed antero-dorsally. Responsiveness was very small as the organ was still very bulky.

From about the third week the uterine walls had become so thin and pliable that uterine sensitivity could be detected with ease when it occurred. This sensitivity consisted of responsiveness to rectal manipulation of the uterine horns, these organs becoming firmer, circular in outline, turgid and resembling a roll of sponge rubber to the touch. Nevertheless as was shown in

Table/...

TABLE NO. 27.

	Mare.	Foaled.	Approximate date minimum size.	Size.	Approximate interval in days.	Interval between foaling and last service date with conception in days.
1.	ARMORIAL	7/11/52	28/12/52	RHB 2" LHB 3"	51	Not pregnant
2.	AUDITION 2nd	3/8/52	22/10/52	Contraction LHB 2"	80	38
3.	BARCAROLLA	27/9/52	3/12/52	RHB 2½" LHB 3"	67	68
4.	BLUE VISION	20/10/52	18/11/52	RHB 2½" LHB 2½"	29	11
5.	FATA MORGANA	24/8/52	18/12/52	RHB 3" LHB 1½"	116	75
6.	FLAMING RIVER	21/10/52	7/1/53	RHB 3" LHB 1½"	58	32
7.	FLORA SANDES	12/11/52	8/1/53	RHB 1½" LHB 1½"	57	40
8.	FRESCOE	21/8/52	28/10/52	RHB 1½" LHB 1½"	68	64
9.	HATS OFF 2nd	21/9/52	23/10/52	RHB 2" LHB 2"	32	8
10.	HATTIE HART	28/10/52	23/12/52	RHB 2½" LHB 2"	56	28
11.	KINGS FLAME	9/11/52	2/12/52	Contraction LHB 2½"	23	12
12.	OLIVE GROVE	22/9/52	6/11/52	RHB 1½" LHB 3"	45	36
13.	PROTECT	8/11/52	3/12/52	RHB 1½" LHB 2½"	25	35

Note : RHB - right horn base
LHB - left horn base

Table number 27, a variable and sometimes considerable time was required for the uterus to return to its normal, non-pregnant, resting stage.

During oestrus the normal healthy womb was found very sensitive to rectal palpation, contracting very readily and becoming circular, firm and turgid. This responsiveness was most marked during heat, and although considerably decreased in the inter-oestral periods, was never quite lost during the breeding season in the non-pregnant mare.

This sensitivity was absent or could only be detected in a very slight degree in cases of nymphomania, metritis, delayed uterine involution, and in barren mares during deep anoestrus of winter. In those cases the organ is invariably found to be oval in outline, relaxed, soft and pliable, the walls so flabby that they can be rubbed against each other between thumb and forefinger.

This lack of uterine sensitivity was encountered early in the season in the non-pregnant mares CASTANIA and CARA NOSTRA, whilst the pregnant mares WYNDSONG and CONTRAST developed it after foaling. The mare CASTANIA eventually improved and conceived, but the others failed to improve and remained barren.

Responsiveness of the uterine horns was observed early in the season in FRESCOE, HELIOTROPE 2nd, PAVANE, and TERAI, and these mares conceived without difficulty and carried their pregnancy successfully.

(3) The Pregnant Mare.

The sensitivity of the uterus during pregnancy is dealt with under the heading PREGNANCY.

D. THE CERVIX AND ANTERIOR VAGINA.

Review of the literature.

A considerable amount of literature exists on the subject of the optimum time of mating during the long heat period of the mare. It appears as if it is a well known fact that the

changes/...

changes occurring in the cervix are closely correlated to ovarian development.

So for instance Sharpe (1930) states that broadly speaking the period of oestrus lasts about 7 days, and that generally there is little or no change as regards dilatation of the os during the first two days; the next three days there is full dilatation followed, during the final two days, by a rapidly increasing contraction. He compares the rigid os to the tight, hard, rosebud, and the relaxed cervix to the full-blown rose just past its prime, and claims that the full-blown rose stage, concurrent with a clean, normal-coloured mucuous membrane, is the physiological moment for service. The chances of conception he claims are then 99 per cent.

These observations have been confirmed by the following research workers, Zivotkov (1935), Caslick (1937), Satch and Hoshi (1936), Gans (1939), Heer (1939), Day (1939), Von Korff (1940), Andrews and McKenzie (1941). They all agree that the rhythmic changes in the tone of the cervical muscles are the most marked and the most constant of the phenomena observed.

The best description is given by Day (1939). He describes the cervix, in dioestrus, as being tightly constricted and erect. The vagina and cervix are a pale pink in colour and the mucus is scantly and rather tenacious to the touch. In oestrus there is a gradual increase in the vascularity of the vagina and cervix, mucus is more plentiful and is quite fluid and slippery to the touch. The most marked change, however, is gradual loss of tone in the cervical muscles. All these changes commence gradually from the onset of oestrus and become more marked as the time of ovulation approaches, when the cervix is completely relaxed and can be seen lying on the floor of the vagina, often with the folds of the cervix appearing somewhat oedematous. After ovulation there is a gradual return to the typical state of dioestrus. In anoustrus, as in

pregnancy/...

pregnancy, the vagina and cervix are very pale and have a blanched appearance. The cervix is constricted, usually turned away from the midline and the external os is occluded by very sticky mucus in the anterior vagina and cervix.

These alterations are also recorded by Götze (1949) who classifies in great detail the differences occurring in the shape, opening, colour, moisture content, and position of the cervix. This classification was found too cumbersome for use in Thoroughbred mares where the changes were generally found more distinct than in other breeds of horses. Instead a simplified classification was used and its readings are employed throughout in the records for each mare.

Observations.

(1) During Anoestrus.

a. The Mare WYNDSONG can be taken as the basis for discussion. She developed complete ovarian involution as the result of suckling anaphrodisia. The cervix on 2/11/52 is represendted by the formula, al, AI, i.e.

a. The cervix was narrow, contracted, projecting like a finger.

l. The mouth of the cervix was funnel-shaped and would pass a pencil.

A. It was pale in colour.

I. There was a small amount of moisture.

Rectal examination of the uterus revealed this organ to be flabby and oval. The walls were collapsed and could be rubbed against each other. There was very little response on handling, the organ contracted slowly and not very firmly. The vestibule was pale in colour. It was clear that the tubular organs were completely quiescent.

This condition is often encountered in mid-winter in non-pregnant mares when subjected to adverse climatic and nutritio-

nal/...

nal conditions. It is typical of the condition described in the literature as 'deep anoestrus'.

b. The mare CONTRAST showed a certain degree of development of the ovaric-genital system after which it became more or less static. Although the vestibule remained pink throughout, cervical examination revealed the formula b2, BI, i.e.

b. The cervix was round, rosette-shaped, fleshy.

2. The cervical mouth was open and passed one to two fingers.

B. It was pink in colour.

I. Small amount of moisture was present.

The uterus continued to involute very slowly and the right ovary gradually developed a follicle. The uterus remained soft, flabby, unresponsive, and its walls were moveable. This condition of partial or arrested ovarian development accompanied by a relaxed and unresponsive uterus is frequently encountered in non-pregnant mares during the winter months when they are stabled and receiving extra rations.

The appearance of the cervix and anterior vagina of this mare corresponds to the normal appearance of these organs of non-pregnant mares during the interoestral periods in the breeding season.

(2) <u>During Oestrus</u>.

In the non-pregnant mare the cervix was found relaxed during oestrus to permit intra-uterine insemination by the stallion. Where the heat period was normal the cervix relaxed to reach the formula c3, CIII, at the approximate time of ovulation, but the correlation between these two events will be discussed elsewhere. After cessation of heat the cervix contracted again to a relatively firm consistency, usually of the tyle a1, AII and it was noticed that it never returned completely to the quiescent state during the breeding season. The only exception was the mare WYNDSONG, where

complete/...

complete ovarian involution had resulted in the return of the tubular genitalia (vagina, cervix, uterus) to a state of rest or dormancy, until astificially provoked into functional activity.

The interval between cessation of heat and the time the cervix reached its maximum contraction is given in Table number 28.

The period of maximum contraction of the cervix after heat was found to vary from 6-10 days with an average of 7.6 days. The interval between ovulation and complete contraction was somewhat longer, ranged from 7-11 days, with an average of 8.5 days.

These figures support the observation of Satch and Hoshi (1938) who found cervical contraction at its maximum 9 days after ovulation. This interval corresponds closely with the histological findings of Hammond and Wodzicki (1941) who record that the size of the lumen of the superficial uterine glands became smaller eight days after cessation of heat. Andrews and McKenzie (1941) state that the vaginal epithelium was most active during oestrus, and the uterine epithelium usually reached its greatest height during the latter stages of oestrus and the first 5-8 days of inter-oestrus.

These changes correspond to the time that the cervix reaches its maximum contraction and indicates the return of the tubular genitalia in general, to its resting or non-functional state.

Table/...

TABLE NO. 28.

Maximum Contraction of the Cervix following Oestrus in the Non-pregnant Mare

Mare.	Heat period	Ovulation	Maximum contraction of cervix after heat	Intervals in Days	
				After heat ceased	After ovulation
1. CASTANIA	11-16/9/52	inknown	22/9/52	6	-
2. FATA MORGANA	22-26/9/52	25/9/52	2/10/52	6	7
3. FLAMING RIVER	20-23/11/52	22/11/52	3/12/52	10	11
4. OLIVE GROVE	7-9/10/52	9/10/52	17/10/52	8	8
5. PROTECT	16-24/11/52	24/11/52	2/12/52	8	8
			Average:-	7.7	8.5

(3) During Pregnancy.

Review of the literature.

Clinical examination of mares for pregnancy by observing alterations in the vaginal portion of the cervix and anterior vagina has been described in great detail by Kurosawa (1931). He found that the vaginal method of inspection of the os uteri and anterior was only certain and practical after 21-30 days of pregnancy and that during that period it was 94.7% certain.

Miller and Day (1939) observed that as early as thirty days of pregnancy the vagina and cervix become very much paler in colour and present a pearly appearance, with the small capillaries standing out as a fine network. A little later in gestation these capillaries disappear and the whole of the mucuous membrane becomes very blanched and pale. On introduction of the speculum, the vagina does not balloon immediately as in non-pregnant mares, but its walls separate slowly and appear quite dry. The folds of the cervix are sealed together with a sticky mucuous secretion so that the external os is obliterated. The apex of the cervix is invariably turned from the midline; usually downwards or to one side and occasionally upwards.

Observations.

Smears were made from the cervix by means of a long-handled paintbrush in the manner described by Kurosawa (1931), Miller and Day (1939), and others. Early in the commencement of this work a streptococcus was isolated in a smear, and as the mare concerned was an extremely valuable one, it was decided to discontinue this line of observation and to concentrate rather on rectal palpation of the cervix itself.

The danger of the use of the vaginal speculum for daily examination of large numbers of mares is shown by the frequency with which infection was encountered, e.g. FATA MORGANE, FLAMING RIVER,

etc/...

etc. Its application as a method of routine examination in a Thoroughbred Stud is limited. Even apart from the possibility of transmitting infection, it must be recorded that the cervix of the pregnant mare is very sensitive to manipulation or trauma. Gonzaga and Ebora (1936) observed that artificial insemination of pregnant mares always resulted in abortion, a view endorsed by Amoroso, Hancock, and Rowlands (1948). A similar experience is known where the intra-cervical injection of 4 ounces of a sterile solution of penicillin in Propamidine-intra-uterine caused abortion of a near full-time foetus within a month afterwards. Several instances are known of mares that were served and which dropped a dead foal within a few days.

Rectal examination of the cervix proved satisfactory for the purpose of determining the gradual relaxation of the os uteri until it was so relaxed that its outlines disappeared at the height of oestrus. After oestrus it gradually contracted again until it became a firm palpable organ once more. Where pregnancy supervened its firmness increased and its diameter decreased. The observations support the findings of Gans (1939) who states that rectally the relaxation of the cervix can be detected for a period of 3-4 days, and that 85 per cent of ovulations occur during this period. He is of opinion that vaginal examination is not so reliable nor is it as safe because of the manual manipulation, and the danger of bacterial infection.

Although inspection of the cervix and anterior vagina by means of the speculum was discontinued as a routine measure in these investigations, sufficient information was collected to allow of certain conclusions.

The maximum dilatation of the cervix in relation to the heat period and ovulation, as well as the approximate interval it takes to reach the typical picture of pregnancy as indicated by the symbols, ao, AI are reflected in Table number 29.

In/...

In these cases ovulation occurred during the period of maximum dilatation of the cervix. This period was, however, found variable, extending from 5 days before, to 2 days after ovulation. Once ovulation took place, contraction of the cervix was noticeable within 1-2 days afterwards.

An exception to the above observations was the mare ORNAMENT 2nd, who during her heat period of 24 days, i.e. 11/9 - 4/10/52, failed to rupture a large follicle of 3.5 cm. in the right ovary. The cervix was completely relaxed with a reading of c3, CIII In the case of the mare WYNDSONG there was no ovarian development whatsoever when brought into oestrus by means of hormone injections. Her heat period was of normal length, i.e. 6 days, with a cervical relaxation of c3, CIII.

The cervical formula of ao, AI denoting changes typical of pregnancy was reached 16 days after heat in the case of CASTANIA. In ORNAMENT 2nd it was detected 46 days after oestrus, but in her case cervical inspection was only carried out on her service date and on 7/11/52, with rectal palpations between those dates. It is likely that the cervical changes of pregnancy would have been diagnosed at a much earlier date if the speculum had been used before 7/12/52. It would appear as if rectal examination of the cervix constitutes no aid to early pregnancy diagnosis.

On an average it took 29.72 days after heat, for the os uteri and anterior vagina to reach the formula ao, AI of pregnancy. This corresponds with the general observation of Miller and Day (1939), that the typical changes of early pregnancy could be detected as early as thirty days in most mares. It also agrees with the conclusion of Kurosawa (1931) who found the vaginal method of inspection of the os uteri and anterior vagina only certain and practical after 21-30 days.

(4)/...

TABLE NO. 29.

Maximum Contraction of the Cervix following Oestrus and during early Pregnancy.

Name.	Heat period	e3, CIII	Ovulation	ao, AI.	Interval in Days after	
					Heat	Ovulation
1. AUDITION 2nd	8-10/9	9-11/9	10/9	9/10	29	29
2. BARCAROLLA	4-5/12	4-5/12	4/12	8/1	34	35
3. CALAMITY JANE	21-24/11	23/11	23/11	24/12	30	30
4. CASTANIA	4-12/10	7-12/10	11/10	28/10	16	17
5. FRESCOE	23-24/10	24-26/10	24/10	27/11	34	34
6. HATS OFF 2nd.	28/9-1/10	29/9-1/10	30/9	23/10	22	23
7. HATTIE HART	22-26/11	Rectal diag. 22-25/11	25/11	23/12	27	28
8. HOLY GRAIL	27/11-3/12	2/12	2/12	8/1	36	37
9. ORNAMENT 2nd	16-22/10	16-21/10	21/10	7/12	46	47
10. PAVANE	30-26/9	22-26/9	26/9	14/10	18	18
11. TERAI	12-17/9	14-15/9	15/9	22/10	35	37
				Averages-	29.72	30.45

(4) Abnormal behaviour of the Cervix and Anterior Vagina.

Review of the literature.

Perusal of the literature indicates that a sharp distinction is made between the psychological behaviour of the mare during oestrus, i.e. her sexual behaviour, and the appearance of the cervix and anterior vagina as well as the ovarian changes during this period. The changes are classified for convenience into two groups, e.g. the external or outer, and the internal or inner symptoms of heat.

That these two phenomena may not be correlated is observed by Zitvotkov (1935) who as a rule found them to correspond, except in 10-20 per cent of cases. The latter he classifies as (1) false or incomplete heat where only the outer symptoms occur and (2) silent heat in young and shy animals where the outer symptoms are absent. Heer (1939) records that in only 60 per cent of his mares did the external and internal signs of heat coincide, 13 per cent showed ovarian changes only, whilst in 27 per cent of cases neither ovulation nor external signs of oestrus occurred over a period of 9 months.

This dissociation of external and internal symptoms of heat is a well known experience of all horse-breeders. The most common abnormality is the mare showing symptoms of heat not accompanied with cervical relaxation or ovarian development. This condition is most frequently seen in young maiden mares brought to stud for the first time. It is also observed early in the season in non-pregnant mares that have gone through deep anoestrus during the winter months. Such mares accept service willingly but do not conceive.

Miller and Day (1939) mention that mares going into anoestrus, and certain mares with cystic ovaries, show changes which cannot be distinguished from those of pregnancy.

Dimock/...

Dimock (1947) states that in 75 per cent or more of cases the the vaginal mucosa is pale, dry and gummy and the cervical seal is pronounced. Of the remaining 25 per cent some will appear to be red and congested, with almost no gum present; in others, an actual vaginitis may be found, and in rare instances a thin muco-purulent discharge may be present in the vagina.

Observations.

The condition of heat without genital development (relaxation of the cervix, follicular development in the ovary, etc.) was not encountered in the non-pregnant mares during the breeding season of 1952.

Several abnormalities however occurred in the foaling mares after parturition. ORNAMENT 2nd had a prolonged heat period of 24 days with a cervical formula of c3, CIII without ovulation taking place. FLORA SANDES had a silent heat for 2 days (23-24/11) with a cervical formulae b2, CII without ovulation. She had another silent heat of 2 days (10-11/12/52) accompanied with a cervical reading of c3, CIII with ovulation taking place on 9/12/52. The mare WYNDSONG under hormone treatment came into heat for 6 days (24-29/11/52) with a cervical reading of c3, CIII but the ovaries remained completely involuted and non-functional.

Vaginal infections may alter the appearance of the cervix and vagina considerably. The mare UNCONCERN examined rectally on 10/5/51 was found in foal. Vaginal inspection revealed a red, glistening and congested vagina with a tightly constricted, red, shiny cervix projecting centrally into its lumen. No cervical seal was observed. There was a muco-purulent discharge in the vagina which took months to clear up under treatment. She foaled a normal viable foal on 7/8/51.

During the present investigation the mare FATA MORGANA developed a copious and persistent vaginal discharge which soiled the inside of the hindlegs and hocks (see photo 29 and 30).

Aerovagina/...

Aerovagina was so pronounced that on 31/10/52 air was detected in the uterine cavity. She received treatment and conceived to a service on 7/11/52. On 14/1/53 aerovagina was again diagnosed and the vagina found to contain large numbers of air bubbles. On 23/1/53 the condition had become worse. The mare was treated and the Caslick operation performed. The cervical reading on that day was b2, CIII, i.e.

b - cervix round, rosette shape and fleshy.
2 - the os open sufficiently to allow the passage of 1-2 fingers,
C - anterior vagina and cervix hyperaemic and red in colour,
III - a fair amount of moisture present of a glary, tenacious and glistening type.

Pregnancy conforms as a rule to the cervical reading of ao, AI and the reading b2, CIII in this mare 77 days after conception can only be ascribed to the aspiration of air and consequent infection. The mare foaled normally on 10/10/53.

The observation on the effects of aerovagina during early pregnancy confirms the findings of Miller and Day (1939). They mention that mares suffering from an aerovagina will not show the typical changes in the vagina and cervix expected in early gestation - that is, not until about ninety days or more after the onset of pregnancy.

E. THE VESTIBULE AND VULVA.

With the decision to discard the vaginal speculum as a practical means for routine and indiscriminate use, it was decided to concentrate on the appearance of the external vulva and vestibule instead, in the manner outlined under "Methods of Examination" 3(c).

No reference could be found in the literature to the appearance of the vulva and vestibule during the various phases of the oestrous cycle. From the present study it was observed that in

the/...

the non-pregnant mare during inter-oestrus, as well as in the majority of pregnant mares, the vulvar lips were thin, puckered and the orifice firmly closed. Opening of the orifice was usually accomplished with some difficulty. On inspection the vestibule invariably revealed a pale, blanched mucous membrane which appeared dull and lifeless to the eye and dry to the touch. Many mares objected to the examination and had to be restrained by means of a nose twitch to allow it to proceed.

When oestrus developed in the non-pregnant mare, the lips of the vulva became swollen, the puckered appearance disappeared, the edges became rounded and the orifice elongated. At the height of heat the mares, on being teased, straddled, showed the clitoris repeatedly and ejected small amounts of mucus and urine. At this stage vestibular examination could be performed without difficulty the mare was docile and easily handled. The vulvar lips could be parted without effort permitting inspection of the vestibulum with ease. At the height of oestrus the mucous membrane was hyperaemic and congested, red in colour, the surface shiny and covered by a thin, glistening, lubricating mucus.

The vulvar and vestibular changes are recorded in the case histories of each mare. It will be noted that the changes that occur are distinct and that their maximum development lasted several days during which ovulation, as a rule, took place. As such, it serves as a valuable and practical guide to the Studmaster in deciding when to mate a mare under ordinary stud conditions.

2. THE EXTERNAL CYCLE AND PSYCHOLOGICAL HEAT.

By the external cycle is meant the sexual behaviour of the mare. The sexual cycle of the mare consists of oestrus and dios-trus; and the beginning of the oestrus cycle is dated from the first day of oestrus until the beginning of the next oestrus.

Examination/...

Examination of the literature on the sexual cycle of domestic animals reveals that it is divided into four accepted phases, e.g. proöestrus, oestrus, metoestrus, and dioestrus. (Heape, 1900). The reasons for these sub-divisions are that they are based on differences in the external behaviour of the animals, e.g. the physiological pro-oestrus in the sheep is detected externally by congestion of the vulva and a discharge of mucus (Marshall, 1922), and oestrus as the period of sexual desire.

It has generally become recognised today that the external behaviour of the mare is not always an indication of the internal behaviour of her genitalia, and that her external manifestation or psychological response, is frequently dissociated from the internal physiological development of her reproductive organs. This is particularly evident from the work of Andrews and McKenzie (1941), who went further and divided oestrus into psychological and physiological heat.

For the purpose of this study the four divisions of Heape (1900) had to be discarded as it found no practical application. The external sexual cycle of the mare is divided simply into oestrus and inter-oestrus (dioestrus). Oestrus is again subdivided into psychological heat, indicating the external signs of sexual desire; and physiological heat, by which is meant the development of the reproductive organs to the stage necessary for successful breeding.

The symptoms of psychological heat will be dealt with later. In general, it is recognised by general irritability of the mare with frequent urinations and movements of the clitoris and vulva; in some individual mares, however, especially if they are kept by themselves the signs are not marked and only become evident when the mare associates with other mares, or is 'tried' by a stallion.

A./..

A. FOALHEAT.

(1) Occurrence of foalheat.

Review of the literature.

'Foalheat' is a general term used in Thoroughbred breeding to refer to oestrus that occurs within a certain period after parturition. A study of the literature on Thoroughbred breeding makes this clear enough. So for instance, Quinlan (1952) mentions that it is customary for breeders to mate mares on the ninth day following foaling during foalheat. Foal heat, he states, usually commences on the 7th to 8th day following foaling and ends on the 11th to 12th day.

Williams (1943) found that the mare is commonly in heat at not later than the 8th or 9th day after foaling, and states most appropriately, that according to tradition this is definitely the best time to breed her, and the tradition is so ancient that it is wellnigh sacrosanct.

The introduction of the term 'foalheat' to scientific research has led to the erroneous belief by some that it indicates the first heat after parturition irrespective of the interval. Satoh and Hoshi (1934) record a foalheat 100 days after foaling, and Andrews and McKenzie (1941) observed 6 mares to show foalheat 21-30 days after foaling.

The term 'foalheat' is used by the Thoroughbred breeders in the Karroo Midlands to denote that oestrus which occurs within 15 days after foaling. It is proposed that this definition be accepted.

Constantinesou and Mauch (1936) in a study of 1,366 oestrous cycles in mares, found heat after foaling to occur between the 4th and 17th day. In 90 per cent of cases it occurred between the 7th and 11th day. The arithmetical mean day for the onset of oestrus was 9.13 ± 0.047.

Aehnelt and Plas (1946) record that out of 44 mares foalheat occurred in 84 per cent of cases between the 5-13th day,

and/...

and 36.4 per cent of these cases were on heat on the 9th day. Duration of foalheat varied from 2-13 days, with an average of 5.7 days and the majority lasted only 4 days.

Trum (1950) observed that 93 per cent of mares showed foalheat within 5-16 days after foaling in 1,543 oestral cycles studied. It appeared on the 5th day in 2.5 per cent; 6th day in 5 per cent; 7th day in 11 per cent; 8th day in 20 per cent; 9th day in 33 per cent; 10th day in 13 per cent; 11th day in 7 per cent, and from the 12th to the 18th day inclusive, in 8.5 per cent of mares.

Seventy per cent were in heat on the 9th day following foaling. He points out that it was impossible to find so many mares willing to accept the stallion on any other specific day during the oestrous cycle.

Observations.

In most Thoroughbred studs it is the practice to start testing mares for heat at the commencement of the breeding season, i.e. from the first week in September. This stud was no exception and for that reason there are no records for those mares which foaled during August. Appendix VI reflects the foalheats of the mares under observation from 1950 to 1952. It is generally accepted that the interval between foaling and foalheat includes the day of foaling, but not the day of occurrence of heat. (Andrews and McKenzie, 1941). Hence foalheat occurs the day after the stated interval e.g. seven mares had an interval of seven days between foaling and the occurrence of foalheat; consequently foalheat occurred on the 8th day from the date of foaling.

Table number 30 reflects the incidence of foalheats.

TABLE/....

TABLE NO. 30

Number of Foalings	Occurrence of Foalheat	Percentage
7	8th day	22.6
15	9th day	48.4
5	10th day	16.1
1	11th day	3.2
3	12th day	9.7
31	Average 9.3 days	100

A graphic representation of the frequency distribution of the total is shown in Figure 2. The mean number of days from foaling to and including the first day of heat is 9.3. days. These figures correspond in all respects with those found in the literature.

Fig/...

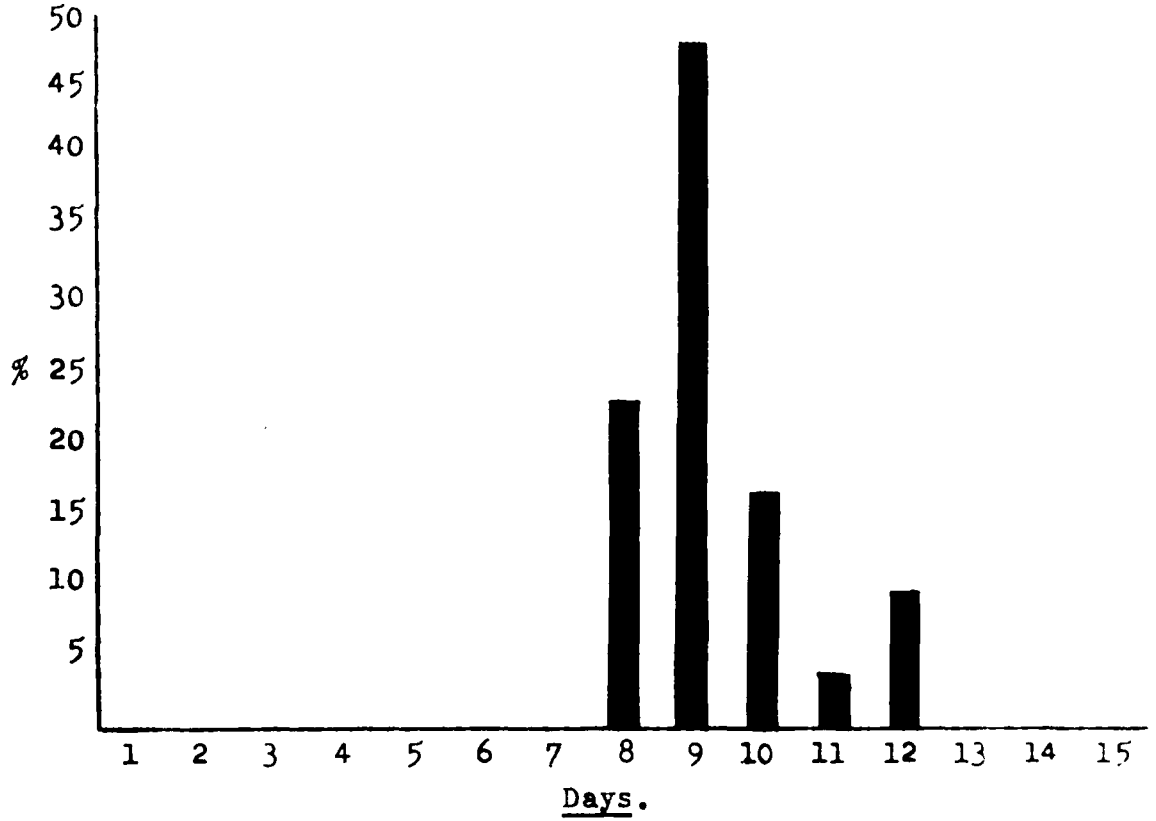


Fig. 2. **Frequency graph showing the length of the interval from foaling to foalheat.**

Duration of Foalheat.

The duration of foalheat is shown in Table Number 31.

TABLE NO. 31

Duration in Days	Number of Foalheats	Percentage
1	1	3.2
2	2	6.5
3	6	19.3
4	7	22.6
5	7	22.6
6	5	16.1
7	0	0
8	1	3.2
9	2	6.5
Average 4.6	31	100

A graphic representation of the frequency distribution of the total is shown in Figure 3. The mean duration of foalheat was 4.6 days, but the majority lasted 4 and 5 days. These findings correspond with those of Aehnelt and Plas (1946.)

Fig./...

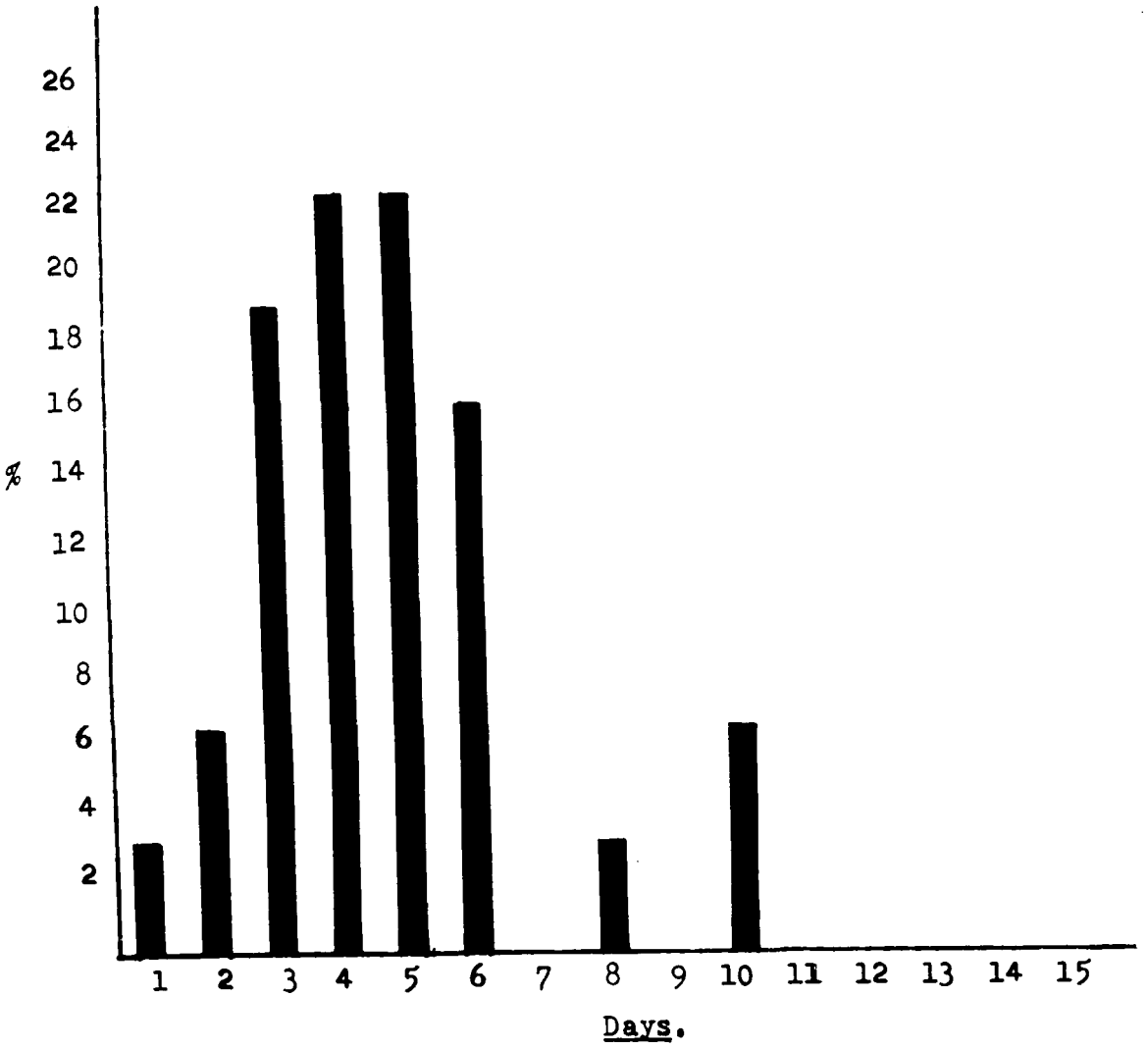


Fig.3 . Frequency graph showing the duration of foalheat.

(3) Incidence of Ovulation and Conception during Foalheat.

Review of the literature.

Considerable divergence of opinion exists as to whether foalheat should be utilised or not for breeding purposes. Götze (1935) states that the first heat after foaling is the most favourable for for conception, and if this is missed the mare may go barren for a long time. Wagner (1935) records a conception rate of only 56.7 per cent for mares bred during foalheat of 9-18 days after foaling. He suggested, in view of the high percentage of mares which failed to conceive during foalheat, that this may be due to failure of the Graafian follicle to rupture. Andrews and McKenzie (1941) record that only 54 per cent of their mares were actually on heat on the

9th/...

9th day and of these 12.5 per cent did not even ovulate. They also observed that at foalheat involution may be incomplete. In 8 out of 9 mares studied the surface of the uterine mucosa was not covered by epithelium, the subepithelial area of degenerating glandular epithelium was highly disorganised and contained large numbers of leucocytes. They think that the uterus under those circumstances is not in a perfectly favourable state for sperm transport and viability.

Jennings (1941) correlates increased abortion, dystocia and dead foals with matings during the first heat after foaling. He states that 43.7 per cent of his group of mares conceived when bred on the 9th day, whereas 63.7 per cent conceived when bred after the 9th day. He concludes that breeding on the 9th day should be practised as infrequently as possible and then only after a strict examination.

Berliner (1945) relates that many progressive breeders in the U.S.A. have given up breeding during foalheat.

Observations.

The incidence of ovulation and conception during foalheat of the group of mares under obsservation during the 1952 breeding season is recorded in Table number 32.

Table/ ...

TABLE NO. 32.

	Mare	Foalheat	Service Date	Estimated Date of Rupture of Graafian Follicle.	Results
1.	BARCAROLLA	4-8/10/52	Not served	No Rupture	Returned
2.	BLUE VISION	28/10-1/11/52	29/10 & 31/10/52	31/10/52	In foal
3.	FLAMING RIVIER	29/10-3/11/52	Not served	31/10/52	Returned
4.	FLORA SANDES	23-24/11/52	23/11/52	No Rupture	Returned
5.	HATS OFF 2nd.	28/9-1/10/52	29/9/52	30/9/52	In foal
6.	HATTIE HART	4-7/11/52	Not served	6/11/52	Returned
7.	KINGS FLAME	17/11-22/11/52	18/11 & 21/11/52	22/11/52	In foal
8.	OLIVE GROVE	7/10-9/10/52	7/10/52	9/10/52	Returned
9.	PROTECT	16/11-24/11/52	17/11 & 20/11/52	24/11/52	Returned

The results of these observations are as follows:

Failure to ovulate occurred in 2 out of 9 mares or 22.2 per cent
Ovulation occurred in 1 mare 3 days before end of heat 11.2 "
" " " 3 " 1 " " " " " 33.3 "
" " " 3 " on the last day of heat 33.3 "

Ovulation occurred in 66.6 per cent of cases within 24 to 48 hours prior to cessation of heat, and in 11.2 per cent of cases 3 days before the end of the heat.

Out of a total of 31 foalheats for the period 1950-1952, service could not be permitted on 13 occasions (41.9 per cent) because of a torn vulva, bruised vagina or purulent discharge. The remaining 58.1 per cent were served and of these 18 foalheats seven conceived, or 38.9 per cent, and eleven were barren or 61.1 per cent.

This figure of 38.9 per cent conception rate for foalheat breeding is considerably higher than is usually encountered in the Thoroughbred studs in the Karroo Midlands. The owners and managers of most Thoroughbred studs do their own selecting of mares considered suitable for breeding. This selection is based upon the general appearance of the mare, as well as upon the examination of the external genitalia, vestibule and absence of a discharge from the vagina. As a rule only one mare out of four bred during foalheat settles, or a conception rate of about 25 per cent. If the total percentage conception rate is considered for the 1950-52 breeding seasons, irrespective of the fact that certain mares were not served because of various factors, it will be seen that only 7 mares conceived out of a total of 31 foaling mares, or an overall fertility rating of only 22.6 per cent.

This low fertility of foalheat matings, as well as the contentions of Jennings (1941) have led to a widespread agitation in many periodicals and publications to dispense with foalheat breeding altogether. This view-point is undoubtedly correct in the case of those breeds of horses which have an unrestricted breeding

seas...

season. It has no application in Thoroughbred breeding where aging rules constrict the breeding season into a very short period. To illustrate this one only has to visualise a mare foaling late in November or December. Should she conceive to a foalheat mating she will foal a month earlier the following year. If this heat be discarded and the mare bred the following heat she perpetuates the error of producing a late foal again the next year. For such late foals there is no ready sale.

The only publication in connection with this aspect in Thoroughbred breeding is by Mahaffey (1950). He found that in a Thoroughbred stud of 27 mares, only 59 per cent came in heat on the 9th day during the 1948 breeding season but 7.4 per cent failed to ovulate. During the 1949 breeding season 34 per cent of the mares came in heat on the 9th day, but 20 per cent did not ovulate. He found that with appropriate selection of mares following ovarian palpation and examination of the genital organs some 70 per cent of those served during foalheat would conceive. He concludes that in a Thoroughbred stud where no time can be lost if a high final percentage of conception is to be achieved during the short season, mares should be served during foalheat.

The figure of 70 per cent conception during foalheat quoted by Mahaffey is considerably higher than the 38.9 per cent obtained in this stud during the 1952 breeding season. Mahaffey does not state the percentage of mares selected as suitable for breeding during foalheat, nor does he mention on what criteria this selection is based. It is also not clear whether the high percentage of mares which failed to ovulate during foalheat were discarded as unsuitable for breeding or whether they received appropriate treatment to induce ovulation and conception during that period.

The argument advanced by Andrews and McKenzie that the epithelial desquamation and degeneration of the uterine endometrium form an unfavourable mediun for sperm transport and viability during foalheat cannot be accepted without reservation. Insemination by the

stallion/...

stallion is invariably intra-uterine, and the suction-like action of the uterus flushes the great bulk of semen through the uterine cavity to the papilla intra-uterina of the Fallopian tubes. It is only from there that the sperms migrate by their own motility along the oviduct. As it takes about 5-6 days or even longer for the fertilised ovum to reach the uterus there is sufficient time for considerable recovery of that organ from any injuries sustained during parturition.

(4) The Interval between Parturition and Oestrus following Foalheat.

According to Jockey Club rules the aging of Thoroughbreds takes place from the 1st of August each year. Foaling consequently commences from that date. As the gestational period is approximately 11 months, breeding starts only from about the 8th of September. The mares that foal early in August cannot be served during foalheat, because if they conceive they would foal down in July the next year. The resultant foal would be registered as a yearling on the 1st of August, although it would actually be only a few days old. For such foals there is practically no sale.

Foalheat during August and the first week in September is for that reason never utilised for breeding. The usual practice in the Karroo Midlands is to start teasing mares when the breeding season starts, i.e. from the first week in September. Heats, including foalheats, taking place before that time are therefore not known. In addition many mares fail to show foalheat within 15 days after foaling. It follows that it becomes a matter of practical importance to have some indication of when the first heat after foalheat may be expected.

Table number 33 records the interval between parturition and the oestrus following foalheat in 8 August foaling mares.

TABLE/...

TABLE NO. 33.

The interval between Parturition and Oestrus following Foalheat

Name	Foaling Date	2nd Heat	Interval	Remarks
1. AUDITION 2nd	17/8/50	21-24/9/50	35 days	Spontaneous heat
"	3/8/52	8-10/9/52	36 "	" "
2. CALAMITY JANE	13/8/50	8-17/9/50	26 "	" "
" "	8/8/51	8-7/9/51	28 "	" "
3. DAROR	25/8/50	17-21/9/50	23 "	" "
4. FATA MORGANA	24/8/52	22-26/9/52	29 "	" "
5. FRESCOE	21/8/52	28-29/9/52	38 "	" "
6. HOLY GRAIL	25/8/50	19-24/9/50	25 "	" "
7. PAVANE	10/8/51	7-8/9/51	28 "	" "
8. UNCONCERN	7/8/51	8-15/8/51	32 "	" "
"	7/8/52	2/9/52	33 "	" "

The interval ranged from 23 to 38 days with an average of 31 days. The great majority of heats i.e. 77.8 per cent occurred between 25-35 days after parturition. This means that if a mare fails to come in heat within 38 days of foaling she requires examination and treatment.

Such an instance was encountered in the mare CALAMITY JANE. She foaled on 6/8/52 but had not given any oestrus indications by 16/10/52. She was examined and treated on that date as a result of which she came in heat on 21/10/52, or 107 days after parturition.

B. THE OCCURRENCE OF OESTRUS DURING THE BREEDING SEASON.

Review of the literature.

Satoh and Hoshi (1932) found that the semi-wild mare of Korea was monoestrus. The breeding season extended from April to September, but the greatest number of conceptions occurred in May, June and July. They agree with Heape's opinion that the domesticated/...

ted mare is a poly-oestrous animal with a tendency to mono-oestrus.

Day (1930) observes that the normal breeding season for the mare is the spring and summer months, and while some mares continue to come in oestrus throughout the year, most of them go into anoestrus during the winter months. Mares well fed and stabled usually tend to come into oestrus throughout the year, while those at grass go into anoestrus. These observations are confirmed by Andrews and McKenzie (1941), Burkhardt (1948), Marshall and Hammond (1949).

Aehnelt and Plas (1946) in investigating the influence of the time of the year on reproductive function of the mare, state that disorders in the oestrous cycles are maximum in February, but decrease or disappear in the later months of spring and summer. A strong seasonal influence was detected as well in relation to disturbances in ovulation. In general these also occurred most frequently at the beginning of the mating season and were least frequent at the end of the period. In the first months of the year conception figures were comparatively low, but a marked increase in conception was observed in May, particularly June and July.

Data on the duration of oestrus and the oestrous cycle show considerable variation between breeds and in different regions of the world.

Küpfer (1928), Constantinescu and Mauch (1936), and Caslick (1937) have reported oestrus lasting a single day, and Caslick has observed mares to be in continuous heat for as long as 103 days. Satoh and Hoshi (1934) give a duration of 108 days. Van Rensburg and Van Heerden (1953) record a prolonged heat period of 171 days which ended in a spontaneous ovulation.

Von Korff (1939) quoted by Götze found that 39.6 per cent of mares had an oestrous cycle of 21-22 days, with a variation from 15-33 days. He states that 71.7 per cent of the cycles vary around three weeks (20-25 days) and 22.64 per cent at four weeks (26-33 days).

Day/...

Day (1940) gives the average length of oestrus as varying from 3-54 days but averaging from 7-8 days. The length of dioestrus varied from 5-30 days, but in most cases was 11-16 days.

Andrews and McKenzie (1941) found the average length of the complete oestrous cycle to be 20.7 days with a range of 10-37 days. The average duration of oestrus was 5.3 days with a range of 1-37 days.

Aehnelt and Plas (1946) record that 75 per cent of the heat periods lasted 8-10 days, but that they became progressively shorter as the season advanced from February to July.

Hancock (1948) observed an average length of oestrus of 5.3 days with a range of 1-9 days. The average duration of dioestrus was 16 days with a range of 11-21 days.

Trum (1950) finds oestrus to vary from 2-40 days and gives the most frequent length of oestrum as 4 days. Oestrous periods of 10 days or longer were found most frequently in early spring and decreased as the season went by, until during June and July when the majority of periods were 4 days or shorter in length. Dioestrus varied from 2-59 days. Generally the maiden mare had the shorter inter-oestrous period.

Quinlan, van Rensburg and Steyn (1951) record that the majority of their stabled mares kept at Onderstepoort, had oestrous cycles throughout the year, but that these occurred at irregular intervals. Only 64.2 per cent of the oestrous cycles fell within the 'normal' limits of 16-25 days. The greatest irregularity occurred during February to July, when the average oestrous cycle was 35.9 days in duration as against 23.8 days during the period August to January. The average duration of oestrus throughout the year was 6.93 days with a range of 1-55 days, but only 29.5 per cent fell within 5-7 days, whereas 33.2 per cent lasted 2-4 days. Oestrus tended to be longer in the early part of the breeding season.

Observations/...

Observations on the length of the Oestrual Periods.

The length of the oestrous periods, excluding foalheats, for the breeding season of 1950 to 1952 are reflected in Appendix VI, and summarised in Table number 34.

TABLE NO. 34.

Length of Oestrous Periods in Days	No. of Oestrous periods	Percentage.
0	1 mare was anoestrus	0.8
1	1	0.8
2	9	7.5
3	16	13.3
4	19	15.7
5	25	20.7
6	12	9.9
7	18	14.9
8	8	6.6
9	3	2.5
10	3	2.5
13	1	0.8
14	1	0.8
17	1	0.8
21	1	0.8
24	1	0.8
33	1	0.8

In one case a mare failed to come in heat during the breeding season. In the other cases oestrus lasted from 1-33 days, with an average duration of 5.9 days. This corresponds with the average duration of 5.3 days of Andrews and McKenzie and Hancock, and is shorter than the period recorded by Day, Aehnelt and Plas, and Quilan et al. It was also observed that all heat periods of 10 days and more occurred during the early part of the season, i.e.

early/...

early spring.

A graphic representation of the frequency distribution of the total is shown in Figure number 4.

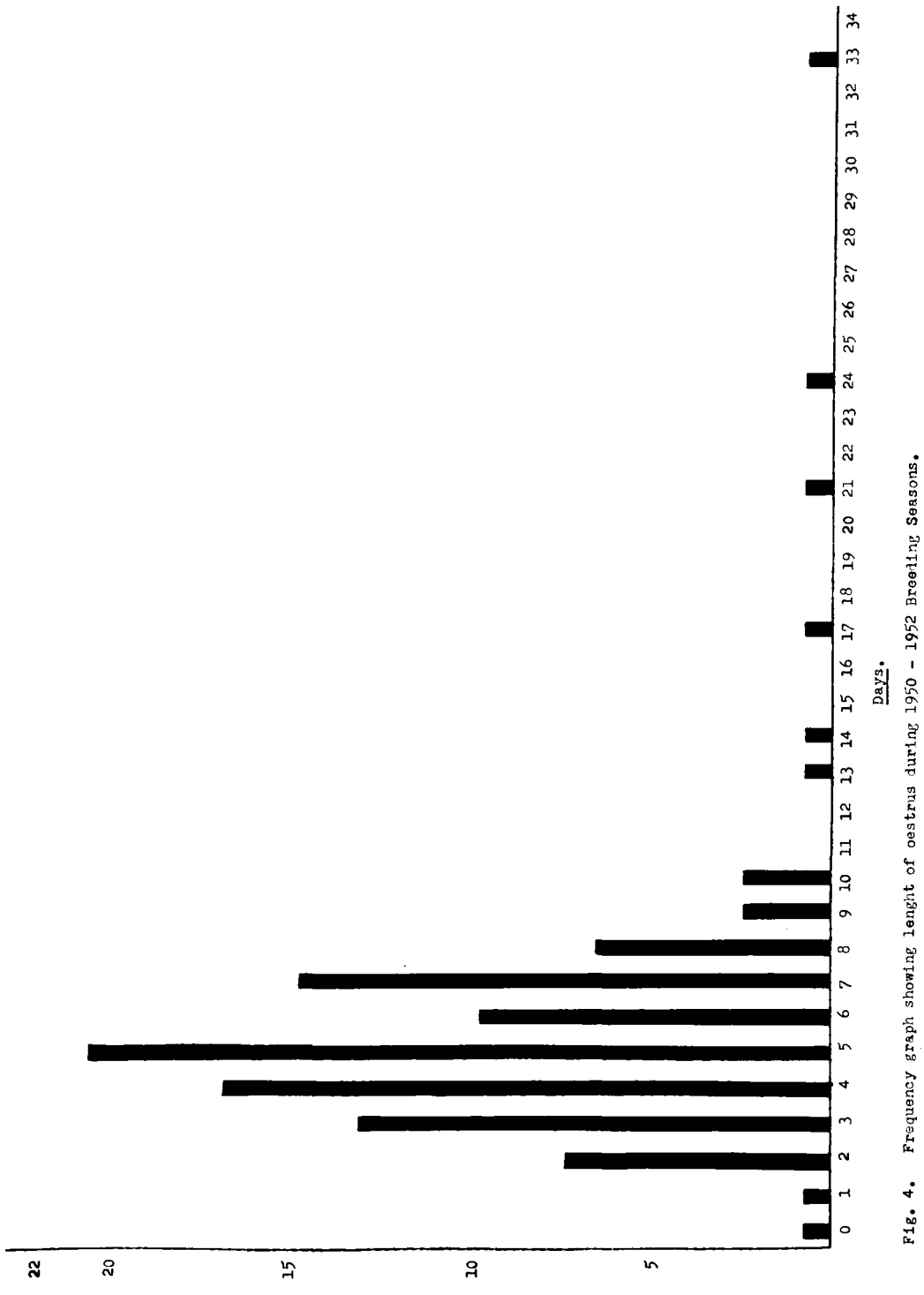


Fig. 4. Frequency graph showing lenght of oestrus during 1950 - 1952 Breeding Seasons.

C. THE/...

C. THE OCCURRENCE OF DIOESTRUS DURING THE BREEDING SEASON.

Observations.

The lengths of the inter-oestrous periods, excluding foalheat intervals, for the breeding seasons 1950 to 1952, are reflected in Appendix VI, and summarised in Table number 35. It excludes the dioestrous periods of those mares that foaled during August and whose foalheats are not known.

One mare did not come in heat for the breeding season. In the other cases the inter-oestrous periods varied from 7-78 days, with an average duration of 18.2 days. It must be stressed here that the inter-oestrous periods of 38, 65, 74 and 78 days were encountered in mares where ealy foetal death was suspected. If these particular inter-oestrous periods are disregarded, the mean duration becomes 15.8 days. Table number 35 indicates that 70 per cent of the inter-oestrous periods varied in length from 13-17 days, which interval corresponds closely with the observations of Day (1940).

TABLE NO. 35

Length of Dioestrus in Days	No. of Dioestrums	Percentage
7	1	1.2
9	1	1.2
10	2	2.5
11	2	2.5
12	2	2.5
13	9	11.2
14	13	16.1
15	12	14.9
16	11	13.6
17	11	13.6
18	5	6.2
19	1	1.2
23	3	3.7

27/...

(Table No. 35 Cont.)

Length of Dioestrus in Days	No. of Dioestrums	Percentage
27	1	1.2
33	1	1.2
37	1	1.2
38	1	1.2
65	1	1.2
74	1	1.2
78	1	1.2
Indefinitely	1 mare was anoestrus	1.2

A graphic representation of the frequency of the total is shown in Figure 5.

Figure/...

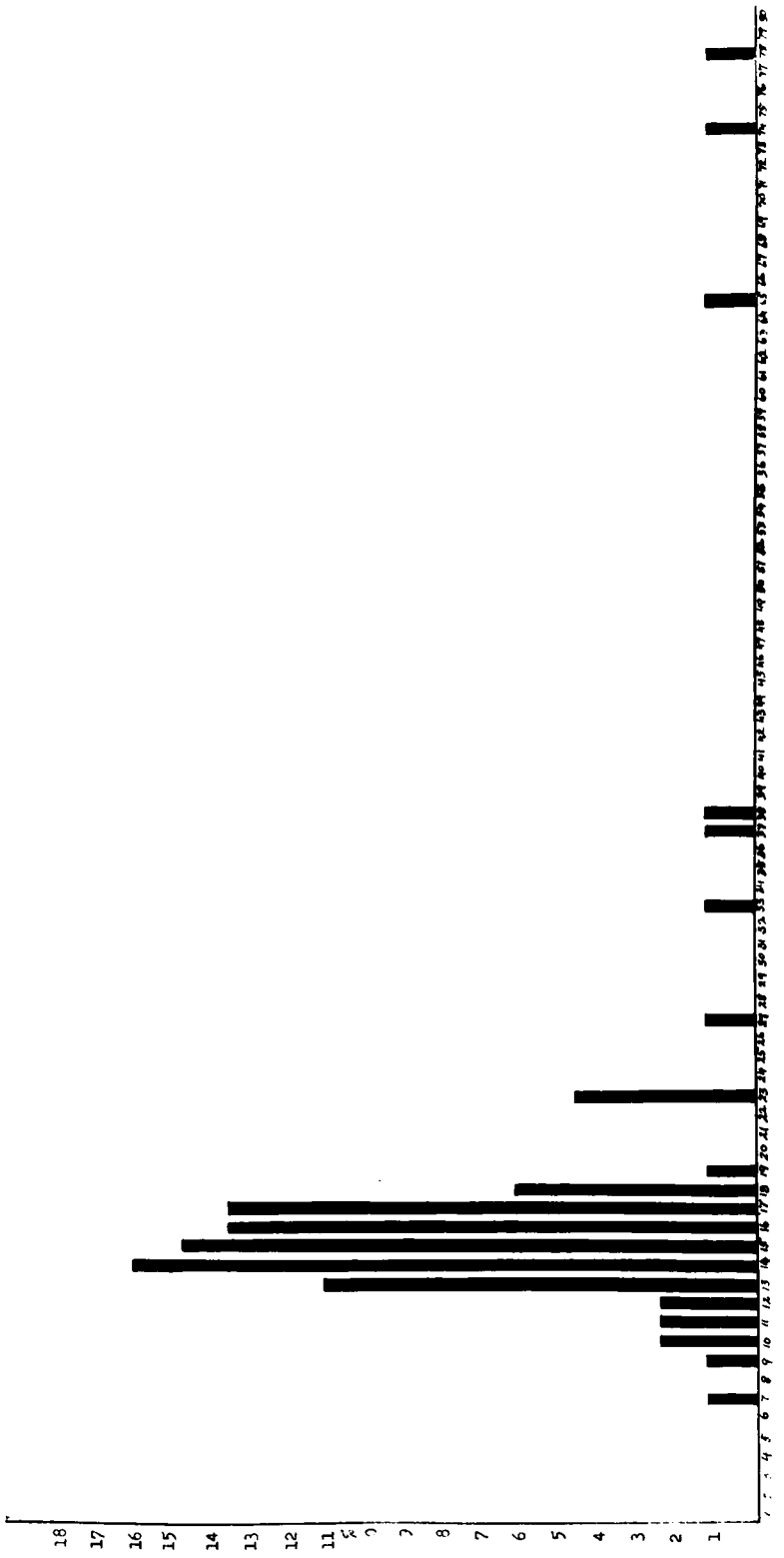


Fig. 5. Frequency graph showing the length of the interostral period.

D. THE BREEDING SEASON IN THE KARROO MIDLANDS.

Review of the literature.

Küpfer (1928) working on mares kept under ordinary veld conditions of South Africa, concludes from his observations that "the appearance of ovulation and oestrus in donkeys and horses is seasonal, occurring only at a certain time of the year. For the rest of the year ovulation and symptoms of heat are entirely absent".

Quinlan and others (1951) carried out observations on mares stabled at night at Onderstepoort. The mares were never let out but but received uniform rations throughout the year with the exception that green feed was given during the summer months but not during the winter. These mares were tested for oestrus daily by a teaser stallion and it was observed that oestrus occurred irregularly throughout the year but that the months of April, May, June and July were found to be barren in so far as none of the mares that were mated then became pregnant. With one exception all cases of anoestrus commenced during the first 7 months of the year. There was an increase in the mean duration of the oestrous cycle in January indicating the end of the optimum breeding season. They observed that gonadotrophic activity during July appeared intense and there was far greater variation in the duration of oestrus in July than in any other month. Breeding commenced in August but best results were obtained in November.

Observations.

The factors which limit the period during which the breeding of Thoroughbreds is conducted, were discussed in the introductory remarks of this study. It was pointed out that the Jockey Club of South Africa rules that ageing of Thoroughbreds shall take place from the 1st of August each year. This ageing forms the basis of accepting horses for the Junevile, two- and three-year old races. As there is a great demand for well-grown yearlings to com-

pete/...

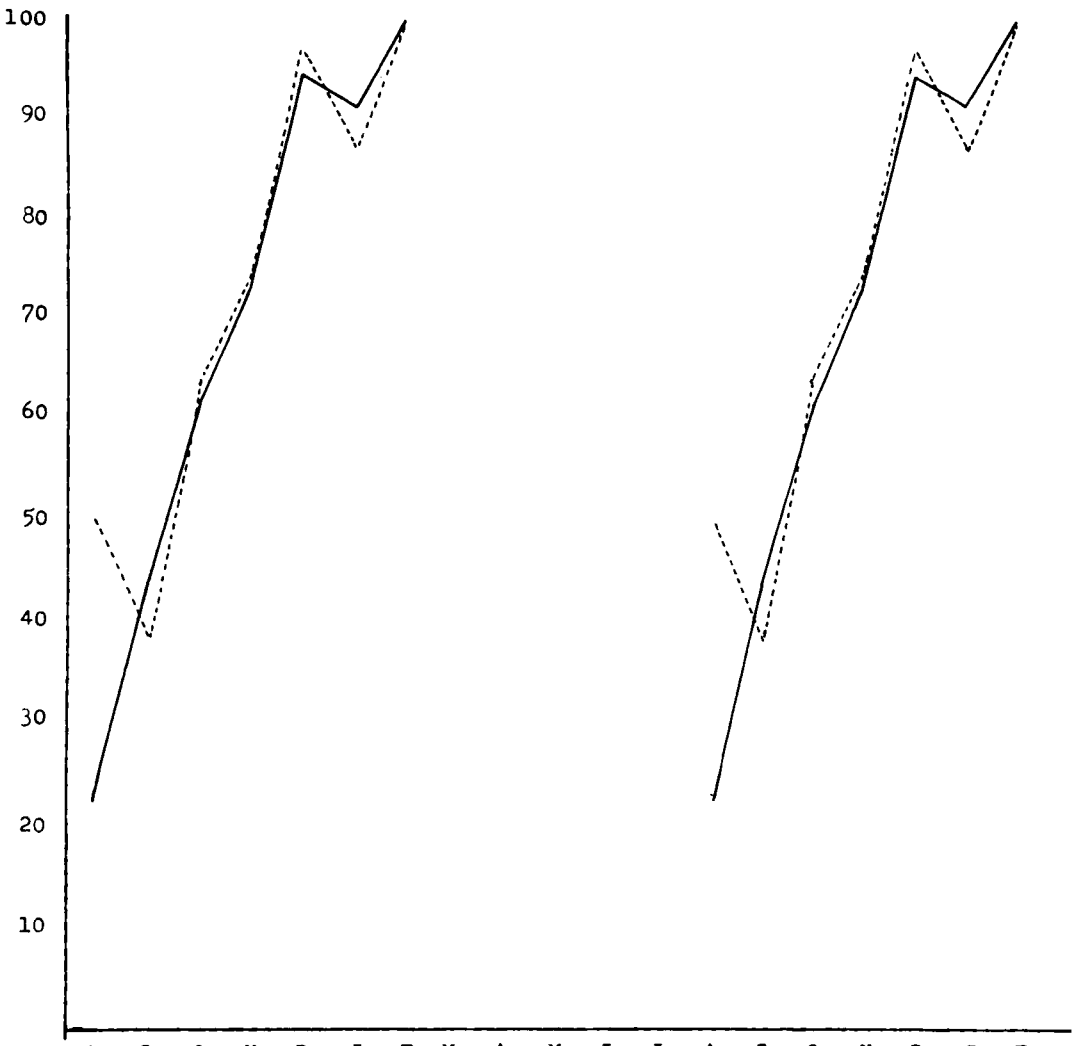
pete in these races, it follows that the breeder is compelled to mate his mares during a period which will result in foaling as soon as possible after the 1st of August.

The age rule of the Jockey Club of South Africa artificially restricts breeding to a period extending roughly from about the 7th of September to about the end of December. Today this is the accepted breeding period for Thoroughbreds in South Africa. The question, however, arises in how far this mating period corresponds to the natural breeding season of horses in the Karroo Midlands.

Figure 6, based upon the particulars contained in Tables 5 and 11, reflects the frequency graph showing the conception percentages in Thoroughbreds for the months of August to December 1950, and January to February, 1951. Two frequency graphs are given, the one for the Cape Province in which the Karroo Midlands is situated, and the other for the entire Union of South Africa. The two conception rates run more or less parallel and rise steeply from September to November, showing a slight decline during December, to rise again to reach its maximum during February.

Figure 7 gives the curve for the average length of day-light hours registered at Grootfontein School of Agriculture, Middelburg, Cape. The School is situated about 12 miles from the farm Askania Nova, and the figures may be taken as representative for the Karroo Midlands. The curve is lowest during June, and rises sharply from July to reach its zenith during December. During June its average length is 10.14 hours and during December 14.16 hours, which represents a 39.64 per cent increase in total daylight hours.

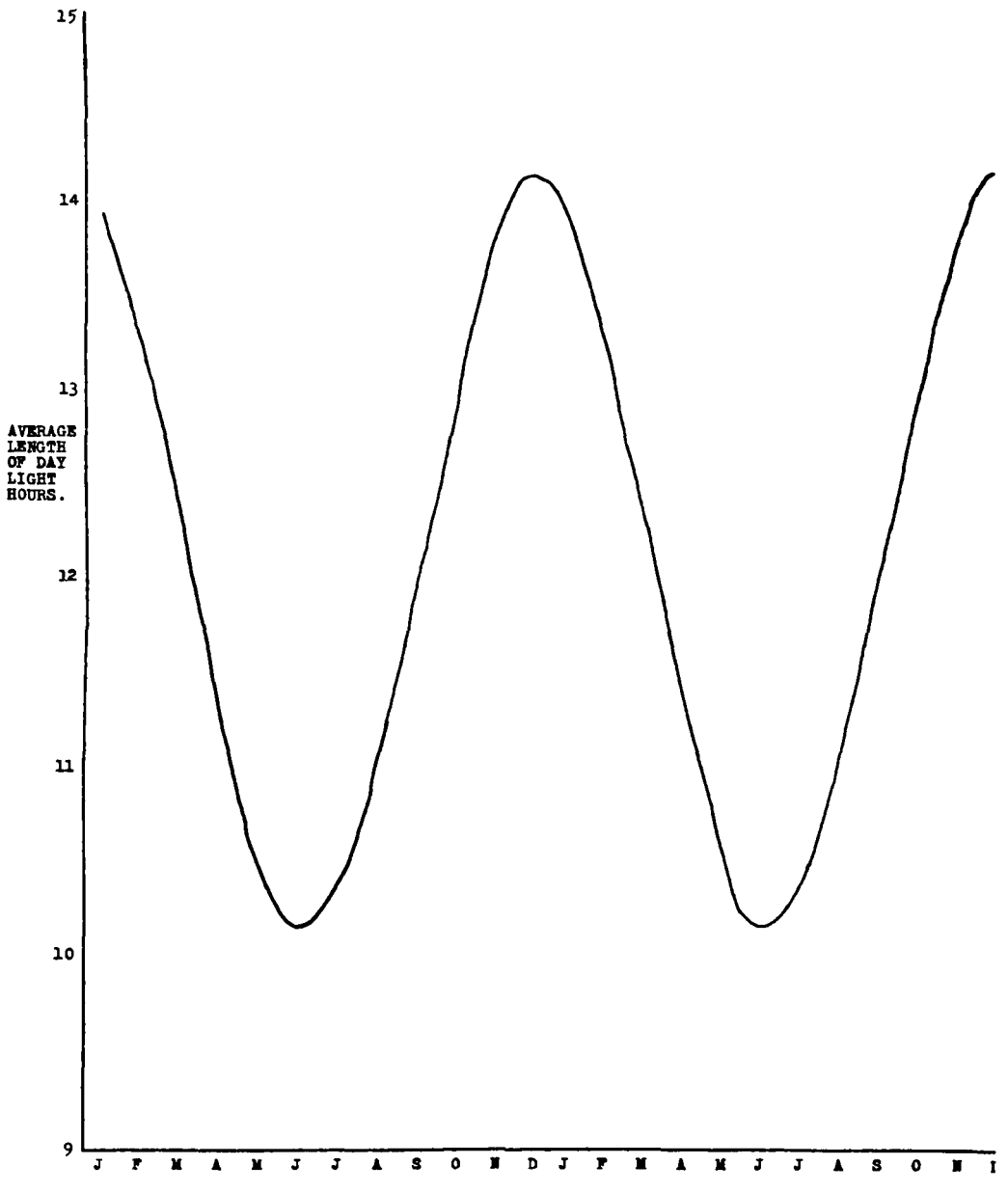
Figure/...



_____ : Monthly Conception Percentage for the Union of South Africa.

-------- : Monthly Conception Percentage for the Cape Province.

Fig. No. 6. Frequency graph showing the conception percentages for the 1950 - 1951 breeding season.



J	13.94	J	10.31
F	13.24	A	10.98
M	12.31	S	11.87
A	11.35	O	12.83
M	10.54	N	13.70
J	10.14	D	14.16

Fig. No. 7. **Average Daylight Hours, Grootfontein College, Middelburg, Cape.**

Figure 8 records the average rainfall for Grootfontein over a 30 year period, details of which are reflected in Appendix 1. It will be noticed that the rainfall is very unevenly spread throughout the year. The spring months of August to October receive very little, and it is only from the latter part of October and during early November that there is a rainfall exceeding 1 inch per month.

Figure 9 reflects the maximum monthly temperatures at Grootfontein. The maximum temperature rises from July to reach its maximum during January or February, but variation occur from year to year. Normally the rains during October and November cool the air and the temperatures do not rise so steeply during those months. This can be detected in Figure 9 for the years 1950 to 1952.

These four graphs become highly significant when correlated. They indicate that the ascending rate of conception is closely connected with increasing daylight hours, rainfall and warmth.

Observation of investigators throughout the world confirm the existence of a definite breeding season in horses during which reproduction is successful. Küpfer (1928) states that under South African veld conditions this period extends from the end of October to the end of March. This period corresponds roughly with the summer months. Figure 7 indicates that during the period October to March the length of daylight hours reaches a maximum of 14.16 hours during December, to decrease again towards March. During the entire period it does not fall below 12 hours a day. The rainfall increases from an average of 1 inch during October to a maximum of $2\frac{1}{2}$ inches during March. With the longer hours of daylight, the increase in rainfall and the great increase in temperature, the veld responds rapidly and the new plant growth provides abundance of food which causes the shedding of the winter coat, rapid improvement in condition and the awakening of reproductive function.

Figure/...

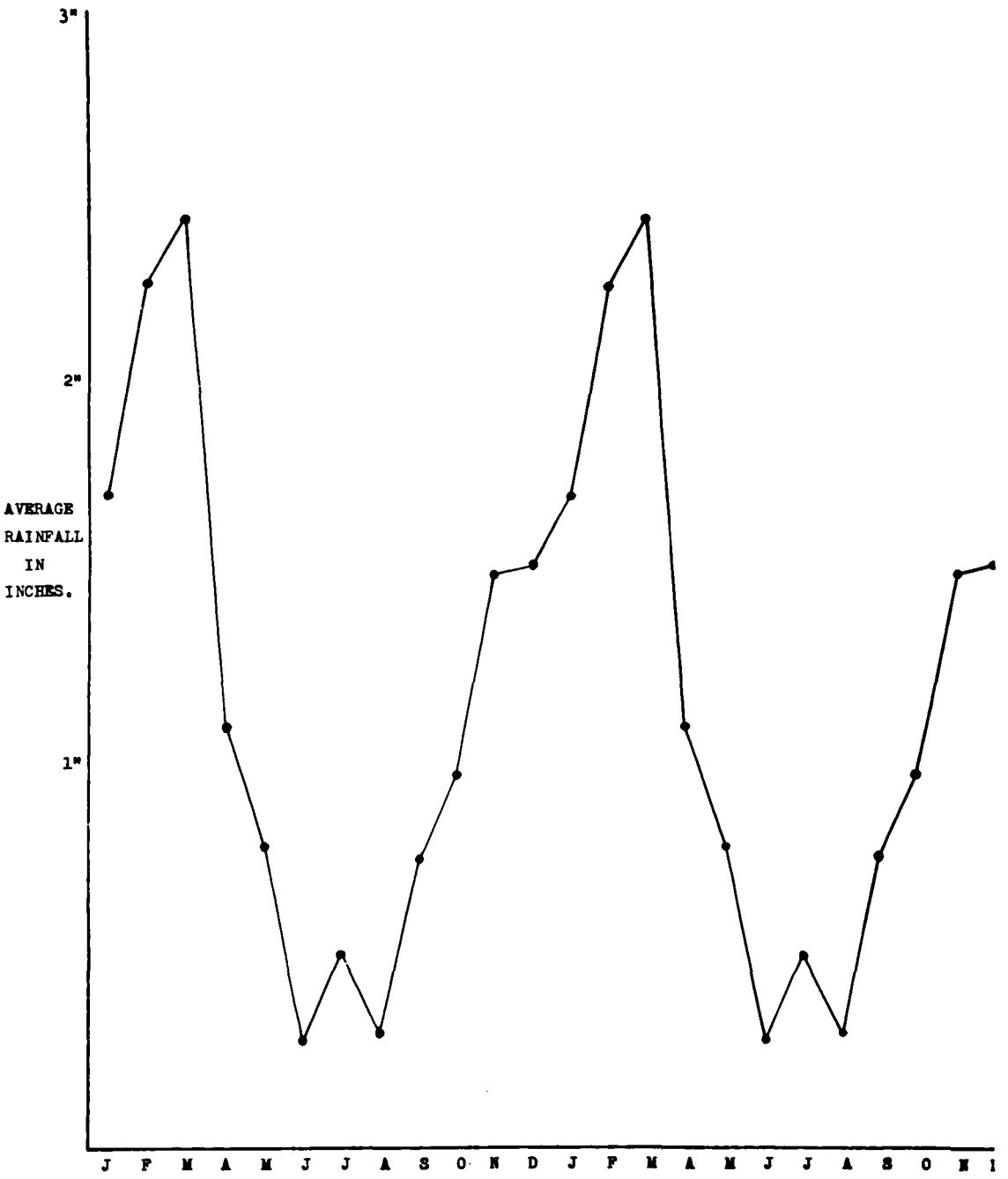


Fig. No. 8. Average Monthly Rainfall
1923 - 1952
Grootfontein College,
Middelburg, Cape.

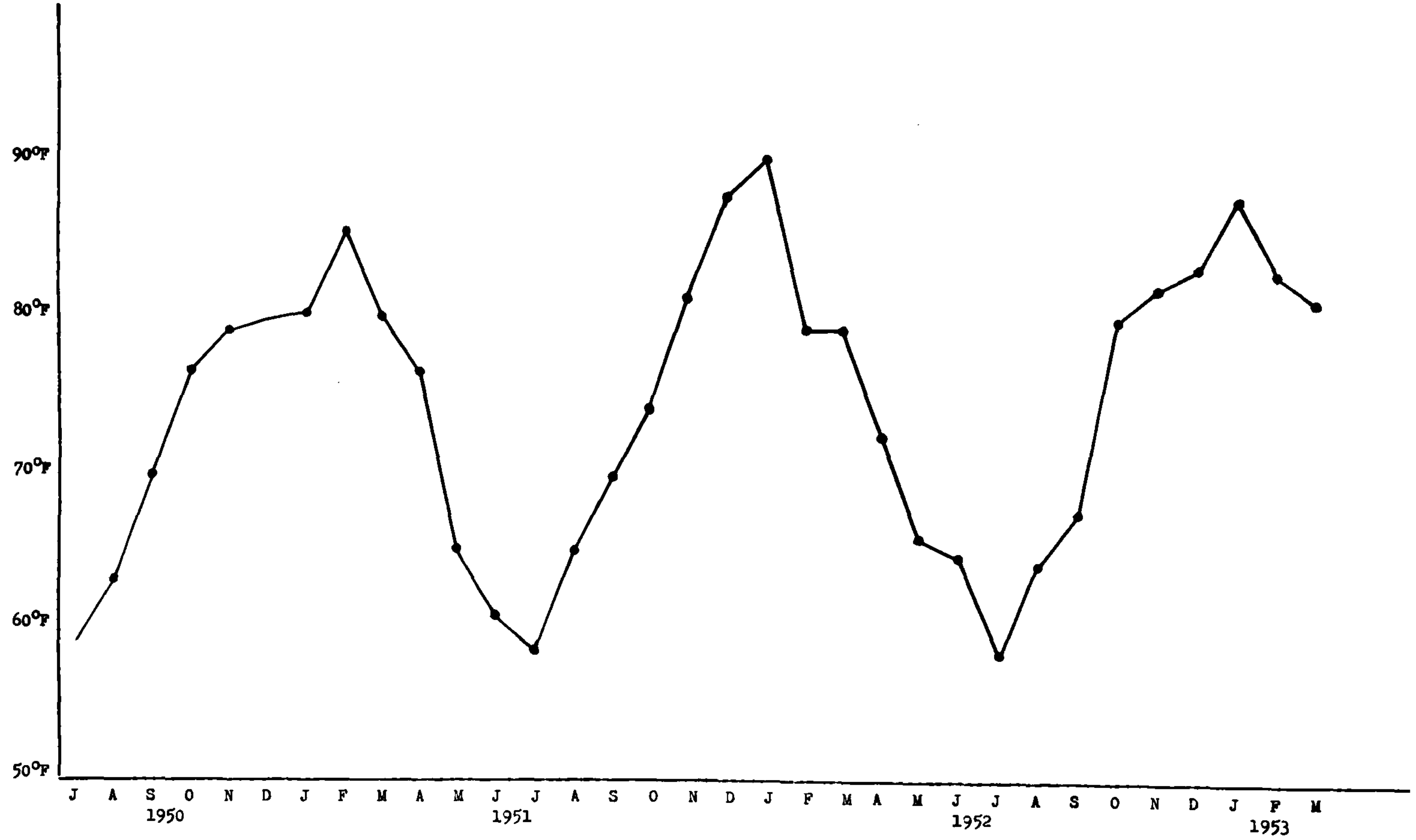


Fig. No. 9. MAXIMUM MONTHLY TEMPERATURES - Grootfontein College, Middelburg, Cape.

Hammond and Marshall (1949) stress the fact that where ewes were brought to a high degree of nutritional activity by extra feeding, without being in too high a condition, a greater percentage of lambs was produced. Küpfer (1928) in discussing the breeding season of horses in South Africa, specifically mentions "that this breeding season will vary from year to year, in as much as both the beginning and the end of the active season are subjected to influences which determine the condition of the animal".

As the curve for the average length of daylight hours in Figure 7 is an annual constant, the fluctuations in the commencement and duration of the breeding season cannot be ascribed to it, and its causes must be sought elsewhere. Where horsebreeding is conducted under natural veld conditions in the Karroo Midlands, (e.g. Percherons, Arabs, Saddlehorses, etc.) maximum fertility is only obtained during the period November to March, i.e. during the period when the veld and its natural grazing has recovered from the winter. In those years where rains fall during early spring, the breeding season starts earlier. The advancement of the breeding season can hence only be ascribed to an earlier improvement in the condition of the animal as a result of the improved nutritional intake. The contention that the beginning of the breeding season is not determined solely by the increase in daylight hours is supported by the statement of Day (1940) that mares running out during winter go into anoestrus, and the findings of Quinlan and others (1951) who record the fact that stabled mares when given additional food, continue to show oestrus throughout the year.

The observation that a rising plane of metabolism is required for the initiation of reproductive function, provided the animal is not in too high a condition at the commencement, was only found applicable to Thoroughbred mares in the Karroo Midlands. This was performed by running non-pregnant mares out in the veld

from/...

from January and giving them only a little supplementary feeding if considered necessary. The mares usually lost condition and became lean and thrifty. The commencement of the natural breeding season was considerably advanced and accelerated by bringing such mares on artificial pastures of wheat, oats or barley, grown under irrigation, and supplying additional feed such as rolled oats, maize and lucerne hay. (Belonje, 1949).

This forcing of mares to a higher nutritional activity with its consequent improvement in condition and higher metabolism was performed at Askania Nova Stud during July, i.e. mid-winter, and continued until the end of the breeding period.

This procedure initiated the œstrous cycle and favourably influenced follicular development. Most of these mares were fit to breed by the time the breeding period commenced, i.e. the 7th of September and the majority settled readily.

E. THE INTENSITY OF OESTRUS DURING THE BREEDING SEASON.

Review of the literature.

Andrews and McKenzie (1941) and Götze (1949) have described the oestrous responses of the mare in great detail. Andrews and McKenzie were able to recognize eight different types of sexual behaviour which they were able to represent in a graph.

Observations.

The beginning of oestrus was dated from the time a mare showed evidence of receptivity to the attentions of the teaser stallion, and ended when she passed into a non-receptive state. The oestrous cycle was taken from the 1st day of oestrus until the beginning of the next oestrus.

Figures 10 and 11 in Appendix XI reflect the details for these Thoroughbred mares for the 1950 to 1951 breeding seasons.

During the 1952 breeding season, the intensity of the sexual responses of these mares to the attentions of an active, vigorous stallion were carefully observed and recorded. It soon

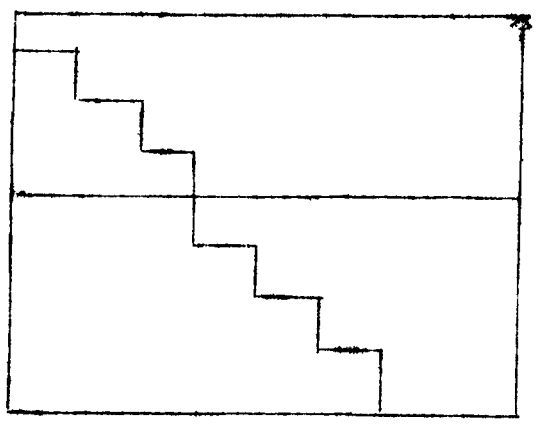
became/...

PHOTO 20: ORNAMENT SHOWING OESTROUS SYMPTOMS ON HER OWN.

PHOTO 21: ORNAMENT EXPOSING AND RAISING CLITORUS

PHOTO 22. DURING OESTRUS SMALL AMOUNTS OF URINE ARE VOIDED

became evident that the classification of Andrews and McKenzie proved unsatisfactory in its application to Thoroughbred mares. Their classification was consequently altered by simplification and each type of sexual response more clearly described and defined. Seven types of sexual responses were noted and detailed under Experimental Procedures. Its graphic representation is as follows:



3. XXX. Very receptive
2. XX. Moderately receptive.
1. X. Mildly receptive.
0. Passive - Indifferent.
1. -. Mild resistant
2. --. Actively resistant.
3. ---. Violently resistant.

Each square represents one day.

Figure 12 reflects the sexual cycles and the intensity of oestrual responses of these Thoroughbred mares during the 1952 breeding season.

Considerable fluctuations in sexual behaviour during oestrus have been observed in other Thoroughbred studs. Some heats were found very prolonged, other short, and in a few cases heat was interrupted by a few days rest before reappearing again. The observations of Küpfer (1928) on the irregularities in the recurrences and duration of the heat periods of ordinary horses and donkeys were found to be present in most Thoroughbred establishments. The very short interval of rest during a heat, designated as 'split' oestrus by Andrews and McKenzie, have also been encountered in Thoroughbred mares. Most of these irregularities are encountered in young maiden mares, or in non-pregnant mares in the early part of the breeding season, particularly when a cold and dry spring prevails and no supplementary feeding is resorted to.

In the/...

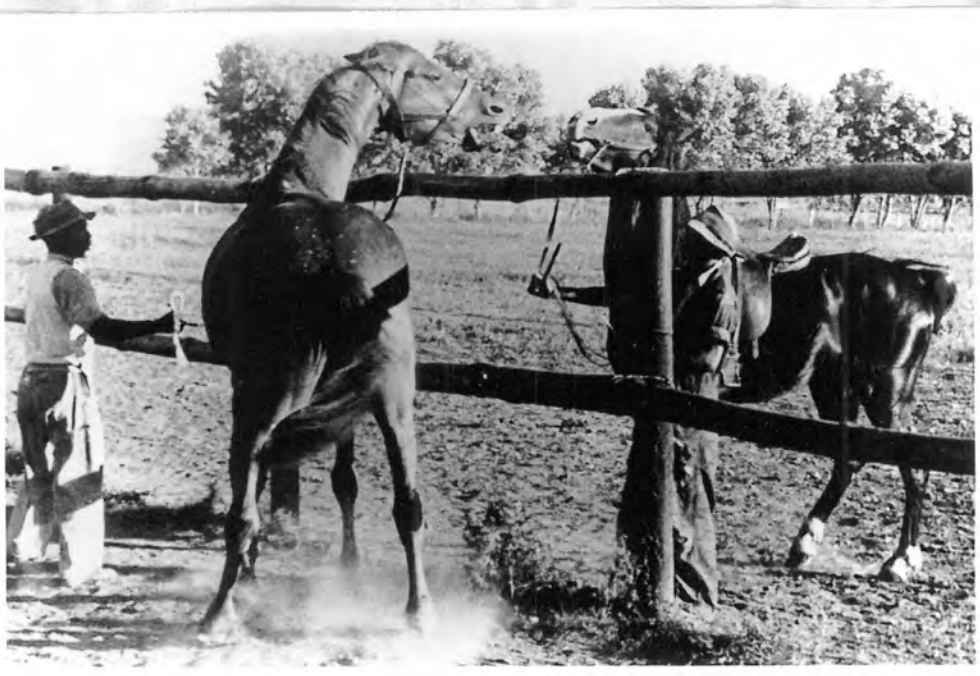


PHOTO 23 - 25: PSYCHOLOGICAL HEAT. CALAMITY JANE SHOWING INTENSE RESENTMENT TO THE TEASER STALLION.

In the group of mares under observation no cases of split oestrus were observed during 1950-52, nor was a single mare found 'passive' to the attentions of the teaser stallion. Most mares were actively resistant during inter-oestrus, with the exception of FLORA SANDES and CALAMITY JANE. Both these mares were violently opposed to the presence of the stallion during inter-oestrus and resented his attentions intensely.

The process of coming into heat was not found to be a gradual one, but occurred abruptly and was immediately detectable. The degree of receptivity, however, varied considerably from mare to mare, and often from heat to heat in the same mare. Because of the variability encountered, no definite conclusions are possible and attention is directed to Figures 10, 11 and 12, as to the behaviour of each individual mare.

It will be observed that the reactions are generally distinct and the graphic fluctuations recorded by Andrews and McKenzie (1941) absent. The explanation for this difference may be that the Thoroughbred is characterised by a higher nervous development and consequently react in a more decided manner to external stimuli. The other reason may also be that the non-pregnant mares had been carefully conditioned for breeding some time before the mating season commenced, so that by the time teasing started their oestrous cycles had become stabilized and their reactions better developed.

Figure/...

1952.

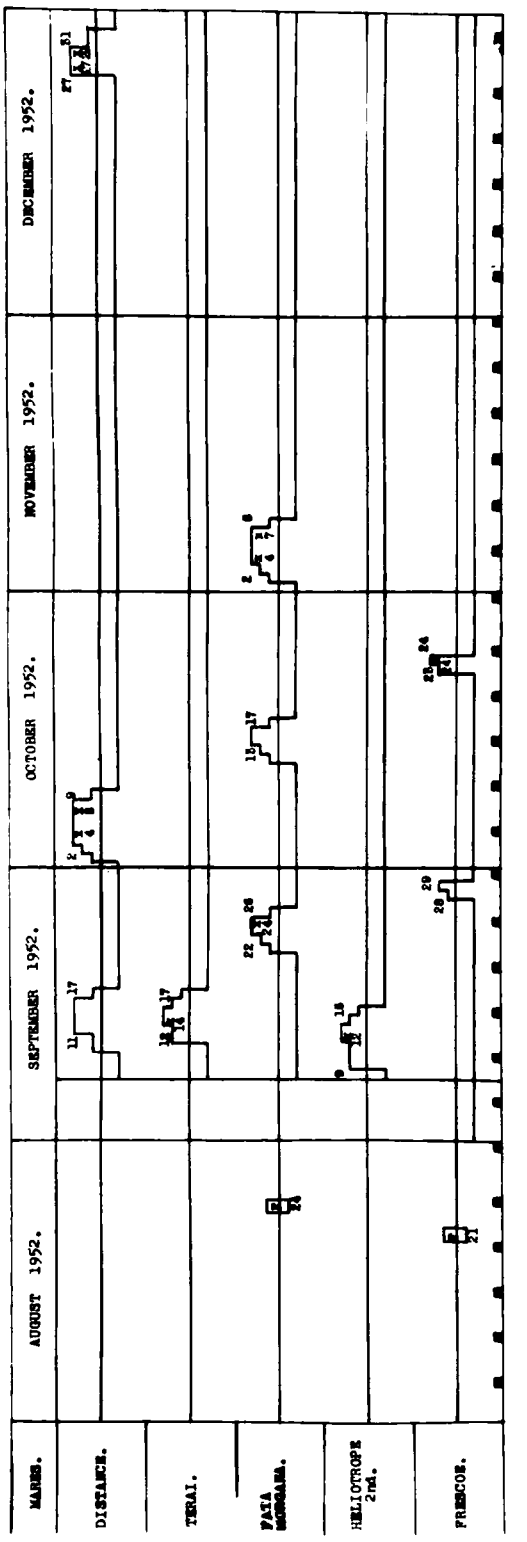


Fig. 12.

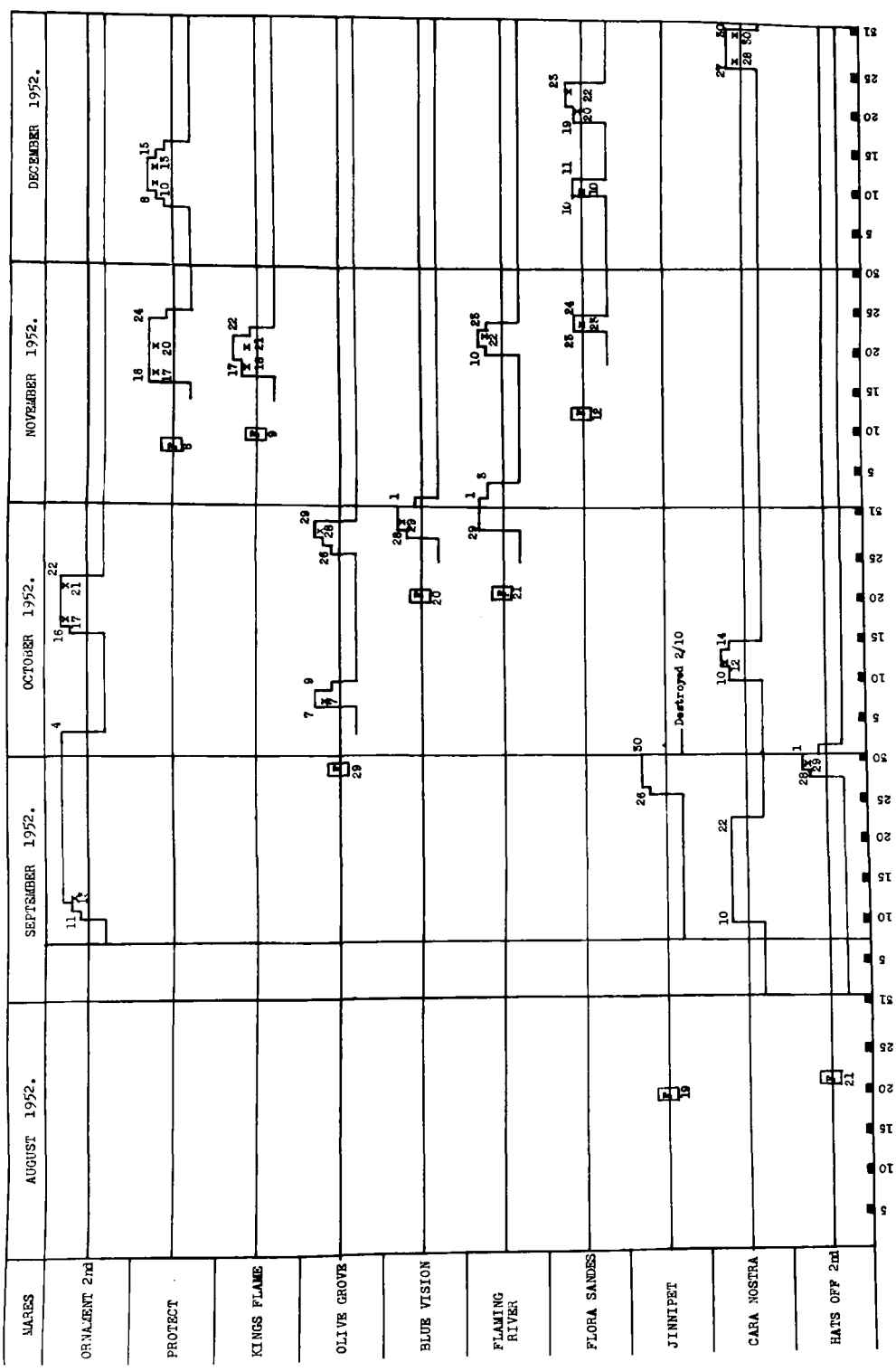


Fig. 12.

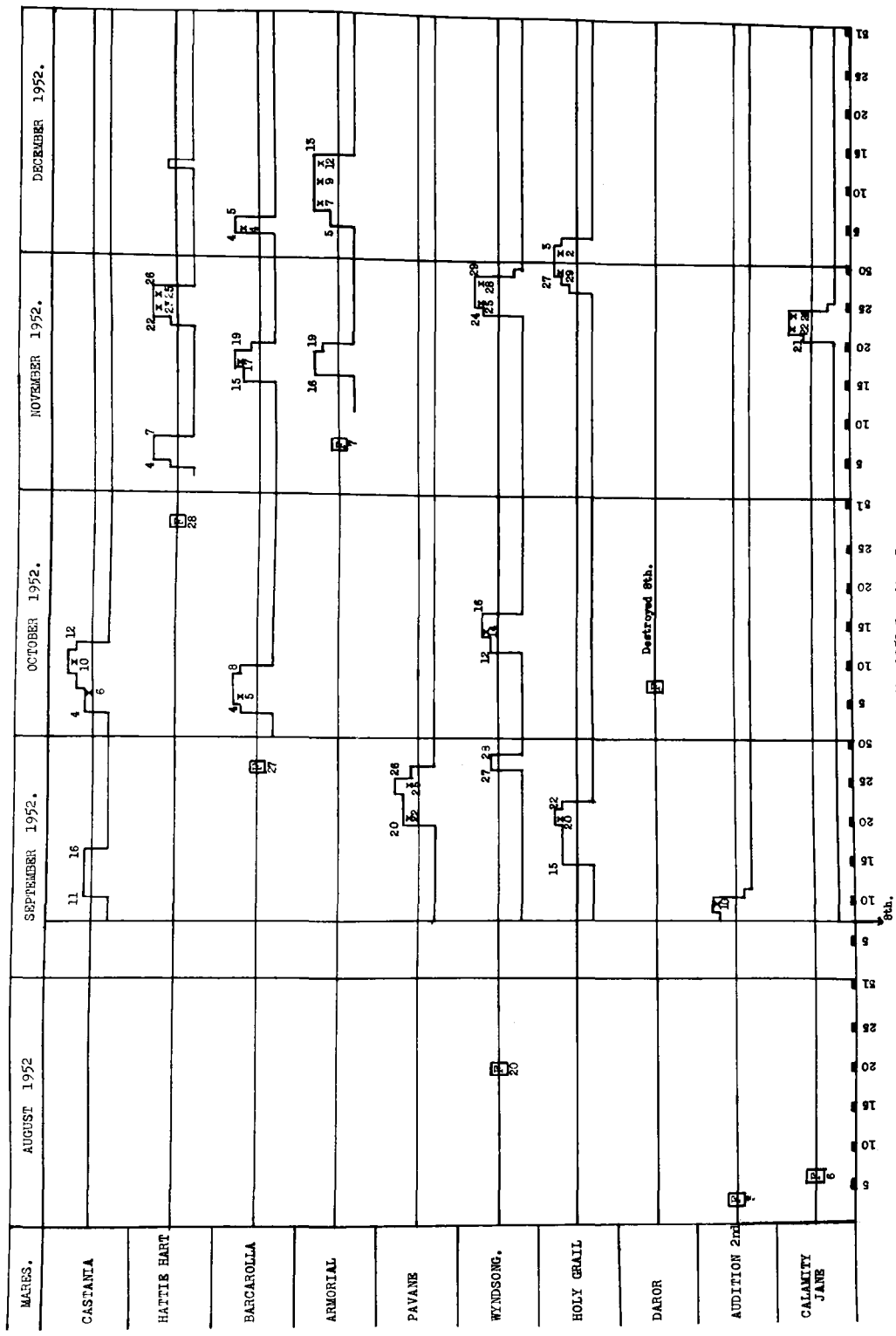


Fig. 12. Intensity of Oestrus ing the 1952 Breeding Season.

F. THE ARTIFICIAL REDUCTION OF OESTRUS.

Review of the literature.

Mirskaya, Kedrov and Lihacev, (1936) succeeded in shortening the normal duration of heat in mares by giving 2 subcutaneous injections of 500 M.U. Prolan at 6 to 8 hours interval. The duration of heat was 3.84 days in the treated mares as against 7.55 days in the normal untreated mares.

This work was confirmed by Petropavlovskii (1938) and Mirskaya and Petropavlovskii (1938).

Day (1939) found that in mares which had a follicle of sufficient size in the ovary, the intravenous injection of 1,000 to 2,000 international units of Human Pregnancy Urine Extract (P.U.) caused ovulation at any time in the oestrous cycle. Further, that in those mares which were in oestrus at the time of injection, ovulation occurred 22 to 30 hours after injection and the length of oestrus was reduced from 7 to 9 days to 3 days. In those mares that were not in oestrus at the time of injection ovulation occurred 30 to 60 hours after injection.

McKenzie (1940) found the interval to be 42 hours after injection in 12 out of 19 cases or 63 per cent. In all of the cases ovulation occurred in 4 days or less.

Davison (1947) found that the size of the follicle gave no indication of the approach of ovulation, and he placed more reliance on the consistency and in particular the thickness of the follicular wall. When the follicle wall appeared to have become very thin pregnancy urine extract was injected, regardless of the size of the follicle. He records that 19 out of 24 mares ovulated between 24 and 48 hours and one ovulated 4 to 5 days later, but can offer no explanation for this instance.

Burkhardt (1948) maintains that when a follicle has sufficiently developed to justify the use of pregnancy urine extract, i.e. in his experimental ponies a follicle of approximately 2.5 cm.

2.5 cm. in diameter, ovulation will follow 40 to 48 hours after injection with almost clockwork regularity.

The dose of the Pregnancy Urine Extract used by these authors varied between 500 to 1,500 international units and was administered intravenously.

Observations.

Luteinising hormone was used on the fellowing mares:-

1. HOLY GRAIL
2. CARA NOSTRA
3. FRESCOE
4. FLORA SANDES
5. PROTECT
6. ORNAMENT 2nd.

The result obtained were as follows:-

1. HOLY GRAIL. This mare had a heat period of 8 days from 15-22/9/52. She was served on 20/9/52 and 1,500 units Prolan injected intravenously immediately afterwards. Ovulation occurred the next day and within 40 hours. The mare had wintered badly and at the time of service was still in poor condition and had not shed her winter coat. There is no doubt that conception occurred but early foetal death followed.

It is generally accepted that the hormone Progesterone exerts an effect on the uterus and prepares it for the reception and nidation of the fertilised ovum. Further that this action is only manifest after the genitalia have been stimulated by oestrogens. The results of Mirskaya and Petroplavlovskii (1938) would suggest that this preliminary period of oestrogen stimulation, while shortened by the use of luteinising hormone, was at least adequate. Unfortunately they do not state during what period of the breeding season these experiments were conducted. It is possible that they were performed during or towards the end of the breeding season and the

mares/...

mares on which these experiments were done had passed through one or more oestrous periods and the genitalia sensitised to the luteinising hormone and progesterone.

Prolonged heat periods are not uncommon amongst maiden mares and mares that have wintered badly in the Karroo Midlands. These long heat periods are invariably encountered during early spring, i.e. during the early part of the breeding season. To my mind this long duration of oestrus is required for the development of the tubular genitalia, and appears to be a normal physiological process of conditioning and maturation of the genital tract. Luteinising hormone has been used in such cases, either intramuscularly, subcutaneously or intravenously or a combination of any of the foregoing, with consistently disappointing results. Frequently the heat period continues undisturbed without follicular rupture, in other cases follicular rupture takes place but is not followed by conception. These results are particularly seen in young maiden mares. During the middle and late summer the ovary becomes very sensitive to luteinising hormones and even very small doses will cause ovulation of a fair-sized follicle and cessation of heat.

The mare HOLY GRAIL wintered badly and the possibility exists that she was given insufficient time for full genital development and that this factor may be responsible for early foetal death.

2. CARA NOSTRA. The position in this mare is somewhat different from the preceding one. Her condition was so bad that service was withheld from her first heat of 10-22/9/52. This heat continued for so long that it was decided to shorten it by the use of luteinising hormone. On 20/9/52 she was given 500 units Prolan subcutaneously and the next day 1,000 units Prolan S.C. Rupture of the follicle occurred on 21/9/52.

A normal interoestrous period of 17 days followed and she returned in heat on 10-14/10/52. She was bred on 12/10/52 and it is considered that conception took place but early foetal death followed.

whether/....

Whether the artificial reduction of the previous heat had any influence on the subsequent heat, or if the heat periods were too short for the successful development of the genitalia is most difficult to decide at this stage. It may be that undue shortening of the prolonged preparatory heats early in the season is inadvisable because of the possible repercussion of early foetal death later. It is significant that Caslick (1937) in Kentucky observed that it takes, on an average, 3 heat periods before a mare is settled.

3. FRESCOE. This mare came half-heartedly in heat on 28-29/9/52. Rectal examination revealed the presence of a fully developmed Graafian follicle in the left ovary and a healthy responsive uterus. As she failed to make any progress 1,000 units Pregnant Mare Serum was given subcutaneously on 21/10/52. She came in heat on 23-24/10/52, was served on 24/10/52 and 1,000 units luteinising hormone, given intravenously. It is estimated that the follicle ruptured within 12 hours and pregnancy resulted.

This mare foaled on 21/9/52 and was in perfect condition for breeding. In her case a diagnosis was made of partial suppression of ovarian development by the lactating and maternal reflexes. The responsiveness of the ovaries to the hormonal injections indicate that their development had been adequate and the pregnancy was successful.

4. FLORA SANDES. This mare had a history of being a shy breeder, having silent heats, and normally has to be twitched when brought to the teaser stallion. She had two unsatisfactory heats during the 1952 breeding season; the one from 23 to 24/11/52 which was anovulatory, and the other taking place from 10 to 11/12/52 with ovulation occurring the day before, i.e. on 9/12/52. She returned in heat on 19-23/12/52 when she had a small, tense follicle of 2 cm. in diameter in the right ovary. She was served on 20/12/52 and 2,500 units Prolan injected intramuscularly. The follicle appeared to ripen as it became soft, fluctuating, and the mare a little more

responsive./...

responsive. She was served again on 22/12/52, i.e. 48 hours later and another 2,500 units Prolan given intramuscularly. Ovulation followed within 12 hours afterwards resulting in conception and successful pregnancy.

The 'shy breeder' or the mare with silent heat, is characterised by giving very little outward indication of oestrus or sexual desire. One may therefore question the validity of the assumption that one or more heat periods are required for the maturation of the genital tract in such animals where symptoms of heat do not occur or only to a very slight degree. Robson (1947) however states that the doses of oestrogens necessary to induce mating are however much larger than those which will induce morphological changes in the secondary sex organs.

This mare FLORA SANDES is an example of a 'shy breeder' where where oestrogenic output was sufficient for full genital development (Physiological heat) but not enough for outward symptoms of sexual desire. (Psychological heat).

Although this mare received 2,500 units luteinising hormone during her heat period, the follicle failed to rupture under 48 hours. This is contrary to the findings of Day (1939), but corresponds with those of Hancock (1948). The latter treated 20 mares in heat with Pregnancy Urine Extract with the following results. Three ovulated within 24 hours, 13 ovulated between 24 to 48 hours later, and one ovulated between 48 and 72 hours. Of the remaining 3 mares, one showed a cystic follicle which luteinised without rupture, the second was an aged mare which never showed a follicle greater than 3 cm. in diameter, and the third mare had a follicle 3 cm. in diameter at the time of injection but failed to ovulate until 7 days later. The dose of P.U. used varied between 500 to 1,500 international units given intravenously.

5/...

5. PROTECT. This mare had a foalheat of 9 days from 16 to 24/11/52, during which period the uterus showed little tendency to involute further. She was served on 17 and 20/11/52, but ovulation only occurred on 24/11/52 and she failed to conceive.

Her following heat was prolonged (8-15/12/52) and it was decided to shorten the period to coincide ovulation with service. She was served on 10 and 13/12/52, and after the second service was given 2,500 units luteinising hormone intramuscularly. She ovulated within 24 hours and conceived with a successful pregnancy.

The only reason why luteinising hormone was used in this case was the unexpected length of foalheat, and the fact that ovulation occurred on the last day of her previous heat. The service of 20/11/52 could not have left any viable semen for fertilisation of the liberated ovum on 24/11/52.

6. ORNAMENT 2nd. This mare was purchased in France and imported to South African during 1952. She foaled on the farm Askania Nova on 21/4/52, i.e. outside the normal foaling season.

She came in heat on 11/9 - 4/10/52 for a period of 24 days but failed to ovulate. She returned in oestrus on 16-22/10/52 and was served on 17 and 21/10/52. She ovulated on 17/10/52 in the left ovary but failed to produce a palpable bloodclot and corpus luteum. Service was withheld until 21/10/52 to see if the mare would go out of heat. On that day she had a ripe, soft, fluctuating follicle of 3.5 cm. in diameter in the left ovary and was very much in season. She was served on 21/10/52 and 2,000 units luteinising hormone given intramuscularly. Ovulation took place within 12 hours and pregnancy resulted.

The reason for the employment of the luteinising hormone in this case was the fear of the mare having another prolonged anovulatory heat. The mare was in excellent order with a responsive uterus and her behaviour was ascribed to lack of acclimatisation.

The/...

The influence of acclimatisation upon fertility of horses was described by Basov (1935) who was able to show decreased fertility in mares imported into the Northern Caucasus from various other areas, although marked differences appeared to exist between different types of horses.

This temporary infertility in mares imported into the Karroo Midlands from various countries overseas has been encountered on several instances. So for instance in this group of mares TERAI is an example of a mare imported during 1951 and which failed to settle during that breeding season. Yet during 1952 she had only one heat, 12-17/9/52, and became pregnant to one service on 14/9/52.

Discussion.

Several cases of shock have been observed in Thoroughbred mares following the intravenous administration of luteinising hormone. Symptoms invariably occurred within 20 minutes after injection. The animal shows muscular tremors, with marked quivering of the muscles of the hindquarters, weakness and anxiety. Two Arab mares collapsed on the ground within a few minutes. Both recovered within a hour and both conceived to a service that had been performed immediately prior to the injection.

Although no fatalities are known following intravenous use of these hormones, it was decided to use the intramuscular route in preference. Peck (1952) recommends doses up to 10,000 international units of luteinising hormone by this route, but experience has indicated that doses of 2,000 to 2,500 units are adequate to cause ovulation within a reasonable period. So far no cases of shock have followed this procedure.

It is not known if the luteinising hormone is directly responsible for the reaction or whether this is due to a foreign protein-like body within it, and against which the body has been previously sensitised. Burrows (1945) experimental work indicates

that/...

that repeated injections of a gonadotrophic extract may cause a recipient to become resistant to the hormone action of that extract, either by the formation of antibodies or by some process not yet understood. Subsequent experiments have afforded evidence that the resistance produced by repeatedly giving a particular gonadrophin, is largely due to an immunity developed against a foreign protein-like body and that it is not, as much of the literature seems to imply, a reaction which can be described correctly as anti-gonadotrophic. The cases of shock experienced after the intravenous administration of luteinising hormone are in all probability similar in nature and represent a type of anaphylactic reaction.

There was not the slightest indication in the mares under observation that the luteinising hormone exercised any influence over the actual growth in size of the Graafian follicle. In the case of FLORA SANDES the follicle felt tense at the time of the first injection. It is possible that it might have matured slowly and ovulated spontaneously later on. The second injection was given when the follicle had become soft and fluctuating, and rupture followed within 24 hours afterwards. Nevertheless the intramuscular injection of 2,500 units Prolan had failed to cause ovulation within 48 hours of an existing follicle during a heat period.

G. THE ARTIFICIAL INDUCTION OF OESTRUS.

Review of the literature.

It is apparent from the literature that the various methods employed to induce oestrus in anoestrual mares depend entirely upon the state of development and responsiveness of the ovaries to the various stimuli used.

It is now generally agreed that the mare with the 'deep' anoestrus of winter, is refractory to all types of treatment (Burkhardt, 1948), while the 'shallow' anoestrus encountered during the breeding season has proved amenable to treamtnet, either by means of gonadotrophins or oestrogens. (Burkhardt, 1947;

Berliner/...

Berliner and Scales, 1944; Nishikawa et al., 1952, and others).

During the early part of these studies it was pointed out that the use of the terms 'deep' and 'shallow' was undesirable, as it merely implied the ease or not by which a mare can be brought in heat, as well as a certain condition of the ovaries associated with 'deep' anoestrus. It was also pointed out that small, hard, retracted ovaries have been encountered in mares in continous heat so that the state of the ovaries and the libido of the mare are not necessarily correlated in a definite clinical relationship. For that reason it is suggested that these terms be rejected and a more accurate diagnosis made in respect of the morphology of the genital organs and the outward behaviour of the mare.

METHOD OF PREPARATION OF CHORIONIC- AND SERUM-GONADOTROPHIN.

A. Chorionic Gonadotrophin.

Synonyms: Gonadotrophinum Chorionicum, Luteinising Hormone, Pregnant Womens' Urine Extract, Pregnancy Urine, P.U.

This substance conforms to the requirements of the British Pharmacopoeia. Chorionic gonadotrophin is a dry sterile preparation of the gonadstimulating substance obtained from the urine of pregnant women. It contains not less than 400 Units per mg.

The best commercial source of luteinising hormone is still the urine of pregnant women, the largest amounts being secreted in the first months of pregnancy, especially about 50th to 60th day following the last menstrual period, when an enormous secretion is observed.

It may be prepared by the following method. The acidity of the urine is adjusted to about pH 6 and Alcohol (95 per cent) is added until the concentration of ethyl alcohol is about 50 per cent v/v. A precipitate of inert matter is removed by filtration. To the filtrate, dehydrated alcohol is added until the concentration of ethyl alcohol is increased to between 80 and 90 per cent v/v, and the acidity of the liquid is adjusted to pH 5. The precipitate,

obtained/...

obtained by allowing the liquid to stand for several hours, is collected by centrifuging, and washed successively with Alcohol (90 per cent), dehydrated alcohol and Solvent Ether.

The precipitate, obtained by this or other suitable method, is dried under reduced pressure, powdered, and assayed biologically.

Chorionic gonadotrophin is assayed biologically by means of its direct action on the ovaries of immature rats or mice, or by its indirect action on the accessory reproductive organs of these species (e.g. changes in the uterine weight or cornification of vaginal epithelium). The potency of any preparation of chorionic gonadotrophin is expressed in international units, one unit being the specific activity contained in 0.1 milligram of the Standard Preparation at present in use (1952). The Standard Preparation is an extract of the urine of pregnant women which has been reduced to dryness and diluted with lactose. This unit should only be employed to assay gonadotrophic extract prepared from human pregnancy urine. Any preparation of chorionic gonadotrophin may be diluted with lactose to the desired strength.

<u>Preparations from Pregnancy Urine (P.U.)</u>

Antuitrin S (Parke, Davis, London).

Gonan. (British Drug Houses, London).

Physostab (Boots, Nottingham).

Pregnyl (Organon Laboratories, London).

Prolan (Bayer Products, London).

Luthormone (Burroughs Wellcome, London),

<u>For Actions and Uses.</u>

British Pharmacopoeia 1953.

Biritsh Veterinary Codex 1953.

The Extra Pharmacopoeia (Martindale) 1941.

B./...

B. Serum Gonadotrophin.

Synonyms: Gonadotrophinum Sericum, Pregnant Mares' Serum, P.M.S.

This substance conforms to the requirements of the British Pharmacopoeia. Serum gonadotrophin is a dry sterile preparation of the follicle stimulating substance obtained from the serum of pregnant mares. It contains not less than 100 Units per m.g.

It may be prepared by the following method. The blood from pregant mares between the sixtieth and seventy-fifth days of pregnancy is collected over sodium oxalate and allowed to stand overnight. The plasma is separated and its alkalinity is adjusted to pH 9 with a solution of Sodium Hydroxide. An equal volume of Alcohol (95 per cent) is then added and a precipitate of inert protein removed by filtration. To the filtrate, dehydrated alcohol is added until the concentration of ethyl alcohol is increased to 70 per cent v/v, and the acidity of the liquid is adjusted to pH 5. The precipitate obtained by allowing the liquid to stand for several hours is collected and suspended in water, the alkalinity is adjusted to pH 9, and an equal volume of Alcohol (95 per cent) is added. A precipitate of inert matter is removed by filtration. To the filtrate, dehydrated alcohol is added until the concentration of ethyl alcohol is 70 per cent v/v. The acidity of the liquid is adjusted to pH 5, and the precipitate which forms on allowing the liquid to stand for several hours is collected.

The precipitate obtained by this or other suitable method is dried under reduced pressure, powdered, and assayed biologically.

Serum gonadotrophin is assayed biologically by means of its direct action on the ovaries of immature rats or mice, or by its indirect action on the accessory reproductive organs of these species. The potency of any preparation of serum gonadotrophin is expressed in international units, one unit being the specific, activity contained in 0.25 milligram of the Standard Preparation at present in use (1952). The Standard Preparation is an extract of the serum of pregnant mares which has been reduced to dryness and diluted with

lactose/...

lactose. This unit should only be employed to assay gonadotrophic extracts prepared from the serum of pregnant mares. Any preparation of serum gonadotrophin may be diluted witn lactose to the desired strength.

Preparations from Pregnant Mares' Serum (P.M.S.)

Antostab (Boots, Nottingham).

Gestyl (Organon Laboratories, London).

Serogan (British Drug Houses, London.)

Pregnant Mare Serum (Burroughs Wellcome, London).

For Action and Uses.

British Pharmacopoeia 1953.

British Veterinary Codex 1953.

The Extra Pharmacopoeia (Martindale) 1941.

Observations.

A. INTRA-UTERINE DISTENSION. The mare CONTRAST foaled on 14/10/52 but had failed to come in heat by 27/11/52. i.e. 44 days later. She was given 1,000 ml. sterile, warm, physiological saline intra-uterine, introduced under pressure by means of a syringe and one-way catheter. She failed to come into season by 31/12/52, although cervical examination gave a formula b2, BII, and the ovaries were in a developed but arrested state and containing follicles.

Anoestrus in non-pregnant mares with a static but developed ovary is frequently favourably influenced by manual manipulation of the vagina and os uteri in the presence of the stallion. More recent work indicates that anoestral mares can be brought into sexual activity by irrigating the uterus with sterile, warm, normal saline. (Quinlan, 1952).

It was noticed that the injection under pressure of 4 to 6 ounces of Propamidine Intra-uterine (M & B) solution into the womb of non-pregnant mares during the winter months, was

responsible/...

responsible for a large percentage coming into heat. (Belonje, 1949). The oestrogenic effect of this treatment was not regarded as due to the properties of the Propamidine Intra-uterine as the same effect was obtained by the use of normal saline. Because of expense normal saline was substituted for Propamidine Intra-uterine, and quantities varying from 1,000 to 1,500 ml. used where it was desired to bring a mare on. The solution was forced into the uterine cavity and left there, so that the uterus was distended by it and no irrigation was performed. The cervix in non-pregnant anoestral mares is invariably firmly constricted allowing very little fluid to escape after withdrawal of the catheter.

The neurogenic effect of uterine distension on the oestrous cycle of the ewe has been studied by Moore and Malbandov (1953). They are of opinion that uterine distension may increase the secretion of gonadotrophic hormones of the pituitary and in this way induce oestrus in the anoestral ewe.

The mare CONTRAST failed to respond to this treatment, although ovarian development with tertiary follicles were present. Her case is of interest as it indicates the enormous inhibiting influence of suckling anaphrodisia over this method of evoking oestrus in a lactating mare.

B. PREGNANT MARE SERUM. (P.M.S.)

1. The mare FRESCOE foaled on 21/8/52 and had not come in heat on 21/10/52, i.e. 61 days later. She had a well-developed follicle in each ovary, which gave every indication of being in a static state. This was confirmed by the psychological behaviour of the mare towards the stallion. Her cervical reading of a1, BII also indicated that physiological heat was not developing. She was injected with 1,500 units P.M.S. subcutaneously on 21/10/52, and came in heat on 23/10/52

during/...

during which she conceived. In her case the diagnosis was that suckling anaphrodisia arrested further genital development.

2. The mare HOLY GRAIL conceived to a service on 20/9/52 which was followed by early foetal death. She had not come into heat on 22/11/52, i.e. 63 days later, when rectal examination revealed the fact that the ovaries were commencing to involute. She was injected with 1,000 units P.M.S. subcutaneously and came in heat on 27/11/52 and conceived during that heat. In her case the diagnosis was the development of the condition of pseudo-pregnancy.

3. The mare DISTANCE after indicating early foetal death after conceiving to a service on 8/10/52 had failed to return on 10/12/52, i.e. 63 days later. She had developed a very large Corpus luteum which reached a maximum diameter of 4½ inches on 5/12/52, with the ovary being extremely sensitive at this stage. She was injected with 3,000 units P.M.S. subcutaneously but by 22/12/52 had failed to come in heat. It was decided not to wait any longer and another 1,500 units P.M.S. administered subcutaneously on 22/12/52. She came in heat on 27/12/52 during which period she conceived.

The diagnosis in this case was the development of the condition of pseudo-pregnancy dominated by the formation of an extremely large and functional Corpus luteum.

4. The mare CARA NOSTRA indicated early foetal death after conceiving to a service on 12/10/52. By 10/12/52, i.e. 59 days later, she had failed to return in heat. On that day she had developed a very large Corpus luteum measuring 5 cm. in diameter in the left ovary which was extremely sensitive to handling. She was injected with 3,000 units P.M.S. subcutaneously but by 22/12/52 had failed to return. The Corpus luteum had reached considerably and it was decided not to wait any longer and another 1,500 units P.M.S. was given subcutaneously. She came in heat on 27/12/52, but failed to conceive during that heat.

The/...

The diagnosis here was the development of pseudo-pregnancy dominated by the formation of an extremely large and active Corpus luteum.

C. PREGNANT MARE SERUM AND PREGNANCY URINE EXTRACT.

Götze (1949) recommends the simultaneous administration of P.M.S. and P.U. extract in cases of anaphrodisia in mares. It was decided to employ this method in the case of CALAMITY JANE. This mare had foaled on 6/8/52 but on 16/10/52 had not come into season after an interval of 71 days. She violently opposed all attentions of the teaser stallion, and on 16/10/52 gave a cervical reading of ao, AII. On that day 1,500 units P.M.S. and 1,000 units Prolan were injected separately subcutaneously. On 16/11/52, i.e. 31 days later rectal examination revealed no further genital development, the ovaries remaining static and the cervical reading constant at ao, AII.

The diagnosis in her case was that suckling anaphrodisia prohibited further genital development and that this treatment failed in its purpose of bringing the mare in heat.

D. COMBINATIONS OF HORMONES.

1. The mare CALAMITY JANE failed to come in heat 31 days after receiving simultaneous injections of P.M.S. and L.H. hormones. Her outward behaviour expressed the strongest resentment to the presence of the stallion and she objected violently to his attentions (photo 25). Psychologically she was a typical case of extreme anaphrodisia, although her genital organs were in a partial but arrested state of development.

On 16/11/52 it was decided to force the issue. On that day 1,000 ml. sterile, warm, physiological normal saline was introduced into the womb under pressure; 3,000 units P.M.S given subcutaneously, and 25 mgm. Progesterone injected intramuscularly. Follicular response was rapid, she came in heat on 21/11/52 and conceived during that heat.

2./...

2. The mare WYNDSONG foaled on 20/8/52. She came in heat for 2 days on 27 and 28/9/52, but was not served during that period. She came on heat again for 5 days, 12 to 16/10/52 but failed to conceive to a service performed within 48 hours prior to ovulation. Her ovaries progressively became smaller and firmer, and the tubular genitalia flaccid and unresponsive. On 16/11/52 her cervical formula was a1, AII, the ovaries very small, flat and hard, indicating complete involution.

She was given 1,000 ml. warm, sterile physiological saline under pressure into the womb, 1,500 units P.M.S subcutaneously, and 25 mgm. Progesterone intramuscularly. Six days later no ovarian development was detected and 5 mgm. Stilboestrol diproprionate was administered subcutaneously. She came in heat on 24/11/52 for a period of 6 days, during which period her cervical formula was c3, CIII, the uterus responsive and contracting readily on palpation. The extraordinary part was, however, that although the tubular genitalia were in the normal state of development for physiological heat and the mare behaved outwardly in the normal psychological manner, the ovaries remained completely involuted and non-functional. She was served twice during the heat, but naturally failed to conceive.

Small doses of Stilboestrol Diproprionate have failed to evoke oestrus in anoestral mares with involuted ovaries (Burkhardt, 1947, 1948). Large doses may cause the appearance of male-like desire, such as mounting other mares, etc., from about the 15th day after the start of the injections. (Belonje, 1949; Nishukawa, Harada and Sugie, 1952). It is considered that the small dose of 5 mgm. Stilboestrol Diproprionate injected subcutaneously in the mare WYNDSONG was not responsible for the appearance of oestrus two days after the injection. It is felt that this oestrus was evoked

by the/...

TABLE NO. 36.

Length of Interval between Ovulation and Involution of the Ovary in the Pregnant Mare.

Mare		Size of Ovary prior to Ovulation			Size of Involuted Ovary during Pregnancy.			Intervals in days.
	Name	Date	Left Ovary	Right Ovary	Date	Left Ovary	Right Ovary	Days
1.	BARCAROLLA	4/12/52	2½ x 1½ x 1½	- 5½ x 2½ x 2½	19/2/53	2 x 1½ x 1½	- 1½ x 1 x 1	77
2.	FATA MORGANA	7/11/52	1½ x 1 x ½	- 4½ x 3 x 3	14/1/53	1 x ½ x½	- 1½ x 1 x 1	68
3.	FREBCOE	24/10/52	3½ x 2½ x 2	- 5 x 3½ x 3½	14/1/53	1½ x 1½ x 1	- 1½ x 1 x ½	82
4.	HATTIE HART	25/11/52	4 x 2½ x 2	- 2½ x 1½ x 1	21/3/53	1½ x 1 x 1	- 1 x 1 x 1½	116
5.	HATS OFF 2nd.	30/9/52	4 x 2½ x 2½	- 2½ x 1½ x 1	11/12/52	2 x 1½ x 1	- 1½ x 1 x ½	72
6.	HOLY GRAIL	2/12/52	3½ x 3 x 3	- 2½ x 1½ x 1½	27/2/53	2 x 1½ x 1	- 1½ x ½ x ½	87
7.	KINGS FLAME	22/11/52	3½ x 2 x 2	- 3 x 3 x 3	18/2/53	1½ x 1 x ½	- 2 x 1½ x 1½	88
8.	ORNAMENT	21/10/52	4 x 3 x 3	- 2 x ¾ x ½	15/1/53	1½ x 1 x 1	- 1 x 1 x ½	86
9.	TERAI	15/9/52	2½ x 2½ x 2	- 4½ x 3 x 3	5/12/52	2½ x 2 x 1½	- 3 x 2½ x 2	81
10.	UNCONCERN	18/11/52	5 x 3 x 3	- 3 x 1½ x 1½	19/2/53	2 x 2 x 1	- 2 x 2 x 1	93
						Average:-		83

by the combination of intra-uterine distension and the simultaneous administration of Pregnant Mare Serum and Progesterone.

Discussion.

The above treatments were applied to certain mares at the Askanie Nova stud during the 1952 breeding season. It by no means represents all experiences in this connection as many other cases were encountered in other breeding establishments.

The use of synthetic oestrogens in the treatment of anoestrus in mares have proved disappointing and unreliable. Doses of 25 mgm. Stilboestrol diproprionate caused symptoms of male-like desire in mares (Belonje, 1949). In cases of complete ovarian involution and anoestrus, doses of 25 mgm. administered singly or repeatedly, failed to stimulate ovarian development or evoke heat. In cases of partially developed but static ovaries doses of 10 to 15 mgm. Stilboestrol diproprionate were sometimes successful in stimulating ovarian progress and initiating heat.

Because of its unreliability and incompleteness of its effects, its use has been limited to initiate genital development in maiden and non-pregnant mares during the winter months and about two months before the breeding season. The method of preparing such mares has been discussed and it is stressed that only 10 mgm. Stilboestrol diproprionate is employed. This amount is injected subcutaneously in the perineal region as it is believed to exercise a decided local effect. (Robson and Adler, 1940).

In cases of retained afterbrith or purulent metritis doses from 20 to 30 mgm. Stilboestrol diproprionate intramuscularly is normally given as a single dose or repeated at short intervals of a few days, with very satisfactory results. Such mares usually fail to conceive during the particular mating season, but conceive readily the next year. This temporary infertility cannot be ascribed to the action of oestrogen as it is the normal sequel to retain afterbirth, metritis or eversion of the womb, even when treated by other methods.

Pregnant/...

Pregnant Mare Serum proved successful in stimulating sexual activity in all cases where ovarian development had reached a certain size. In the case of FRESCOE and HOLY GRAIL a single injection of 1,500 units proved adequate. In the case of DISTANCE and CARA NOSTRA the presence of a large and active Corpus luteum prevented the action of 3,000 units P.M.S. A further amount of 1,500 units was, however successful in bringing the mares in heat after the Corpus luteum had decreased in size and presumably in functional activity.

A combination of P.M.S. and luteinising hormone failed in the case of CALAMITY JANE, where the suckling reflex was held responsible for the continued anaphrodisia.

Dukes (1947) states that in some species of mammals it was found that sexual receptivity could be evoked more readily if a very minute amount of progesterone was injected with oestrogen. Combined oestrogen-progesterone therapy has been tested out on anoestral mares in other studs with negative results, even where such mares had follicular development in their ovaries. Oestrogen alone also proved unreliable and unsatisfactory. As P.M.S. gave promising results it was decided to use Progesterone with it in cases of obstinate anoestrus. This procedure has subsequently been supported by the findings of Dutt (1953) who was able to induce oestrus and ovulation in anoestral ewes by means of progesterone and pregnant mare serum.

Where very obstinate cases of anoestrus were encountered use was made of uterine distension with sterile, warm, physiological saline and the injection of P.M.S. and Progesterone. This procedure was applied to CALAMITY JANE which came in heat and conceived during that period. The mare WYNDSONG responded to the treatment in so far that she came into heat in the absence of any follicular development in the ovaries.

3. PREGNANCY.

Review of the literature.

The study of ovarian changes during pregnancy in the mare and the hormonal relationship existing during that period have

led/...

led to a much clearer understanding of the reproductive mechanism involved.

Aitken (1928) observed that the corpus luteum did not become as large as the follicle it replaced, and that it varies in consistency from firm to fluctuating and reduces beyond what would be considered functional size, before the middle of the gestational period. The ovary, he states, develops its maximum size during an orgy of follicle formation early in pregnancy, then goes to the opposite extreme, its minimum size, late in pregnancy.

Cole and Hart (1930) found a substance in the blood of pregnant mares which had anterior-pituitary like properties on the gonads of immature rats. This substance they called gonad stimulating hormone and which was later designated serum gonadotrophin or pregnant mare serum hormone. They were impressed with the correlation of the rise in potency of the blood serum with that of implantation of the fertilised ovum. They refer to data on implantation in the mare given by Kolster (1902) whose investigation showed that 28 days after breeding, the amniotic sac has a size of 4.2 cm. and is still free in the uterine. After 6 to 7 weeks it has a length of 12 to 14 cm. Its surface is covered with many fine reticular folds and the union between the sac and the uterine wall is well established. The weight of the embryo is sufficient at this time, however, for it to fall away from the uterine mucous membrane of its own weight if the uterus is opened. After 9 to 10 weeks the Allanto-chorionic villi have extended into the sulci of the uterine mucosa, and they feel that if they can accept these observations implantation of the mare occurs between the 40th and 70th day. Their observations show that the serum gonadotrophin rises rapidly in the blood to a maximum after its first appearance between the 37th and 42nd day. Further it remains in this relatively high concentration until about the 80th day. They also refer to the fact that in the human, implantation may take place as early as the 7th day. The early implantation in women is accompanied with the appearance of a gonadotrophic hormone (Prolan or Pregnancy Urine

Extract/...

Extract) in the urine at the end of the first week as shown by Ascheim and Zondek (1928). That the much later appearance of this substance in the blood of pregnant mares coincides with the later time of implantation is evidence to support the idea that this hormone may come to its highest concentration in the blood during the time of implantation on which very important part of intra-uterine life it may exercise some influence.

Ewart (1915) places the end of the 7th week as the time when chorionic villi begin to penetrate into the uterine sulci, and he is of opinion that the blastocyst is held 40 or more days in the urine cavity by hydrostatic pressure within it.

Cole, Howell and Hart (1931) divide ovarian changes during pregnancy as falling within four periods.

Period 1. From 1-40 days after conception large follicles are present in the ovary, but there is no evidence of the gonadotrophic hormone in the blood.

Period 2. From 40-150 days and is characterised by progressive activity in the ovary manifested by continuous formation of follicles and marked luteinisation. They assume that this activity is due to the cummulative effects of the ovary stimulating hormone (P.M.S.) existing in the blood at its highest concentration for some time. The presence of this hormone may be necessary to maintain the functional activity of the corpus luteum of pregnancy. The additional corpora lutea produced at this time may be a factor of safety in insuring implantation. They conclude that ovulation quite frequently occurs prior to luteinisation.

Period 3. This is the period of regression of the corpus luteum. Large follicles are absent. The period begins at the end of the 5th month and may end towards the end of the 7th month, i.e. after 2/3rd of the pregnancy has elapsed. There is a marked decrease in the size

of the/...

of the lutein cells together with vacuolisation which contain fat globules. They draw attention to the correspondence of time between the beginning of regression of the corpora and the disappearance of the gonadotrophin in the bloodstream.

Period 4. The ovary at the end of pregnancy is entirely lacking i in corpora lutea. Although only large follicles were found in the ovaries of only 2 out of 11 mares, oestrin is nevertheless regularly present in the blood-stream in considerable concentration.

Hart and Cole (1934) ovariotomised a mare 200 days after conception and the pregnancy was successfully maintained. They suggest that the source of oestrin must be the foetal placentation, a view also supported by Catchpole and Lyons (1934).

In a further study Cole and Saunders (1935), and Cole (1938), found this gonadotrophic hormone reaching its highest level at about the 70th day of pregnancy. Day and Rowlands (1940) found that in ponies it disappeared more rapidly and had almost completely disappeared from the bloodstream by the 110th day. Oestrin, they found, appears in the urine of the mare at about the 100th day of pregnancy. Thereafter its concentration gradually declines so that by the time of parturition it was very slight. A day or two after parturition, oestrin could no longer be detected in the urine.

Amoroso, Hancock and Rowlands (1948) examined post-mortem the ovaries of 14 mares, when 47 to 73 days in foal and recovered one or more ova from the Fallopian tubes. The ovaries of all the 14 mares contained one or more fully formed corpora lutea; but in none, with the possible exception of 1 mare examined on the 46th day, could the primary corpus luteum of pregnancy be recognised.

Harrison (1946) again observed that the corpus luteum of pregnancy completely filled the cavity of the ruptured follicle in 4 to 6 days, and attained maximum size by 10 to 14 days. Kimura and Lyons (1937) state that regression of the corpus luteum seem to occur at about the end of the first month of pregnancy.

Follicular/...

Follicular development is a common feature of ovarian activity during early pregnancy and Day (1940) records the occurrence of ovulation on the 23rd day of pregnancy by rectal palpation.

Cole, Pencharz and Goss (1940) conclude that purification of the gonadotrophin hormone present in the pregnant mare serum, has not changed its properties, and in particular has not resulted in a separation into Luteinising Hormone (L.H.) and Follicle Stimulating Hormone (F.S.H.) and they suggest that it consists of but one hormone for which they propose the name of "Equine Gonadotrophin".

Cole and Goss (1943) found in 4 mares destroyed between the 62nd and 105th day of pregnancy, distributed over part of the endometrium in apposition to the chorion, special structures which are referred to as 'endometrial cups' and which contained from 4 to 12 I.U. gonadotrophin per mgm. of fresh tissue. Furthermore they elaborate a secretion into the uterine space containing 50-314 I.U. gonadotrophin per mgm. of secretion in the fresh state. The histological character of both the glands and the inter-glandular tissue of these 'cups' differs conspicuously from the endometrium in other areas. They conclude that these endometrial cups are the chief source of equine gonadotrophin.

Rowlands (1949) supports the view that serum gonadotrophin is elaborated by the endometrial cups found in the fertile horn of the uterus. In a twin pregnant mare, however, a high rate of secretion was observed even though the foetuses were in an advanced state of resorbtion and he feels that the presence of a foetus, dead, living and or foetal membranes are necessary for the maintenance of the functional activity of the endometrial cups and consequently for the preservation of a high level of hormone secretion. He concludes that there is a high level of serum gonadotrophin in mares carrying twin foals, when a set of endometrial cups develop in both horns of the uterus. The sudden fall in the potency of the blood of one mare after abortion and the maintenance of a high level in another in which resorbtion had occurred suggests that the conceptus may be necessary for the preservation of the functional activity of these glandular structures in the uterus.

Rowlands/...

Rowlands found the ovaries of all mares post-mortemed between the 46-74 day of pregnancy hypertrophic. Twenty ova were recovered continously during the period between the 46th and 74th day of pregnancy, irrespective of the potency of the blood. The ovaries, consequently, he considers to become progressively less responsive to continuous stimulation by the hormone in the blood. Though the reason for this loss in ovarian sensitivity is not known, it is suggested tentatively by Rowlands that it may be attributed to the prolonged action of oestrogenic hormone secreted by the follicles, even though, as is well known, the very high level of blood-oestrogen does not occur until later in pregnancy. There is good reason to believe, in his opinion, that oestrogen is involved in this ovarian refrectorines because of the complete quiescent condition of the ovaries in late pregnancy when oestrogen is abundant in the blood. (Cole et al. 1931). If this is the case the hormone must either act directly on the ovary or indirectly on it, by disturbing the normal rate of pituitary activity. The extent to which pituitary gonadotrophin participate in this massive ovarian development in pregnancy is not fully realised, but they may well be required to promote a certain threshold of activity before serum gonadotrophin can exert its maximun effect. This being so, the decreasing effectivenss of the latter hormone might be due to the gradual failure of the pituitary gland under prolonged (inhibitory) action of oestrogen to maintain the basic level of ovarian activity.

Schweitzer (1949) reports that the gonadotrophic hormone level is higher in mares with twin foetuses, and states that the diagnosis of bichorionic twins is possible provided the gonadotrophin level of the single foetus is known. His findings confirm the previous work that this hormone is produced almost exclusively by endometrial tissue.

Amoriso and Rowlands (1951) draw attention to the gonadotrophic phase covering the period between the 40th and 120th

day of/...

day of pregnancy (Cole and Hart, 1930; Day and Rowlands, 1940), and state that the gonadotrophic potency of the blood is highest at about the 60th day. The usual pattern of ovarian behaviour during early pregnancy is disturbed in the mare by the presence of this hormone, but gonadal development of the foetus is not affected because serum gonadotrophin does not cross the placental membrane.

Recently Rowlands (1949) has shown that the ovaries of 17 mares examined post-mortem between the 46th and 74th day of pregnancy contained on an average of 5 follicles (1 to 3 cm. in diameter) and three fully formed corpora lutea. Evidence of recent ovulation, and even super ovulation, was obtained by the recovery of 1 to 3 ova from the Fallopian tubes of 11 of the 17 animals. A decrease in follicular activity was found to occur during this period which follows closely that of the gonadotrophic potency of the blood. Cole, Hart, Lyons and Catchpole (1933) have shown that by the 120th day, ovaries have ceased to form follicles, but that the last formed follicles last for about another month.

Cole and Saunders (1935) detected the presence of small quantities of oestrogen in the urine of the early pregnant mare and observed the rate of oestrogen secretion mounting rapidly after the disappearance of the gonadotrophin. Maximum excretion occurred between the 7 to 8th month, and thereafter the output of oestrogen declined gradually during the remaining 3 months. These findings have been confirmed by Köber (1938) who found the greatest amount of oestrogen excretion between the 168th and 252nd day. After the 280th day of pregnancy there is a marked drop. The decrease in activity of the maternal ovaries observed during the latter part of the gonadotrophic phase is continued to the time when the oestrogen is maximal. At this time the ovaries are without visible follicles and contain no trace of a corpus luteum. Histologically the cortex is very fibrous and contains only a few primordial follicles. The ovaries are completely inactive and it is highly probable that they

play/...

play no part in the maintenance of pregnancy. The removal of the ovaries in a mare 200 days after conception by Hart and Cole (1934) and the successful maintenance of the pregnancy indicates that this is so.

In women the sudden withdrawal of oestrogens which occurs just before or during parturition, would seem to lead to an intense but temporary release of pituitary follicle stimulating hormone, and this stimulates the ovaries to the production of oestrogen, which in turn inhibits the pituitary production of F.S.H.

Day (1939) removed the foetuses between the 51st and 105th day of pregnancy without any detrimental effects in 7 Welsh pony mares. The subsequent oestrous cycles of the mares did not appear to be influenced by the stage at which the foetus was removed. Thus it appears that the presence or absence (as after normal parturition) of the gonadotrophic hormone in the blood does not in any way affect the maturation and ovulation of ovarian follicles a few days after the cessation of pregnancy.

According to Rowlands (1949) and others, the foetal gonads grow remarkably during the oestrogenic phase. Enlargement begins during the 4th month and continue for about 3 to 4 months during which their weight increases from 1 to 150 gm. When fully enlarged the gonads weigh twice as much as the ovaries of the parent. They are about 5 to 7 cm. long, about 4 cm. in diameter, kidney-shaped, dark red and smooth in outline. The enlargement which occurs in the male and female gonad alike is caused by a prodigious increase in the number of interstitial cells.

According to Cole and others (1933) regression of the foetal gonads sets in at about the 8th month, and is due to the disintegration of the interstitial cell-mass; although a few persist into post-natal life. At the same time the germinal epithelium becomes active and small follicles (up to 2 m.m. in size) appear in the peripheral region of the medulla.

The extent to which gonadal development can be attributed to an oestrogenic action is difficult to assess. If oestrogen is involved

it/...

it would seem that it inhibits the formation of germinal tissue and stimulates the medullary mass of interstitial tissue.

The parallelism between the concentration of oestrogen in the urine of the mare and the quantative development and regression of the gonad, points to the existence of an association between this hormone and the medullary tissue which accounts for the great bulk of the organ.

Observations.

The clinical examination of early pregnancy was correlated with the biological blood test (Ascheimzondek Test) performed at the Onderstepoort laboratories. The mucous test was carried out on the spot according to the directions of Kurosawa (1931), Miller and Day (1939) etc.

Early during the work of preparing mucous smears from the cervix and anterior vagina, a streptococcus was isolated. Because of the danger of transmitting this organism or other pathogens and in this manner causing abortions or other complications this method of investigation had to be discontinued. The risk involved in routine speculum examination of extremely valuable mares, makes this method of limited practical value. The study was consequently concentrated on rectal examinations associated with the biological blood test. The influence of infections upon conception, gestation and subsequent viability of the foal will be discussed lated.

A. THE CHANGES IN THE OVARIES DURING EARLY PREGNANCY.

These have been discussed in detail under Development of the Graafian Follicle and Corpus luteum. It is recorded that during early pregnancy Graafian follicles develop which became large, soft and watery and which either regressed completely, or ovulated to form a Corpus luteum, or luteinised without rupturing.

It was also observed that the primary Corpus luteum of pregnancy may remain until the ovary involutes, or its place may be taken

by/...

by another Corpus luteum, which in turn may be replaced by a third one before the ovary retracts completely and becomes quiescent. The literature indicates that the mass luteinisation of existing follicles may not be uncommon during early pregnancy but its incidence in Thoroughbreds is unknown. Rectal examinations were not carried out throughout the gestational period of these mares, but bilateral involution was noted in 10 mares. The details of these are reflected in Table number 36.

The ovaries of these 10 mares contracted to their minimal size, i.e. complete involution, within a period from 68 to 116 days, with an average of 83 days. The mare FATA MORGANA showed the quickest ovarian return to rest, i.e. within 68 days, and HATTIE HART the longest period of 116 days. It must be pointed out however, that the examination of HATTIE HART on 21/3/53 took place 23 days after the previous one. It is considered likely that ovarian involution was completed earlier and that it most probably took place much sooner and towards the end of the third month of pregnancy. In general it may be said that ovarian involution in these Thoroughbred mares occurred within 2 to 3 months after conception. This is considerably earlier than found by Cole, Howell and Hart (1931) who state that regression of the corpus luteum and follicles begin at the end of the 5th month and may end towards the end of the 7th month.

The period encountered here corresponds closer to the observations of Rowlands (1949) who found ovarian activity to decrease continuously during the period between the 46th and 74th day of pregnancy.

The statement that the ovary develops its maximum size during an orgy of follicle formation early in pregnancy could not be substantiated in these studies. The literature also makes no differentiation between pregnancy in a maiden mare, non-pregnant or foaling mare but regards them all alike.

Table No. 36/...

In these Thoroughbreds in the non-pregnant mare group, TERAI and HELIOTROPE conceived readily and their ovaries involuted without further follicle formation. CASTANIA and DISTANCE developed a few small follicles 25 and 31 days respectively, after the last service, although the latter mare was under P.M.S. stimulation. The mare PAVANE developed a follicle 66 days after the last service.

Only three mares conceived during foalheat. BLUE VISION developed a follicle 48 days later, HATS OFF 2nd did not develop any, and KINGS FLAME a few follicles 31 days after the last service.

The remainder of the foaling mare required 2 to 3 heats before settling. AUDITION 2nd developed a follicle 42 days, BARCAROLLA 49 days, HATTIE HART 36 days, ORNAMENT 2nd 14 days, PROTECT 10 days and UNCONCERN 35 days after the last service.

The following mares received treatment varying from P.M.S., L.H. or intra-uterine medication which may have influenced follicle formation. They formed one or more palpable follicle at the following intervals. CALAMITY JANE 9 days, FATA MORGANA 28 days, FLORA SANDES 17 days, FRESCOE 19 days and HOLY GRAIL 64 days after the last service.

With the possible exception of BARCAROLLA none of these mares showed a progressive activity in the ovary manifested by continuous formation of follicles, enlargement of the ovary, and marked luteinisation either before or after the 40th day.

From these observations as well as others, and from post-mortems conducted on Thoroughbred mares during early pregnancy it is possible to suggest an explanation for these divergent findings.

The completely non-functional ovary can be accepted as involuted, small and hard. Under hormonal influence, one or both ovaries infiltrate with fluid, swell, and become soft and rounded. The tertiary follicles begin to differentiate from the surrounding stroma by the accumulation of liquid in their cavities.

Uni-lateral/...

Uni-lateral ovarian development is very common. This is most probably due to a time lag difference in the responsiveness of each gonad to the hormonal stimulation. Where uni-lateral development is sufficient to produce one follicle with consequent ovulation and conception, there is no further ovarian development. Such an instance is seen in the case history of the mare HELIOTROPE.

In limited bilateral ovarian development there may be one mature follicle in each ovary, with no further follicular formation after conception. This is seen in the case of TERAI. Instances of this nature are as a rule encountered early in the breeding season.

The position alters noticeably when the mare has passed through several heats and the ovaries have been subjected to repeated cyclic hormonal stimulation. Both ovaries become larger, sometimes considerably so, containing one or more palpable follicles on the surface and several in its substance. Such mares may develop mature follicles after conception and may continue to do so for several months. These follicles may regress, ovulate and luteinise or luteinise without ovulation. Mass luteinisation of the follicles within the substance of the ovary is therule and not the exception. Luteinisation occurs then of practically all tertiary follicle present, irrespective of their size.

The foaling mare again has a short but very intense heat during foalheat, during which period the ovary appears to be subjected to considerable hormonal stimulation. Even so ovarian response may be uni-lateral, e.g. HATS OFF 2nd, although more usually both ovaries respond in forming multiple tertiary follicles. If suckling anaphrodisia should supervene, the ovaries remain in this static state. Development does not progress until this restrictive influence abates sufficiently for further development or when the foal is weaned.

The maiden mare usually passes through several heats before settling and some of these heats may be prolonged. Ovarian development is usually considerable in such cases. The same development is encountered in non-pregnant mares during an early spring accompanied

by a/...

by a great improvement in the natural grazing. Such mares pass through several heats prior to the mating season and large ovaries with multiple follicular development is the rule.

These observations cannot support the contention that there is a definite sequence of events in ovarian development during early pregnancy. On the contrary, it would appear as if ovarian behaviour after conception is mainly determined by the extent of its development prior to ovulation, and furthermore, that this development is dependent upon various extrinsic as well as intrinsic factors.

B. THE CHANGES IN THE UTERUS.

Review of the literature.

The changes occurring in the uterus form the basis of rectal diagnosis for early pregnancy in equines. Miller and Day (1939) working on Welsh pony mares give an approximate comparison between the size of the embryonic mass, membranes and fluids, lying in the uterus, and the age of the foetus. Dimock (1947) in discussing the technique of rectal examination in Saddle horses and Thoroughbreds, gives certain superficial details of his findings at approximately 30, 60 and 90 days of pregnancy. So stresses the fact that a considerable amount of experience is required to make an early diagnosis.

Götze (1949) states that a very noticeable ability to contract occurs in theuterus of pregnant mares, and that this occurs at the earliest from 18 days, generally 21 to 23 days, until 40 to 42 days afterwards. He believes that during this period the uterine musculature is so influenced by hormones, that under the stimulus of examination a powerful contraction occurs which lasts for a certain time. He ascribes this sensitivity of the myometrium as most probably due to the ovarian hormone - oestrogen. This action, he believes, is reflexly created and no doubt for the purpose of protecting the unattached egg. Through the erection of the uterus the small ovum is retained in situ. He maintains that in the relaxed womb there is danger that by external influences, suchas manual manipulation,

galloping/...

galloping, etc. the ovum is moved to and fro and may become unsettled. The time, during which the ovum receives this support, he designates as the sensitive stage of early pregnancy.

Observations.

(1) The Sensitive Stage.

The ordinary involuted uterus of a non-pregnant mare during anoestrus was found to have little or no inclination to contract. The uterine walls are relatively thin, soft, flaccid, and can be moved against each other between thumb and forefinger. The body of the uterus has not broadened at that stage, and the horns have an even elliptical shape throughout their length. The cervix can be felt as firm and well-defined in outline.

During the sensitive stage of early pregnancy the uterus was observed to contract readily under the stimulus of rectal palpation. The horns become thick-walled, round in diameter, firm, and cannot be squeezed flat, and resemble a roll of sponge rubber.

a. The mare AUDITION 2nd showed this responsiveness to examination in a marked degree, the uterus becoming circular in outline, firmly contracted, turgid, resembling sponge rubber in consistency. This erectability she maintained from the day of conception, i.e. 10/9/52, until just after 7/11/52. If therefore lasted for at least 58 days after which it disappeared.

This immediate responsiveness after conception was also encountered in the mares PAVANE, TERAI, HELIOTROPE 2nd, whereas KINGS FLAME showed it a day after conception had taken place.

b. In the other mares it made its appearance from 4-27 days after the last service. Six out of 13 mares (including those that conceived during foalheat) had a range between 17-19 days i.e. in 46.2 per cent of cases it made its appearance between 17-19 days after the last service.

c. The/...

e. The duration of the sensitive stage is given in Table number 37. This table reflects the period of sensitivity during early pregnancy following an ordinary heat. It excludes those cases where conception took place during foalheat.

The time at which this responsiveness was lost varied from a minimum of 38 days to 60 days, i.e. roughly after about 6-8 weeks, with an average of 50 days interval after the last service.

d. It was difficult to determine the time of appearance of the sensitive stage in those mares which had foaled recently. It has been stated previously that the uterus immediately after foaling is heavy, pendulous, firm or doughy to the touch. The horns have a thick, firm wall which cannot be compressed. The body and the horn bases at the bifurcation are much larger than the uterine extremities, and these organs appear consequently conical in shape. The continuous process of involution masks any sensitivity of the organ to palpation.

Table/...

NON-PREGNANT MARE.

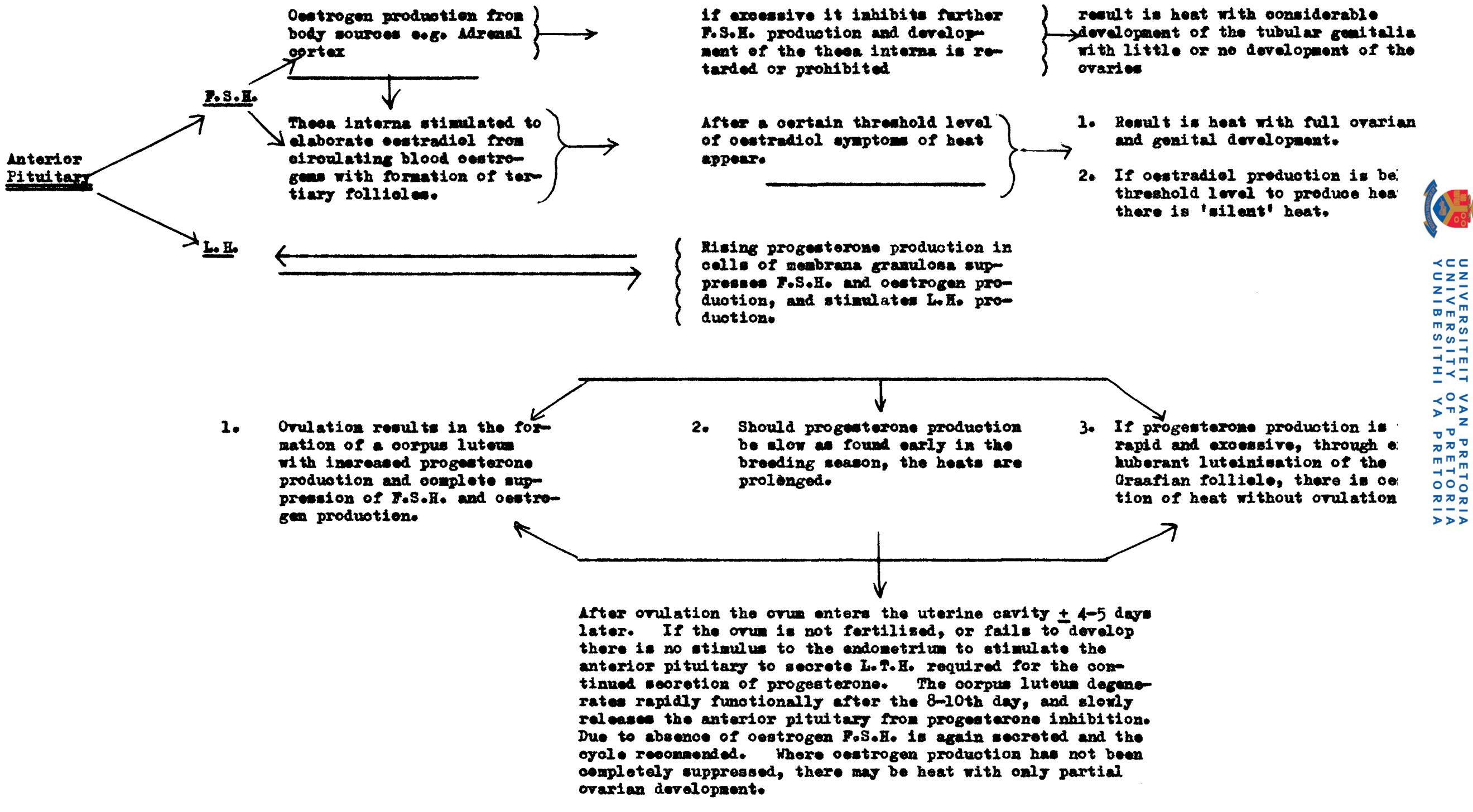


Fig. 13. Diagram illustrating Hormonal Control of the Oestrus Cycle.

TABLE NO. 37.

Duration of the Sensitive Stage in Pregnancy following Conception during an ordinary Heat. (Excluding Foalheat).

	Mare	Date last Service	Date first Reponse	Interval after Service	Date last Response	Interval after Service
1.	AUDITION 2nd.	10/9/52	Immediate	-	7/11/52	58 days
2.	BARCAROLLA	4/12/52	31/12/52	27	29/1/53	56 "
3.	CALAMITY JANE	24/11/52	11/12/52	17	7/1/53	44 "
4.	CASTANIA	10/10/52	16/10/52	6	27/11/52	48 "
5.	DISTANCE -	29/12/52	15/1/53	17	19/2/53	52 "
6.	FATA MORGANA	7/11/52	18/11/52	11	24/12/52	47 "
7.	FLORA SANDES	22/12/52	8/1/53	17	12/2/53	52 "
8.	PRESCOE	24/10/52	28/10/52	4	14/12/52	52 "
9.	HATTIE HART	25/11/52	4/12/52	9	7/1/53	43 "
10.	HELIOTROPE 2nd.	12/9/52	Immediate	-	11/11/52	60 "
11.	HOLY GRAIL	2/12/52	23/12/52	21	22/1/53	51 "
12	ORNAMENT 2nd.	21/10/52	7/11/52	17	15/12/52	55 "
13.	PAVANE	25/9/52	Immediate	-	14/11/52	50 "
14.	PROTECT	13/12/52	23/12/52	10	5/2/53	54 "
15.	TERAI	14/9/52	Immediate	-	22/10/52	38 "

As a rule complete involution is not reached by the 9th day after parturition and when foalheat may be expected.

Only 3 mares conceived during foalheat. In KINGS FLAME sensitivity of the uterus was detected a day after service. This is unusual but in her case uterine involution had progressed considerably. In the mares HATS OFF 2nd and BLUE VISION the first response was experienced from 18-24 days later. These particulars are reflected in Table No. 38. Although the uterus continued to involute slowly to a smaller size, responsiveness to palpation was only lost between 44-47 days, i.e. with the range where it is lost in the ordinary mare (see Table No. 37).

Although the commencement of the sensitive stage during early pregnancy was found extremely irregular, it was noted that 17 out of 19 mares, or 89.5 per cent, had developed it by the 3rd week, and that in all it disappeared again after about 6-8 weeks.

(II) The Saccular Stage.

After disappearance of the sensitive stage at approximately 6-8 weeks pregnancy, diagnosis became more difficult. At this stage it was performed on the uterine dilatation caused by the embryonic mass, fluids and membranes, and their location in the uterus.

This stage lasts from about 6-8 weeks to about 12 weeks, and is characterised by the disappearance of the contraction reflex and the change within the uterus as a result of the growing embryo.

The uterus during this period becomes thin-walled, is found next to the bladder, and covers the anterior edge of the pelvic inlet (pubis). With the increasing weight of the uterus the suspensory apparatus of the ovary and uterus becomes more tense on the side of the pregnant horn, and a comparative examination can be made.

Table/...

TABLE NO. 38.

Commencement and Duration of the Sensitive Stage following Fealheat Conception.

Mare	Date last Service	Date first Response	Interval after Service	Date last Response	Interval after Service
1. BLUE VISION	31/10/52	18/11/52	18	14/12/52	44 days
2. HATS OFF 2nd.	29/9/52	23/10/52	24	14/11/52	46 "
3 KINGS FLAME	21/11/52	22/11/52	1	7/1/53	47 "

After the pregnancy has reached a certain development, fluctuations can be detected and the foetus bounced in the fluid. The sensation to the hand is much like that of tapping a piece of heavy wood floating in water.

The size of the foetus at various stages during early pregnancy was carefully recorded and compared with some common object. These particulars are reflected in Table number 40.

After the 12th week of pregnancy the pregnant horn slips over the pelvic inlet to the ventral abdominal,wall. At this stage the pregnant horn cannot be reached by hand. The pubis is covered by the cervix, the utero-ovarian ligament is tense, taut, and perpendicular, the ovaries small, firm, without follicles and drawn downwards and forwards. The enlargement and characteristic pulsation of the median uterine artery can be detected with ease, and the network of small blood vessels over theuterine walls is also noticeable.

In the great majority of cases there is no difficulty in diagnosing pregnancy from the 5th month onwards. The foetus by this time is well-developed, and the limbs and body can be palpated without difficulty. As the gestation progresses examination becomes easier through the increasing growth and movement of the foetus.

C. TIME OF SERVICE IN RELATION TO OVULATION AND CONCEPTION.

Review of the literature.

It has been known for a considerable time that the rate of conception in mares is not affected by the length of oestrus or the number of matings, but is dependent upon the interval between ovulation and conception. For this reason knowledge of the longevity of the spermatozoa in the female genital tract became of the utmost importance, as well as the viability of the ovum and its capacity of being fertilised after liberation from the follicle. It is only during the last decade that these factors have been considered and that certain data have become available.

(1)/...

(1) Longevity of the Spermatozoa in the Female Genital Tract.

Hammond (1938) based his results on fertility rates where service dates in relation to the end of oestrus were known. He found that matings on the second day before the end of oestrus gave the best results, fertility remained fairly high up to the 6th day, but by the 9th day prior to ovulation all matings were sterile.

Satoh and Hoshi (1939) confirmed these observations and state that in their investigations 69 per cent of mares conceived when served 3 days before ovulation, 53 per cent when served 4-6 days before ovulation, and 10 per cent when served 7 days before ovulation. Day (1940) found that pregnancies resulting from services up to 5 days before ovulation were possible and records one case of a pregnant mating with a sperm survival of 6 days.

Burkhardt (1949) records 7 matings in which the sperm survival times were 66-76 hours in a mixed group of pony mares, resulting in 7 pregnancies. Of 6 matings with an interval of 90-100 hours, 5 proved pregnant. One mare, mated with an interval of 126-138 hours also became pregnant. He concluded that when the stallion sperm is known to be of good quality 3 days at least may be left between services.

Hammond (1944) remarks that in most cases the sperm would remain fertile in the scrotum for about 40 days. When it got into the female tract, in a higher temperature, the period of its viability differed in different animals and in relation to the absence or type of scrotum the inseminating animal has. The turkey, for instance has no scrotum and the life of the sperm is therefore long in the female tract. The sperm of the stallion would live longer in the mare - up to six days or so - than the sperm of the bull. The viability of bull sperm in the female passages is about 30 hours and in the ewe Quinlan, Mare and Roux (1932) were able to show that fertility decreases after a similar interval.

Hammond/...

Hammond ascribes this variation as due to the difference in the type of scrotum in these species. Quinlan and Riemerschmid (1941) were able to show that the temperature of the scrotal skin of the bull is 2°C to 4°C lower than the skin of the body, and that the testicle is similarly lower than body-temperature within a wide range of air temperature from 4°C to 40°C (39°F to 104°F). The scrotal-skin and testicular temperatures remain within a very limited range of constancy in normal animals. Testicals placed in such a position as to approximate body-temperature rapidly become aspermatogenic and remain so until normal topography is restored.

Recent studies in the optimum temperature for the preservation of the life of spermatozoa in vitro have indicated the detrimental influence of temperature, closely approximating normal body-temperature or higher, on spermatogenesis and spermatozoa within the genital tract.

In the stallion the testicles are held close to the body and are accustomed to a higher temperature. Spermatogenesis in all probability proceeds at a temperature slightly below body-heat, and it is not unreasonable to assume that the increased longevity of the spermatozoon in the genital tract of the mare is due to this factor.

Viability of the Ovum.

Salzmann (1939) records a fertility rate of 72.4 per cent in 29 mares bred after ovulation, and a 63.1 per cent in 38 mares bred before ovulation. He concludes that there is no reason to fear a decrease in fertility in mares inseminated after ovulation. Fertilisation took place 12-14 hours after ovulation, but in the majority of cases the interval was probably 6-10 hours approximately. He claims that these results indicate that the time during which the ovum of the mare retains the ability to be fertilised is much longer than that determined by Marshall and Hammond for the rabbit.

Kedrov (1944) states that in one group of mares inseminated 10-12 hours before ovulation 64.5 per cent conceived; the second group

of/...

of mares inseminated on the day of ovulation but prior to its onset 63.6 per cent became pregnant; and the third group of mares inseminated 2-10 hours after ovulation 76.2 per cent became pregnant. He inseminated 241 mares of which the one group inseminated before ovulation gave a 51.8 per cent fertility, and 150 mares inseminated after ovulation giving a 56 per cent conception rate.

Aehnelt and Plas (1946) confirmed the above findings and found that the insemination of mares shortly after ovulation resulted in 62.9 per cent of pregnancies. They are of the opinion, however, that after 24 hours the viability of the ovum decreases.

Observations.

From Table No. 39 the day of service and the estimated day of ovulation can be observed.

Table/...

TABLE NO. 39

Mare	Last Service Date	Estimated Date of Ovulation	Occurrence of Ovulation in Relation to Service
1. AUDITION 2nd	10/9/52	10/9/52	4-6 hrs. before
2. BARCAROLLA	4/12/52	4/12/52	1 hr. before
3. BLUE VISION	31/10/52	31/10/52	12-24 hrs. after
4. CALAMITY JANE	22/11/52 & 24/11/52	23/11/52	24-30 hrs. after
5. CASTANIA	10/10/52	11&13/10/52	24-30 hrs. after
6. DISTANCE	29/12/52	29/12/52	12-24 hrs. after
7. FATA MORGANA	7/11/52	7/11/52	12-24 hrs. after
8. FLORA SANDES	22/12/52	22/12/52	12-24 hrs. after
9. FRESCOE	24/10/52	24/10/52	12-24 hrs. after
10. HATS OFF 2nd	29/9/52	30/9/52	24-30 hrs. after
11. HATTIE HART	25/11/52	25/11/52	12-24 hrs. after
12. HELIOTROPE	12/9/52	13/9/52	24-30 hrs. after
13. HOLY GRAIL	2/12/52	2/12/52	12-24 hrs. after
14. KINGS FLAME	21/11/52	22/11/52	24-30 hrs. after
15. OLIVE GROVE	28/10/52	29/10/52	24-30 hrs. after
16. ORNAMENT 2nd	21/10/52	21/10/52	12-24 hrs. after
17. PAVANE	25/9/52	26/9/52	24-30 hrs. after
18. PROTECT	13/12/52	14/12/52	24-30 hrs. after
19. TERAI	14/9/52	15/9/52	24-30 hrs. after
20. UNCONCERN	18/11/52	18/11/52	12-24 hrs. after

All 20 mares conceived from the above ovulations. It will be noted that AUDITION 2nd and BARCAROLLA settled from services 1-6 hours after the estimated rupture of the follicle. This confirms the view of Salzman (1939) that insemination within a certain time after ovulation need not result in a decreased fertility. It also disproved the contention previously

held/...

held that a certain concentration of sperms had to be present in the Fallopian tube prior to rupture of the follicle.

Salzman (1939); Plas (1946), and Götze (1949) ascribe this longer fertility of the ovum in the mare, in that it maturates in its downward passage along the Fallopian tube. Götze feels that this corresponds with what occurs in nature, in so far that mares, in the majority of cases, remain in heat for one day after ovulation and permit service. He is of opinion that natural service under natural conditions occurs just prior to or immediately after ovulation.

Nine mares conceived to services performed within 24 hours before ovulation, and another 9 mares to services that took place within 30 hours before ovulation.

The history of the mare PROTECT is of interest. She foaled on 8/11/52, and came in foalheat during 16-24/11/52. She was bred on 17 and 20/11/52, ovulated on 24/11/52, i.e. 4 days later, but failed to conceive. She returned in heat on 8-15/12/52, and settled during that period. It would appear as if in this mare the sperms did not survive the 4 day interval between the last service and ovulation during her foal-heat.

The mare CASTANIA came in heat during 4-12/10/52, and was served on the 6th and 10th October, 1952. The first follicle ruptured on 11/10/52 and the next on 13/10/52. This second ovulation took place 3 days after mating. As the mare did not produce twins, it is concluded that fertilisation of the second ovum did not take place.

It is the practice of most Thoroughbred studs in the Karroo Midlands to cover mares at 48 hours interval during a normal heat. Only in a few studs is service permitted at 3 day interval, and this is as a rule only applied during the early part of the breeding season when duration of oestrus in the non-pregnant mare is still unknown. Towards the end of the breeding season they too revert back to the two-day interval service.

Cases/...

Cases are, however, not unknown of mares remaining in heat 4-6 days and even longer (up to 9 days) after the last service and yet proved in foal. In such cases one is inclined to assume that oestrus ceases 1-2 days after ovulation, and that prolonged sperm survival is the reason for the resultant fertilisation. The possibility, however, exists that under certain seasonal influences there may be large multiple follicular development of the ovaries which may obscure a small follicle rupture, and which may be responsible for the prolongation of heat. It is also possible that there may be a second ovulation at the end of heat, which is regarded as the only ovulation for that heat, and the belief that the viability of the sperm is responsible for the fertilisation of this second ovulation, e.g. CASTANIA.

The stallion in this stud was of proven fertility and periodic semen examination revealed no abnormalities. Nevertheless all pregnancies during the 1952 breeding season were the result of ovulation occurring within 30 hours after service, and from services taking place within 6 hours after ovulation. In two mares ovulation occurred 3-4 days after the last service without fertilisation taking place.

The observations made during this study are insufficient to draw any conclusion as to the longevity of sperm in the female genital tract and their fertilising capacity beyond 30 hours. The literature indicates that several grades of fertility may be encountered in a stallion, and that sperm viability in mares differs in different stallions. Consequently sperm longevity in the female tract becomes an individual characteristic of a stallion, and matings at long intervals cannot be recommended unless this factor is determined beforehand.

THE/...

PHOTO 28: FLAMING RIVER.
DISCHARGE FOLLOWING
EARLY FOETAL DEATH.

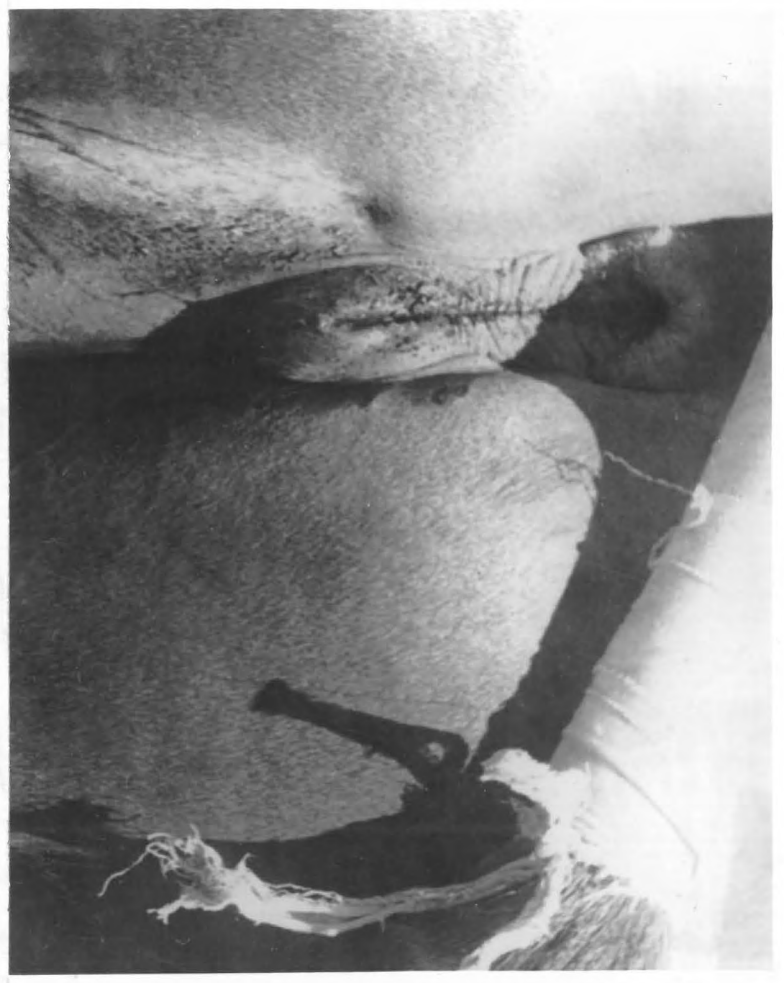


PHOTO 27: LEUCORRHOEA IN A CASE
OF PNEUMO-UTERUS.
(FATA MORGANA).

PHOTO 26: LEUCORRHOEA WITH SOILING
OF THE HOCKS.
(FATA MORGANA.)

PHOTO 31: PURULENT DISCHARGE IN CHRONIC SUPPURATIVE METRITIS. (JINIPET)

PHOTO 30: TORN VULVA AND VAGINA ACCOMPANIED BY SEVERE BRUISING. (DAROR)

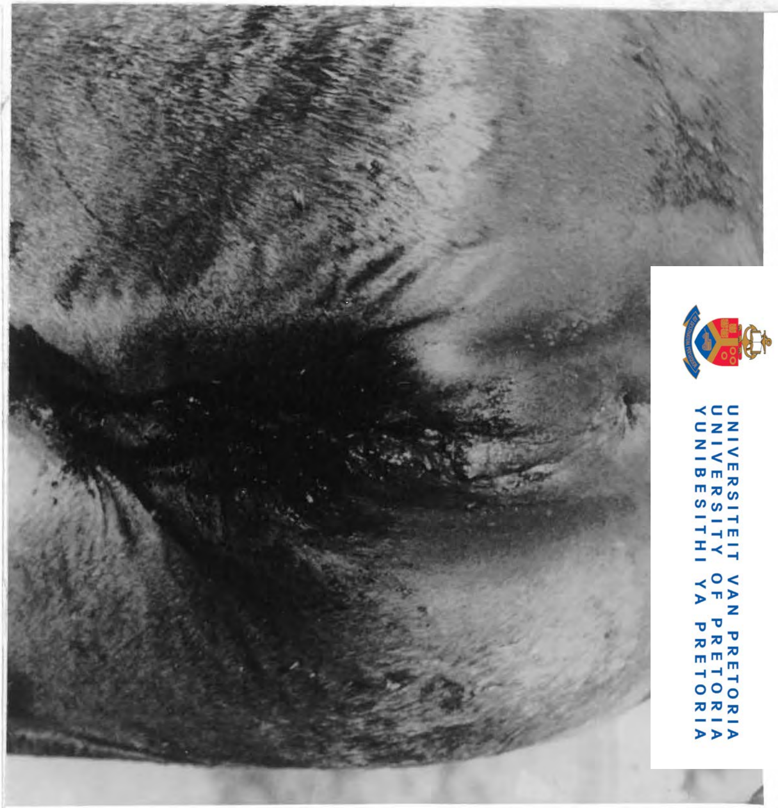


PHOTO 29: TORN VULVA. EXTERNAL VIEW. (DAROR)

D. THE OCCURRENCE OF OESTRUS DURING PREGNANCY.

Review of the literature.

The appearance of oestrus during pregnancy has been recorded by many workers. (Gonzaga and Ebora, 1936). Miller and Day (1939) state that a pregnant mare may show an apparent normal oestral manifestation and may accept service, once or twice and even oftener, after conception. Caslick (1937) remarks that its occurrence is so common in the late breeding season of Thoroughbreds in Virginia, U.S.A., that oestrus for two succeeding days must be shown, before service is permitted.

Observations.

The appearance of heat during early and late pregnancy is frequently observed in the Karroo Midlands. As the length of gestation in the Thoroughbred mare is taken from the date of last service to the date of parturition, it explains why certain gestational periods are extremely short. In those cases the last service was performed during a heat of early pregnancy and a so-called 'premature' foal arrives fully developed and robust after a recorded gestational period of 300-315 days.

Certain data on the phenomenon of heat during pregnancy are herewith recorded.

1. In another stud a young Thoroughbred mare conceived to a service during September. She returned to heat regularly every 3-4 weeks, but refused to be served by the stallion. During November she aborted a small foetus.
2. At another stud a Thoroughbred mare was served during a well marked heat. She accpeted the stallion readily, but the next day threw off a fully developed dead foal.
3. At the Government stud of Percherons at Grootfontein College of Agriculture, Middelburg, Cape, the occurrence of heat during early pregnancy is very common. Normally two days are allowed to elapse before service is permitted. In their case heats during early pregnancy rarely exceeds 1-2 days.

4/....

4. In this study UNCONCERN came in heat on 23/12/52, i.e. 37 days after the last service. HATTIE HART returned on 12/12/52, i.e. 17 days after the last service. The psychological manifestations of heat were distinct, but not excessive, and disappeared by the next day.

In the case of HATTIE HART the cervical and vestibular changes were indicative of the development of oestrus. The interval of 16 days from the cessation of her last heat, constitutes a normal interoestral period. The uterus, however, had entered the sensitive stage. On 23/12/52 she was examined by vaginal speculum and a cervical formula ao, AI, indicative of pregnancy, encountered.

UNCONCERN after a 37 day interval came in heat, but the embryonic mass could be felt distinctly. The vulva was firmly contracted, the cervix firm and rigid, but the vestibule was pink in colour.

In the case of HATTIE HART it would appear as if the rhythmic pattern of alternating oestrus and dioestrus had not been completely suppressed by the developing pregnancy. In the case of UNCONCERN the interval of 37 days suggests the period of implantation of the blastocyst when foetal control over the maintenance of pregnancy may still be weak. This aspect will be considered in greater detail during the discussion on prenatal deaths.

E. THE SIZE OF THE FOETUS DURING EARLY PREGNANCY.

Review of the literature.

The diagnosis of early pregnancy in the Thoroughbred is of considerable importance in view of the fact that the breeding season is artificially restricted to a certain period. It is very surprising to find so little reference in the literature to the results of rectal examinations of Thoroughbreds during early pregnancy.

Day and Miller (1940) working on a group of Welsh pony mares, compared the size of the palpable embryonic mass with some common objects at various stages between the 16th and 70th day of pregnancy.

Dimock/...

Dimock (1947) during his discussion on rectal palpation for pregnancy of the lighter breed of horses (Thoroughbred, standard bred and saddle-bred) mentions that by the 60th day of pregnancy the uterine distention on the average is 3 or 4 inches in width by 6 or 7 inches in length, and extends into the body of the uterus. This is the only measurement he gives.

Observations.

The size of the developing embryo, its membranes and fluid, was compared at various stages with some familiar object. During early pregnancy, when the sensitive stage is present, the embryonic mass is usually circular within the horn of the uterus. Later it extends along the lumen progressing towards the body of the uterus, assuming an oval shape. At this stage the uterine wall becomes thinner and fluctuations can be detected. After the embryonic mass has reached the body of the uterus and fills it, it becomes circular in outline and difficult to differentiate from a partially filled bladder.

Appendix number 7 reflects the details of the rectal examinations. These are extracted and reflected in Table number 40.

TABLE NO. 40.

Size of Embryonic Mass during Early Pregnancy

Duration of Pregnancy in Days	Size of Palpable Embryonic Mass		Position in the Uterus
	Object	Diameter	
25	Pigeon's egg size	1"	In uterine horn.
27	Bantam's " "	1½"	"
34	Hen's " "	1¾"	"
41	Goose " "	2½"	"
46	Orange size	3-4"	"
52	Grapefruit size	5-6"	Migrating towards body of uterus.
62	Small football "	8"	Partially occupying body of uterus.
72	Football "	12"	Predominantly occupying body of uterus
83	Bladder-like "	15"	Predominantly occupying body of uterus.
99	Intra-abdominal	unknown	Unknown

The/...

The embryonic mass appears circular in outline to about the 30th day, after which it assumes a more elliptical or oval shape. At the 40th day its diameter is approximately 2½ inches, but its length varies from 3½ - 4½ inches. In general it may be stated that when the embryo assumes the oval shape, its length is usually 1½ times its width. During this period the uterine wall has developed a degree of tone and rigidity that is usually easily discernible on palpation. The horns are distinctly tubular in outline and the embryo can be felt as a distinct bulge. The bulge is usually in one horn only, just a few inches to the right or left of the point of bifurcation.

From about the 60th day the saccular stage is reached, the uterine walls are thin, fluctuations are easily detected, and the outline usually more circular in circumference, portion of the mass occupying the body of the uterus.

Variation in the rate of growth and consequent size of the embryonic mass was observed. The embryo in HELIOTROPE développed very slowly, that in BLUE VISION grew fast. The comparison in the rate of growth in the two mares is reflected in Table No. 41.

TABLE NO. 41.

Rate of Growth of Embryo in Days during Early Pregnancy.

Mare	Hen's eggs size 1¾"	Orange size 3-4"	Football size 10-12"	Bladder-like 15"	Intra-abdominal
BLUE VISION	26	33	-	76	104
HELIOTROPE 2nd	40	60	84	-	125

Clark (1949) gives the length of gestation of the Thoroughbred in South Africa as most common between 330-340 days. The mare BLUE VISION unfortunately succumbed to Horsesickness during March, 1953, so that her gestational period is not known. During her previous two pregnancies she had gestational periods of 337 and 339 days respectively, and one may assume that she would have had a similar length during this pregnancy. The mare HELIOTROPE carried full-term, with a

gestational/...

gestational period of 352 days. It is very likely that the slow rate of growth of the embryo had a direct bearing on this prolonged gestation.

HELIOTROPE is of particular interest, because of her history of producing a 'barker' foal during 1948, and another one during 1951. As a result of her history she was put up for sale in England and exported to South Africa. Several such 'barker' foals were examined at the Equine Research Station, Newmarket, England, during the 1950 season (Belonje, 1952) and it was observed that all the affected foals exhibited enormous depth of chest. Whether the condition is inheritable or the result of prolonged gestation with alteration in the bony structure of the chest, is still a matter of conjecture. The foal born after this prolonged gestation appears normal in every respect.

Considerable variation in the time of disappearance of the pregnant horn into the abdominal cavity was noticed, the period varying from 67-126 days. Strangely enough the small mares gave the most trouble during examination, showing considerable discomfort when the hand and arm were passed through the small lumen of the anus and rectum. Deep abdominal palpation was impossible in their case. In the case of PROTECT, the pregnancy became intra-abdominal after only 67 days. Her history, however, indicates that the uterine horns remained pendulous after parturition and never involuted completely to a smaller size. The mare BARCAROLLA is also medium-sized, and her uterus also failed to involute rapidly after foaling. It never contracted completely as a result of the succeeding pregnancy, and sank back into the abdominal cavity after 77 days. In 12 out of 16 mares, i.e. 75 per cent the pregnancy became intra-abdominal between 86-112 days.

F. FOETAL MIGRATION.

Review of the literature.

Kedrov (1939) by rectal examination of 574 mares during 804 oestrous cycles found that ovulation occurred 15-20 per cent more often in the left ovary. As pregnancies were observed more frequently (25-30 per cent) in the right horn, he concluded that intra-

uterine/....

uterine migration must occur.

Day (1940) observed that in 5 of the 7 mares examined, the foetus developed in the opposite horn of the uterus to the ovary in which the ovulation of pregnancy occurred, and in the other 2 mares it developed in the same side. He found that foetal migration occurred in both directions within the uterus.

Hancock (1948) observed foetal migration to occur in 8 of 20 mares studied, and these were in all cases from the left to the right.

Observations.

Foetal migration within the uterus was of common occurrence in the group of mares under observation. The details are reflected in Table No. 42.

TABLE NO. 42

Intra-uterine Foetal Migration

Mare	Ovulation	Pregnancy
1. AUDITION 2nd	Left ovary	Left horn of the uterus
2. BARCAROLLA	right "	Left " " " "
3. BLUE VISION	right "	Left " " " "
4. CALAMITY JANE	right "	right " " " "
5. CASTANIA	right "	left " " " "
6. DISTANCE	right "	right " " " "
7. FATA MORGANA	right "	right " " " "
8. FLORA SANDES	right "	right " " " "
9. FRESCOE	right "	right " " " "
10. HATS OFF 2nd	left "	right " " " "
11. HATTIE HART	left "	right " " " "
12. HELIOTROPE 2nd	left "	left " " " "
13. HOLY GRAIL	left "	right " " " "
14. KINGS FLAME	right "	right " " " "
15. OLIVE GROVE	right "	left " " " "
16. ORNAMENT 2nd	left "	right " " " "
17. PAVANE	left "	right " " " "
18. PROTECT	left "	left " " " "
19. TERAI	right "	right " " " "
20. UNCONCERN	left "	left " " " "
TOTAL	11 in right ovary	12 in the right horn of the uterus.
	9 in left ovary	8 in left horn of the uterus.

Intra-/.....

Intra-uterine foetal migration was observed in 9 out of 20 mares or 45 per cent. In 5 out of 9 mares where ovulation occurred in the left ovary, implantation took place in the right horn of the uterus. In 4 out of 9 mares where ovulation took place in the right ovary, implantation was found to occur in the left horn of the uterus. There was no indication of superiority of the left ovary over the functional activity of the right ovary.

Out of a total of 20 conceptions, implantation was found to occur in 12 cases in the right horn of the uterus, and these support the observations made by Kedrov (1939). Contrary to the findings of Hancock (1948) foetal migration did occur from the right horn of the uterus the left. The observations are in agreement with those of Day (1940) who observed the occurrence of foetal migration in both directions within the uterus.

The mechanism involved in foetal migration is not known. It is well established that uterine activity at first increases and then gradually diminishes following ovulation. Boyd, Hamilton and Hammond (1944) state that available physiological evidence clearly suggests that rhythmic peristaltic and anti-peristaltic contractions of the uterine muscle may be among the main factors involved. It is generally recognised that ova and blastocysts have no inherent motility, but that the chorionic sacs may show slight 'creeping growth' as it extends along the uterine lumen.

C. THE LENGTH OF GESTATION.

Review of the literature.

Considerable variation in the length of gestation is found in the literature. So for instance a variation of 329 to 346 days, with an average of 336 days is given by Dukes (1947). Hammond (1949) again gives a wider variation, extending from 305-400 days, but states that it is usually considered 48 weeks (336 days).

Clark/....

Clark (1949) while performing the biological blood tests on 96 Thoroughbred mares in South Africa, records a variation from 301 to 349 days, with the greatest incidence of foaling occurring between 325 and 340 days.

(1) In Relation to the Month of Foaling. There appears to be a definite variation in the duration of pregnancy according to the month in which the foal is due to be born. Hammond (1938) mentions that Wellman in Hungary found this period to vary regularly from 341 days for foals to be born in May, to 323 days for foals due to be born in July. In observing the gestational period of 13 pony mares run out at grass, both summer and winter, Hammond observed a marked seasonal variation, the gestational period becoming shorther if foaling was to take place in summer. He suggests two possible causes for this variation. Firstly, that it is due to different feeding conditions at different times of the year, and that feeding of fresh green food speeded up foaling, whereas feeding on dry feed prolonged it. The second explanation given is that the increase in length of daylight, which affects the breeding season, also affects the duration of pregnancy through the effect on the pituitary secretions. In other words with increasing length of day, the ovarian activity is increased and foaling speeded up.

Uppenborn (1933) again found a definite correlation between the length of gestation to the time of service. Those mares that were covered early in the season carried longer, and he ascribes this phenomenon to the fact that these mares were stabled during the winter, in dark stables, with little exercise and receiving inferior food. He was also able to show that the length of gestation is a transmissible factor, and that this genetic influence can be traced to certain stallions and mares.

Observations.

The length of gestation according to the month of foaling is recorded in Table Number 43 and is extracted from Appendix 8.

TABLE/.....

TABLE NO. 43.

Length of Gestation according to the Month of Foaling

Mare	August	September	October,	November	December
ARMORIAL	-	330	328 331	327 343	-
AUDITION 2nd	335 324 337 331 337	328	-	-	-
BARCAROLLA	-	343 351	-	345	-
BLUE VISION	-	-	339	337	-
CALAMITY JANE	332 316	-	328	-	-
CASTANIA	-	-	357	-	-
CARA NOSTRA	-	339	-	-	-
CONTRAST	-	-	345	-	-
DAROR	335 335	339	336 330	-	-
DISTANCE	-	-	-	329	-
FATA MORGANA	342 327	-	337	-	-
FLAMING RIVER	-	337 338	338 339 335 339	340	-
FLORA SANDES	-	-	342 342	350 338 336	-
FRESCOE	338	335	-	-	-
HATS OFF 2nd	-	334 335 337	-	-	-
HATTIE HART	-	-	338 335	-	-
HELIOTROPE	352	-	-	-	-
HOLY GRAIL	345	349 343 350	-	345	-
JINTPET	329	341 325	353 333	-	-
KINGS FLAME	-	-	344	341 339	-
OLIVE GROVE	-	348	354	335 333	-
ORNAMENT	-	332	-	-	-
PAVANE	334 335	333 335 343	-	-	-

Tabel Con./..

Length of Gestation according to the Month of Foaling

Mare	August	September	October	November	December
PROTECT	-	-	-	331 329 327	-
TERAI	340	-	-	-	-
UNCONCERN	332	-	337	-	-
WYNDSONG	331 329	-	-	-	-
TOTAL	7016	7435	7460	5726	-
AVERAGE	334.10	338.00	339.10	337.00	-

Discussion.

The average length of gestation of these Thoroughbred mares according to the month of foaling was as follows. August 334.1 days, September 338 days, October 339.1 days and November 337 days. These averages subjected to statistical analysis fail to show significance, but the figures are subject to various factors as for example differences occurring in individual mares, different years, etc., which cannot be eliminated in the final analysis. It is assumed probable that if such adjustment be made the tendency will become real.

Hammond (1938) considers that the increase of daylight may affect the duration of pregnancy through the effect it exercises through the pituitary. The factors of daylight and warmth and the influence they exercise upon the breeding season of the Thoroughbred have been discussed in a previous chapter. Figures 7 and 9 indicate the gradual increase of these factors from the beginning to the end of the breeding season, i.e. from August to December. It is evident that they require a certain threshold amount before any results are discernible. It is, however, not clear that they play a direct role in determining the length of pregnancy.

The/.....

The influence of nutrition upon the seasonal reproductive activity of the non-pregnant mare was shown to be of considerable importance. It is equally clear that this factory may have some effect on the duration of pregnancy. The pregnant mares of this stud were let out to graze in the veld during the autumn months. During this period the rainfall is high and the natural grazing excellent. During early winter sufficient green feed in the form of green oats, barley, wheat, etc., was grown to provide artificial pasturage and to which supplementary hay and grain was fed. From July to September the climate as a rule becomes extremely erratic, fluctuating between severe frosts at night cold days with sleet and biting winds. During this period little or no rain precipitates and serial crops grown for grazing, refuse to grow.

It would appear as if mares settled early during the season reach the beginning of winter when the foetus is 7 to 8 months old, and when it starts to grow very actively (Hammond, 1938). Such mares are then run on the green pasturage, and complete their gestational period in a shorter time to foal early in spring. The other mares which have to carry their foetus during its actively growing stage through the lean period July to September when green feed as a rule is scarce or absent, prolong their gestational period. The increased rainfall during October and November promotes the growth of the veld and lands, and a shortening of the length of pregnancy may be expected after the improvement in grazing has exercised its influence for some time.

The nutritional variation in grazing, i.e. the presence or absence of green feeding, which exists during spring and summer in the Karroo Midlands would explain the short gestational period of 334 days in August, the longer periods of 338 and 339.1 days during September and October respectively, and the shortening of its duration to 337 days in November. The factors of increased daylight and warmth would play an indirect role in determining the length of pregnancy through the influence they exercise upon plant growth.

(2)/.....

(2) In Relation to the sex of the Foal. Uppenborn (1933) reviews the literature on the subject and found that on an average a colt foal increased the length of pregnancy from 1 to 5 days. From his own investigations, on various breeds of horses, he concluded that the sex of the foal exercises a decided influence on the length of gestation, the colt foal carrying longer, but that the difference in the majority of cases was only a matter of 1½ days.

Observations.

The length of gestation for colt and filly foals have been extracted from Annexure No. VIII and tabulated in Table number 44.

TABLE NO. 44.

Length of Gestation Period in Relation to the Sex of the Foal.

Mare: Colts:	Length Gestation	Mare: Fillies:	Length Gestation.
ARMORIAL	328 331 330 343	ARMORIAL	327
AUDITION 2nd	335 337 331	AUDITION 2nd	342 328 324
BARCAROLLA	343 345	BARCAROLLA	351
BLUE VISION	337	BLUE VISION	339
CALAMITY JANE	332	CALAMITY JANE	316 328
CASTANIA	357	DAROR	335
CARA NOSTRA	339	DISTANCE	329
CONTRAST	345	FLAMING RIVER	340 338 339 335 339
DAROR	339 336 335	FLORA SANDES	342 338 336
FATA MORGANA	342 327 337	FRESCOE	335
FLAMING RIVER	337	HATS OFF 2nd	334 335
FLORA SANDES	342 350	HATTIE HART	335

Cont./.....

Mare: Colts	Length Gestation	Mare: Fillies:	Length Gestation
FRESCOE	338	HELIOTROPE 2nd	352
HATS OFF 2nd	337	HOLY GRAIL	346
HATTIE HART	338	JINIPET	353 329 341
HOLY GRAIL	349 343 350 345	KINGS FLAME	339
JINIPET	333	OLIVE GROVE	354 348
KINGS FLAME	341 344	PAVANE	335 334
OLIVE GROVE	335 333	TERAI	340
ORNAMENT 2nd	322		
		TOTAL	11,802
PAVANE	333 335 343	AVERAGE	337.2
PROTECT	331 329 327		
UNCONCERN	332 337	TOTAL FOR BOTH FILLIES AND COLTS	27,324
WYNDSONG	331	AVERAGE	337.3
TOTAL	15,522		
AVERAGE	337.4		

Discussion.

In this group of mares no significant difference could be detected in the length of gestation in relation to the sex of the foal, the colt foals being carried 337.4 days and the filly foals 337.2 days.

It will be observed that the variation in the length of gestation is considerable in both groups. In the colt group we find a variation between 322 and 357 days, and in the filly group from 316 to 354 days. The variation in the length of gestation is so great in both

groups/....

groups, that it cannot be assumed that a mare will deliver a colt foal should she go overtime.

H. INFECTIONS OF THE GENITAL TRACT AND THE CASLICK OPERATION.

Review of the literature.

No study on reproductive physiology can be regarded as complete unless attention is paid to the possibility of various infections being responsible for abnormal reproductive behaviour. Many researches into sex physiology of our domestic animals are performed by workers not qualified in pathology and bacteriology with the result that a considerable amount of conclusions are incorrect, being based on false premises. To attribute all infertilities in equines to defective germplasm, hormonal imbalance, gonadal hypoplasia or subfunction is manifestly absurd, as well as the geneticist contention that irregular breeding must be regarded as an inheritable attribute.

Although it is admitted that the above factors may occur and that some of them may at times play a considerble part, there can be little doubt that genital infections play a very important role in the causation of temporary and permanent infertility in Thoroughbred mares.

Bacterial and histo-pathological examinations were not possible in this study; nevertheless the subject is of such importance that a short revision of established facts is essential at this stage before final evaluation of the process of reproduction in the Thoroughbred mare can be made. The literature on this subject was reviewed in a previous publication (Belonje, 1952) and reference will only be made to certain outstanding facts.

Götze (1949) found that the bacteriological examination of approximately 6,000 infertile mares gave the following percentages:

22 per cent free of infection.
32 per cent with a low-grade infection through non-specific organisms.
36 " " " " high-grade " " " "
10 " " the result of infections with haemolytic Strepto-Micro and

Staphylo-/....

Staphylo-cocci, very rarely Salmonella abortivoequi and Shigella equirulis. He claims that the frequency of non-specific bacterial infertility is approximately 40-65 per cent in the mares examined, a considerable higher percentage than in specific cocci infertility.

Dimock and Bruner (1949) emphasise that streptococci occupy the most prominent place in bacterial infections encountered in studying breeding problems of the equine species. They state that this organism lives normally on the skin and external genitalia of mares and stallions. It is present in the straw, refuse, dirt, and dust of horse-barns and on equipment, utensils, and the hands of service personnel. They further claim that these organisms find a foothold in the genital tract when the normal protective structures and constitutive integuments at the portal of entrance have become vulnerable. In such cases the external genital structures frequently have lost their original form. This view is endorsed by Burkhardt (1948) who also believes that equine haemolytic streptococci live as saprophytes in the genitalia of mares, becoming pathogenic when local resistance is lowered.

Cronin (1952) was able to isolate no fewer than 48 strains of Streptococci from the uteri of Thoroughbred mares in Ireland. He states that the results of the pathogenicity tests in rabbits appeared to indicate some considerable variation in virulence from strain to strain and/or individual resistance to infection on the part of inoculated animals. He records that while the pathogenicity for Laboratory animals of strains of Lancefields Group C Streptococci, isolated from the uteri of Thoroughbred mares has been established, the precise role of these organisms in the pathogenesis of equine uterine infections remains obscure in view of the fact that they have been isolated from the uteri of apparently normal healthy mares during a period of 9 days following normal parturition. In many of these animals the organisms disappear after this time.

Dimock and Edwards (1932) found that Streptococci were responsible for 23.4 per cent of cases of abortion, but states that many

cases/.....

cases of abortion occur in which no infection is detectable. These were observed as isolated cases and as quite serious outbreaks. They suggest that in at least two of the outbreaks the feed was involved.

Henning, Keppel and Flight (1943) described an outbreak of infectious abortion in the Cape Province, and isolated Salmonella abortive-equinus as the causal organism. Henning (1945) in investigating an outbreak of infectious equine abortion amongst horses and donkey mares at the remount camp at Pinetown, Natal, during 1945 succeeded in isolating a filterable infective agent corresponding to the Equine Abortion Virus described by Dimock, Edwards and Brunner (1942), although Henning failed to demonstrate the presence of "inclusion bodies" described by those authors as diagnostic of the disease. During subsequent abortions Henning was able to isolate Salmonella abortus-equi from most of the foetal organs and afterbirths examined; and the sera of mares, whose foetuses were infected with S. abortus-equi, gave a positive agglutination reaction with this organism about 10 days after abortion. This organism was also held responsible by Henning and McIntosh (1946) for ulcerations and suppuration of joints in stallions, geldings and mules. They also state that foals born alive from infected mares may suffer from joint-ill from which they usually succumb.

Henning (1953) isolated Streotococcus equi, Type 2 according to the classification of Bazeley and Battle (1940), in a Thoroughbred Stud in the Western Province, where it caused several abortions followed by vaginitis, cervicitis, metritis and consequent infertility. The infection was associated with the introduction of a certain stallion in the stud. The same organism was also isolated in pure culture from an aborted feotus from the Kimberley area.

From the foregoing it is clear that specific as well as non-specific organisms play an important role in the causation of abortion, prenatal and postnatal infections, and infertility. It is also clear that the presence of organisms in the genital tract of the mare constitutes no bar to successful conception, gestation and the pro-

duction/.....

duction of a live, healthy foal. Dimock and Good (1927) and Götze (1949) are of the opinion that if such mares are exposed to a severe injury, great excitement, malnutrition, or extreme exposure during the gestation period, the possibility of abortion would have been greater than in the case of an absolutely healthy mare subjected to the same degree of injury. Belonje (1949) records that galloping often causes abortion in pregnant Thoroughbred mares and he considers that a low-grade endometrial inflammation must be present in such cases.

The Caslick Operation.

Caslick (1937) states that it has always been common knowledge to breeders in Kentucky that a mare with an injury to the upper part of the vulva and rectum was frequently a "windsucking" mare and a bad breeder but, that the importance of the mare aspirating air in conjunction with genital infections and allied diseases, such as barrenness, abortion and infections of the new-born foal, was not realised. The sucking of air into the vagina he controlled by an operation, consisting of suturing or clamping the lips and walls of the vulva together towards the upper commissure.

Day (1939) observes that recovery of the inflammatory condition of the genital tract usually takes from 3 to 6 months after performance of the Caslick operation, but he makes no mention when earliest conception and successful gestation may be expected.

Crowhurst and Caslick (1946) conclude that the operation cannot be expected to give immediate results, and often it may take months for the genital tract of the mare to overcome the infection and to settle down again to a normal state.

Dimock and Brunner (1949) mention that following rational medicinal and surgical treatment, time is frequently the deciding factor in bringing about a recovery.

Observations/....

Observations.

In this stud all mares which failed to conceive to services during the breeding season, were treated during the winter months by means of the intra-uterine medication described elsewhere. Those mares that were "windsuckers", or those with a gaping vulva, or where through atrophy of the perineal tissues a flaccid anus had retracted the upper part of the vulva inwards, etc., were surgically corrected.

The operation consists essentially as described by Caslick (1937) except that considerable more tissue is removed. The area denuded of mucuous membrane is up to 2 inches deep at the upper commissure and extends triangularly to the lowest point, approximately ½ inch above the level of the floor of the pelvis. Tearing of the scar at foaling time is exceptional if the operation is performed in this manner.

In many mares the condition of "windsucking" can only be recognised when the mare is on heat, and as a rule only after she returns to services performed during two or three apparently normal heats. At this stage the middle or end of the breeding season has been reached, and if the operation is performed breeding is further delayed as service can only be allowed after the wound has healed. Should the mare conceive after all this delay the result would be an undesirable late foal.

Belonje (1949) records that "windsucking" mares treated by means of intra-uterine medication, without the Caslick operation conceived without difficulty. This procedure, he claims, avoids the time lag factor stressed by the previous workers, who apparently depend more on the resistence of the mare to cleanse herself, and on the operation to prevent re-infection.

A. Treatment and operation were performed on the following mares prior to the breeding season.

1. FLORA SANDES - operated on 14/8/50 after treatment, and conceived that season.

2. DAROR - operated on 8/8/51 after treatment and conceived that season.

3/....

3. ARMORIAL - operated on 8/8/51 after treatment, and conceived that season.

B. The mare FATA MORGANA was stitched on 19/10/51, seventeen days after her last service date and while pregnant.

C. The Caslick operation was performed on the following mares after pregnancy had been definitely established.

1. PROTECT on 9/1/51
2. BLUE VISION on 9/1/51
3. UNCONCERN on 19/10/51.

D. The mare FATA MORGANA windsucked badly during her heat of 22-26/9/52. A severe white discharge developed subsequently which stained the inside of her hindlegs, soiled the hocks, and glued up the vulva lips and tail hairs. The usual intra-uterine treatment was applied (Propamidine containing penicillin) on the 13th and 15/10/52, but failed to stop the leucorrhoea. The treatment was repeated again on 31/10/52, and while working with the mare it was noticed that the air was aspirated direct into the uterine cavity. As the mare was expected to come into heat in a few days time, it was decided not to delay breeding by performing the Caslick operation. She came into heat on 2-8/11/52, and was bred on the 4th and 7/11/52, and conceived during this period. She was left severly alone, but by 14/1/53 aspiration of air into the vagina became again noticeable on walking. By 23/1/53 this was so pronounced that interference was decided necessary to maintain the pregnancy. On that date her cervical reading was b2, CIII, the anterior vagina was severely inflamed and a purulent exudate had accumulated in the passage. The Caslick operation was performed, and an oily disinfectant consisting of Iodoform, Bismuth subnitrate, Boracic acid in liquid paraffin, run into the vaginal passage. Recovery was uninterrupted and the mare foaled a healthy colt foal after 337 days gestation.

Remarks/.....

Remarks.

The cases recorded here are representative of similar experiences of several scores of mares during the past 10 years. Specific and non-specific bacterial infections play a very important part in the causation of sterility in the Thoroughbred mare in the Karroo Midlands, but most of this sterility is as a rule temporary in so far that sexual rest for 6 months or so is invariably followed by conception and successful gestation. Belonje (1952) remarks that it is an established fact that the majority of Streptpcoccal infections of the genital tract, originate in the mare that has foaled recently. Normally the great majority cleanse themselves before the 10th day, because of the natural bactericidal power of the uterus and the outflow of uterine secretions as oestrus approaches.

Where aerovagina exists, infection is maintained, unless steps are taken to prevent further aspiration. The Caslick operation is adequate in controlling this as most cases are due to malformation of the vulvo-vaginal orifice. As the success of the operation depends upon the resistance of the uterine mucosa to overcome the infection, recovery is naturally delayed. Unless the operation is performed prior to the commencement of the breeding season, it will take another year before the mare settles.

It is for this reason that considerable attention was paid in the past to uterine medication in preference to the Caslick operation, in combating infection and obtaining conception during the same breeding season. The surgical operation is only regarded as a means of preventing re-infection after the pregnancy has been firmly established.

The uterine cavity of a mare which has had several foals is large and spacious. The introduction of small quantities of fluid (20 ml. water containing Penicillin and/or Streptomycin) advocated in cattle practice, is considered insufficient to ensure even distribution throughout the organ. The dyes, such as Rivanol, Acriflavine, Euflavine,

etc.,/.....

etc., were also tried, and introduced in large quantities. Apart from their unpleasant staining properties, it was soon realised that they had considerable spermatocidal properties, which made their use during the breeding season undersirable.

The introduction of 4-6 ounces Propamidine Intra-uterine containing Penicillin, and repeated after 48-60 hours, proved extremely satisfactory. This procedure has been employed subsequently as a routine remedy in all cases of uterine infection. The mare FATA MORGANA conceived in the present study to services within a week after the use of this combination , and previous experiences also indicate that the solution is not spermatocidal.

I. PRENATAL DEATH.

Review of the literature.

Barulin and others (1936) found errors in their work on pregnancy diagnosis by means of the vaginal method, and they ascribe the wrong positive diagnosis to the frequent incidence of early abortion.

Day (1939) and Day and Miller (1940) mention a form of abnormal oestration in some mares, which presents the same clinical history as that observed in early foetal death. The mares had several regular heat periods and then passed into a period dominated by a corpus luteum, during which time no heat was shown even though the mare proved barren. In performing the mucin test Day and Miller (1940) had 4 mares giving positive mucin and blood tests, but which proved subsequently barren. They regard it as highly probable that at the time of their examination the mares were actually pregnant, but at some time subsequently abortion or foetal absorbtion occurred, unknown to owners or attendants.

These findings were confirmed by Andrews and McKenzie (1941), who record even earlier instances of foetal death, in which mares were bred and showed no subsequent heat. Vaginal examination revealed changes characteristic of early pregnancy, yet rat tests were negative and the mare did not foal.

McKenzie/.....

McKenzie (1940), Jennings (1941), Anderson (1941) and Cole and Hart (1942) believe that early foetal death accounts for the majority of cases in which mares demonstrate a positive rat test for pregnancy 45 days after breeding, yet later prove to be barren.

Observations.

1. OLIVE GROVE. This mare had a heat period from 26-29/10/52 was served on 28/10/52, and ovulated on 29/10/52. On 2/11/52 the uterus entered the sensitive stage and became circular, firm and turgid on rectal palpation. The results of her subsequent rectal examinations were as follows:-

26/11/52 - 29 days after service - L.H.B. - Bantam's egg size swelling - 1½" diam.

3/12/52 - 36 " " " - L.H.B. - Hen's egg size swelling - 1¾" diam.

14/12/52 - 47 days after service - L.H.B. - Goose egg size swelling - 2½" diam.

24/12/52 - 57 days after service - L.H.B. - Grapefruit size swelling - 5-6" diam.

On 14/1/53, i.e. 78 days after service the uterus was found empty, and the cervix and anterior vagina free of mucin.

The Ascheim-Zondek blood test was performed at short intervals with the following results:

14/12/52 - 47 days after service - test positive.
14/1/53 - 78 " " " - " "
12/2/53 - 107 " " " - " "
19/2/53 - 114 " " " - " "
27/2/53 - 122 " " " - " "
7/3/53 - 130 " " " - " "
21/3/53 - 144 " " " - at this stage report No. 144/259 of 9/4/53 received from the Onderstepoort Laboratories read as follows: "the test still shows some oestrogenic activity in the serum, but very little gonadotrophic action. As a routine test it would be classed as suspicious or negative depending upon the stage of gestation".

During/.....

During November and December the mare showed the early bloom of pregnancy, i.e. she put on flesh, the coat improved, her temperament became quiet and docile, and her flanks filled out. Only towards the end of January did she change. She suddenly appeared lean, with tucked up flanks, showing the abdominal costal groove readily on walking and turning.

From 12/2/53 determined efforts were made to locate by palpation, any remaining chorionic tissue which might have been responsible for the maintenance of gonadotrophin production in the endometrium. These efforts were unsuccessful and no enlargement of any description could be detected in the uterine horns or body of the uterus. It was however, noticed that the ovary became active, and that the mare ovulated on several occasions. Although the foetus was lost at an early age, the period during which the gonadotrophin circulated in the blood stream remained within the normal limits of ordinary pregnancy, a fact which has been observed im other cases as well. At no stage was any discharge noticed from the genital organs.

2. FLAMING RIVER. This mare had to be assisted during foaling, because of malpresentation of the foetus. She developed a considerable discharge afterwards and was not served during foalheat of 29/10/52 - 3/11/52. Her next heat was from 20-23/11/52, during which she was bred on 22/11/52 and ovulated on 22/11/52. On 9/12/52 the uterus entered the sensitive stage and became responsive, circular and turgid.

Her rectal examinations were as follows:-

19/12/52 - 27 days after service - RHB - Bantam's egg size swelling - 1½" diam.

24/12/52 - 32 days after service - RHB - Hen's egg size swelling - 1¾" diam.

30/12/52 - 38 days after service - RHB - Goose egg size swelling - 2½" diam.

7/1/53 - 46 days after service - RHB - Orange size swelling - 3-4" diam.

On/.....

On 23/1/52 the uterus was found empty, but a crusty white discharge matted the lips of the vulva. She ovulated normally subsequently. The blood test proved negative to blood collected on 7/1/53, i.e. 46 days after service. She appeared on heat on 5/2/53 after an interval of 73 days. A diagnosis of prenatal death was made after the breeding season had closed and the mare could not be bred.

3. DISTANCE. She came in heat on 2-9/10/52, was served on 8/10/52, and ovulated on 8/10/52. By 9/10/52 the uterus was found in the sensitive stage, becoming contracted, circular and turgid on palpation.

Her rectal examinations were as follows:

5/11/52 - 28 days after service - LHB - Pigeon's egg size swelling - 1" diam.

19/11/52 - 42 days after service - LHB - goose egg swelling $2\frac{1}{2}$" diam.

27/11/52 - 50 days after service - LHB - Orange size swelling 3-4" diam.

On 5/12/52 58 days after service the uterus was found empty, the cervix pale, closed and sealed with a sticky gummy mass, and projecting sideways into the anterior vagina. A corpus luteum of 4.5 cm. was present in the ovary. Blood collected on 27/11/52, i.e. 50 days after service was negative for pregnancy.

The diagnosis of prenatal death was made within the breeding season, and with the knowledge that the mare had not gone into serum gonadotrophin production, it was decided to force the mare into season for breeding purposes.

On 10/12/52 she received 3,000 units Pregnant Mare Serum subcutaneously. The corpus luteum receded to 3 cm. by 22/12/52, when she was given a further 1,500 units Pregnant Mare Serum. She came in heat on 27-31/12/52 after an interval of 78 days, and was served on the 27th and 29/12/52, with ovulation taking place on 29/12/52. Her blood collected on 12/2/53, i.e. 45 days later was positive, and she foaled a normal healthy foal on 23/11/53 after a gestation of 329 days.

4./.....

4. HOLY GRAIL. This mare wintered badly and entered the breeding season with her wintercoat.

She came in heat on 15-22/9/52, was served on 20/9/52, and 1,500 units luteinising hormone (Prolan) injected intravenously. Rupture of the follicle was estimated to have occurred on 21/9/52. On 24/9/52, i.e. 4 days after breeding the uterus entered the sensitive stage, becoming circular and turgid on manipulation. Cervical examination on 22/10/52 gave the formula ao, Al, typical of pregnancy.

On 7/11/52 or 48 days after breeding the blood was forwarded to Onderstepoort Laboratories and subsequently returned negative. Rectal examination performed on that date revealed a relaxed and flabby uterus, the organ contracting very sluggishly to palpation.

The mare was injected with 1,500 units P.M.S. subcutaneously on 22/11/52. She came in heat on 27/11- 3/12/52, after and inter-oestral period of 65 days, and was mated during that period. The mare conceived and produced a healthy filly foal on 13/11/52 after a gestation period of 346 days.

5. CARA NOSTRA. This mare also wintered badly and had not shed her wintercoat at the commencement of the breeding season. She had a prolonged heat of 13 days on 10-22/9/52, which was terminated by the use of luteinising hormone (Prolan), 500 units being given on 20/9/52, and another 1,000 units the following day.

She returned in heat on 10-14/10/52, was served on 12/10/52, and ovulated on 13/10/52. On 6/11/52, or 25 days after breeding the uterus entered the sensitive stage, a condition which was maintained for some time. On 27/11/52, i.e. 46 days after breeding the blood was forwarded to Onderstepoort Laboratories and subsequently reported negative.

On 10/12/52 it was decided to force the mare into heat even though a corpus luteum of 5 cm. in diameter was present in the left ovary. 3,000 units P.M.S. was injected subcutaneously and on 22/12/52 a further 1,500

1,500 units P.M.S. administered. The mare came in heat on 27-30/12/52, after an interoestral period of 76 days. She was served on 28 and 30/12/52, and ovulation estimated to have taken place on 29/12/52. No conception took place and the mare was left barren for the season.

Summary.

The blood tests carried out during the 1952 breeding season proved 100 per cent accurate. There is not the slightest doubt that the mare OLIVE GROVE was pregnant of sufficient duration, i.e. 57 days, to have started the production of serum gonadotrophin. Careful palpation failed to reveal the presence of the foetus and/or membranes after the 78th day of pregnancy, but the blood test remained positive for over 130 days after the last service date. The theory is advanced that serum gonadotrophin is produced in the endometrial 'cups', only in the presence of the foetal chorion. It would appear from this case as if the production of this hormone continued along its allotted span irrespective of foetal death and presence or absence of the chorion.

Experience of retained placentas in cattle and horses has been that early dissolution and liquifaction of these tissues take place during the hot summer months of the Karroo Midlands. One would expect complete expulsion of foetus and membranes in the Thoroughbred mare, or that they liquify and are ejected as such. Where mummification occurs, foetus and membranes would be clearly palpable and so located.

Zivotkov (1951) in reviewing the literature and from his own experiences, concludes that resorption of embryos does not occur in mares. He claims that the anatomy, pathology and physiology of the mare's uterus exclude that possibility of resorbtion. The failure to foal in cases where pregnancy was diagnosed, he attributes to either abortion or mistaken diagnosis.

The mares FLAMING RIVER and DISTANCE to my mind represent foetal growth of insufficient duration to have stimulated serum gonadotrophin. The foetal growth in both mares were palpable and reached a quite considerable size. It is possible that their death was due to failure

to/.....

to cause this hormone production which might be essential for their existence. The interoestral period was 73 and 78 days respectively. In the case of FLAMING RIVER there was a history of vulvar discharge after foaling, so that bacterial contamination of the genital tract cannot be excluded as a possible cause of early foetal death.

The mares HOLY GRAIL and CARA NOSTRA gave every indication of early death of the conceptus. They too had an interoestral period of 65 and 76 days before returning to heat.

Discussion.

Early foetal death is a recognized phenomenon, in the Karroo Midlands, and has been frequently encountered in the past 10 years. The history is similar in all instances and may be summarised as follows. The mare shows the principal indications of pregnancy, i.e. service by the stallion; cessation of heat periods; gentleness and docility on the part of the mare; a tendency to put on flesh and become easily fatigued; quietness; laziness; enlargement of the abdomen, especially in the flanks. Then she suddenly 'breaks' by coming into heat after an interoestral period varying from 60-80 days, more commonly between 65-75 days.

It has also been observed that the incidence of this condition increases in those seasons where a dry spring and lack of green feed is followed by good rains during October and November. Many mares which were considered settled early in the season 'break' by coming into heat during late November or during December. This correlation is so noticeable that it is thought that some direct relationship must exist between the nutrition of the mare and these cases of early foetal death. It is believed that the sudden rapid growth of grass, which follows these rains, as well as the hot weather prevailing this time of the year, is responsible for the condition. Latest research has indicated (Legg et al 1950) that actively growing green grass contains considerable amounts of oestrogen. Berthelon and Tournut (1948) while reviewing the

abortifacient/....

abortifacient action of oestrogens, conclude that there is now clear evidence of this action in pregnant animals. They state that in the mare, abortion has occurred at the second and sixth month of pregnancy. The mode of action is uncertain but they consider that it may act in the early stages of pregnancy by preventing proper proliferation of the endometrium and implantation of the ovum. Quinlan (1956) found legumes, such as White and Montgomery Red clovers to possess considerable quantities of oestrogens. He states that these clovers tend to dominate the artificial pastures in the Mooiriver Area of Natal where they may grow 100 per cent pure in a few years and that they are responsible for many cases of early foetal deaths in Thoroughbred mares.

If these views are correct it would explain certain cases of very early foetal deaths, and failure of the endometrium to produce chorionic gonadotrophin. The foetus and membranes at this stage would be small and compact, and abortion could easily escape detection. Such a case was seen during 1953, when a pregnant Thoroughbred mare was put out to veld grazing. She came unexpectedly back into heat after and interoestrus of 63 days. Careful search of the camp led to the recovery of a small aborted foetus enclosed in its membranes.

Cases of mares having a positive blood test, but which proved non-pregnant later on, are not uncommon. At least 50 such cases have been brought to my notice in the past 10 years. During the 1952 season 4 mares at another stud were put out to veld grazing after giving a positive blood test. One mare aborted a small foetus which was recovered and another mare I had to assist in removing the afterbirth. The remaining two returned in heat, but showed no indication of abortion, nor could the foetuses be found. These mares all came into oestrus after an interoestral period of 60-80 days.

From experience I would say that the resorption of perished foetuses is extremely unlikely. It is more probable that the foetus is expelled with or without its membranes, or that it eventually liquifies and is ejected as such during urination. Quinlan (1956) is not in

agreement/....

agreement with these views. He was able to observe lack of growth in the embryonic sac at 35-40 day pregnancy, and states that upon subsequent examinations he was able to follow up uterine changes and to record that the fluid gradually disappeared, the thin walled uterus around the embryo becoming firmer again as the embryo was reabsorbed.

It would appear as if there are several definite periods during early gestation when the pregnancy is very insecure, and when several extrinsic as well as intrinsic factors may cause the death of the foetus.

1. The first period is the period of free existence of the blastocyst in the uterine cavity. Williams (1943) has suggested pathological spermatogenesis and oogenesis, with the production of defective ova and sperms, as the basic aetiological factors in early equine abortion. Other extrinsic factors in early equine abortion are sub-involution of the uterus, faulty endometrial development, genital infections, pyrexia, ingestion by the mare of harmful plants, moulds, poisons, etc.

Very early death of the embryo could be expected, under such circumstances and its occurrence would extend from conception to about 20 days. There has been no implantation, and the mare comes in heat after an interoestrus of 30-40 days.

2. The second period appears to be when the foetus is attempting to establish implantation. This period is estimated as extending from 20 to approximately 35 days. The foetus can be rectally determined during this period, but dies off, most probably as a result of lack of nourishment throug failure to establish the necessary close contact with the uterine endometrium. No endometrial cups are formed and no chorionic gonadotrophin is produced. The blood test during this period is always negative, but the mare is diagnosed in foal by rectal examination. The mare returns in heat after an interoestrus of 60-80 days.

3./.....

3. During the third period implantation takes place with chorionic gonadotrophin production. The blood test is positive and the presence of the foetus can be detected with ease by rectal palpation. Death of the foetus takes place between 35-55 days, with the mare coming into heat after 60-80 days, interoestrus. The mares falling under group 1 and 2, have a reasonable chance of getting into foal if served during the succeeding heats. The mares falling under group 3 do not appear to be able to conceive again during the same season. This aspect will be dealt with in greater detail under the discussion of the biological test for pregnancy.

4. The fourth critical period for the continuation of pregnancy is the transition period when serum gonadotrophin disappears from the circulating blood, and the oestrogen level rises. This period is variable and extends roughly from 100 to 300 days. Whether the change in this hormonal secretion is responsible for the many slips that occur during this period is unknown. It is, however, also the period during which the entire progesterone production is taken over by the chorion. The importance of progesterone in the maintenance of pregnancy is now well established and requires no elaboration here. Most cases of slipping in mares with a history of habitual abortion, occur between the 5th and 10th month of pregnancy. Several such mares have been carried to full term by repeated injections of progesterone, and they delivered normal viable foals after a normal length of gestation.

It may be that insufficient development of the area of implantation interferes with the adequate production of hormones essential for maintaining pregnancy. Errington (1942) has shown that in twin pregnancy, the area over which the two chorions are in contact, have no villi and no placental function. Usually one twin is smaller than the other, and both are aborted before full time, although abortion of one twin, and carrying to full term of the second twin has been observed. Usually the chorion of one twin has a considerable larger area of placental

attachment/....

attachment than the other and there is little doubt that the twin with the smaller placental attachment succumbs first. These observations have been corroborated in all cases of premature abortions of twins in Thoroughbred mares in the Karroo Midlands.

The possibility cannot be excluded that a similar situation might occur in the case of a single conception where inadequate chorionic development and implantation may lead to the death of the foetus after a variable period of gestation. The basic fault may be defective growth of the foetal membranes, a pathological response of the maternal endometrium, or failure of the chorion to develop the necessary hormones, in particular progesterone, required for the maintenance of the pregnancy.

The history of the mare JINNIPET is therefore of considerable interest in this connection. This mare has a history of repeated abortions. She slipped a foal on 22/8/46, 2/7/47, and 15/5/49 after gestational periods of 297, 239 and 221 days respectively. During the 1951 season she conceived to a service on 30/10/51, but on 28/11/51 she showed signs of impending abortion. She was injected with 60 mgm. progesterone intramuscularly on 28/11/51, 31/12/51, 28/1/52, 25/3/52, 28/5/52 and 15/7/52. The dose w decreased to 50 mgm. progesterone on 28/8/52 and 5/9/52. A further amount of 25 mgm. was administered on 10/9/52, after which no further injections were given as it was considered that it might interfere with the normal duration of pregnancy.

She foaled fully developed twin foals on 19/9/52, after a normal gestation period of 325 days. The one foal was stillborn, the other died four days later.

Twin pregnancies in Thoroughbred mares are very rarely carried to fullterm, a phenomenon also observed in other breeds of horses by Uppenborn (1933), Wagner (1934) and Koroljkov (1951). The mere fact that this mare, with a history of habitual abortion, was able to do so can only be ascribed to the influence exercised by the parenteral administration of progesterone.

The/.....

The suitability or otherwise of the endometrium for nidation is in the first instance dependent upon the secretions of the corpus luteum. After nidation, however, the continued activity of the embryo provides the stimulus for the production of chorionic hormones which in the mare, replace that of the corpus luteum during the very early stages of pregnancy, and which in turn influences the character of the endometrium. There is therefore a direct link between the genetic composition of the embryo and the continuation of the production of chorionic secretions. The intra-uterine environment is thus genetically determined and nature has in this manner imposed upon the embryo the necessity to provide for its own existence.

This linkage between genetics and environment brings into consideration the stallion's contribution, and apportions to him part of the responsibility of the vitality of the embryo, because a weak embryo means a weak stimulus and a weak stimulus a deficiency of chorionic hormones with a resulting poor environment and probable death and expulsion or liquifaction of the foetus. Nature by herself has thus determined that mammalian embryonic environment shall be genetically controlled and thus those embryo's which fail to elaborate enough hormones for their own survival are discarded. There is no doubt in my mind that in the Karroo Midlands the many slips occurring during this period of pregnancy, are the direct result of inadequate hormone production of the chorion.

J. THE BIOLOGICAL BLOOD TEST FOR PREGNANCY.

Review of the literature.

Clark (1949) describes the modified Ascheim-Zondek test in use in South Africa for the diagnosis of pregnancy in mares. He stipulates that the samples must only be taken between the 40th and 100th day of suspected pregnancy. Three immature female white mice, between 21 and 28 days old are used for each sample. The mice are injected with one c.c. of the serum subcutaneously on 2 successive days and killed for examination 48 hours after the second injection. The diagnosis is made on the reaction of the uterus and ovaries, the main criteria

being/....

being follicular stimulation and the presence of blood points on the ovaries. He records that 5 out of 117 positive reacting mares did not foal, and believes that these animals were pregnant at the time of the test and that unobserved abortion or reabsorption of the foetus must have taken place. He claims that the test was 97 per cent accurate.

McKenzie (1940) found the biological test for pregnancy to be 98 per cent accurate. Errors in the test are also recorded by Day and Miller (1940), Anderson (1941) and numerous other workers. In all cases the errors consisted in obtaining positive reactions in mares which did not foal.

Dimock (1949) in assessing the value of the biological test, remarks that clinical examination of the mare is the most reliable and instructive method of determining pregnancy. He mentions that his records on several hundred mares examined clinically at 30-60 days after service show that the incidence of early abortion is lower than that reported in mares pronounced pregnant by the biological test. He gives various reasons for errors in the test but continues to say that the clinical examination is more reliable being wholly under the judgment and ability of one person, with few side possibilities to upset his judgement.

This view-point is supported by Quinlan (1952) who recommends the examination of mares for pregnancy on the 40th day as more reliable than the biological test, although he regards the latter as most useful when rectal examination is impracticable.

Observations.

The results of the blood tests performed on 24 Thoroughbred mares are reflected in Table number 45.

TABLE/.....

TABLE NO. 45.

Results of the Modified Ascheim-Zondek Test for Pregnancy.

Mare	Service Date	Bleeding Date	Interval in Days	Result	Remarks
1. ARMORIAL	12/12/52	29/1/53	48	negative	-
2. AUDITION 2nd	10/9/52	31/10/52	51	positive	-
3. BARCAROLLA	4/12/52	23/1/53	50	"	-
4. BLUE VISION	31/10/52	14/12/52	44	"	-
5. CALAMITY JANE	24/11/52	7/1/53	44	"	-
6. CASTANIA	10/10/52	27/11/52	48	"	-
7. CARA NOSTRA	12/10/52	27/11/52	46	negative	Early foetal death
"	30/12/52	12/2/53	44	"	-
8. DISTANCE	8/10/52	27/11/52	50	"	Early foetal death
"	29/12/52	12/2/53	45	positive	-
9. FATA MORGANA	7/11/52	24/12/52	47	"	-
10. FLAMING RIVER	22/11/52	7/1/53	46	negative	Early foetal death
11. FLORA SANDES	22/12/52	12/2/53	52	positive	-
12. FRESCOE	24/10/52	14/12/52	51	"	-
13. HATS OFF 2nd	29/9/52	14/11/52	46	"	-
14. HATTIE HART	25/11/52	7/1/53	43	"	-
15. HELIOTROPE 2nd	12/9/52	31/10/52	49	"	-
16. HOLY GRAIL	20/9/52	7/11/52	48	negative	Early foetal death
"	2/12/52	23/1/53	52	positive	-
17. KINGS FLAME	21/11/52	7/1 /53	47	"	-
18. OLIVE GROVE	28/10/52	14/12/52	47	"	Late foetal death
"		7/3/53	130	"	Uterus empty on 14/1/53
19. ORNAMENT 2nd	21/10/52	7/12/52	47	"	-
20. PAVANE	25/9/52	14/11/52	50	"	-
21. PROTECT	13/12/52	29/1/53	47	"	-
22. TERAI	14/9/52	31/10/52	47	"	-
23. UNCONCERN	18/11/52	7/1/53	50	"	-
24. WYNDSONG	28/11/52	7/1/53	40	negative	-

Discussion.

The blood test performed on the blood samples collected from 24 Thoroughbred mares between the 40th and 52nd day after the last service/....

service, proved 100 per cent accurate if allowance is made for the knowledge of foetal death in the mare OLIVE GROVE. The incidence of early foetal death is discussed in detail in the previous chapter, and the fact is recorded that although the foetus could no longer be palpated on the 78th day of pregnancy in OLIVE GROVE, the blood test was still positive on the 130th day after the last service.

Under ordinary circumstances this mare would have been regarded as in foal, until the foaling season when it would be discovered that she was not pregnant, and the error of diagnosis ascribed to an error in the test. Should the result of this blood test be regarded as a mistake, than one error occurred in 27 tests performed, giving an accuracy of 96.3 per cent.

From the literature it is evident that the biological test for pregnancy in mares is regarded as 95-100 per cent accurate, so that the percentage of 96.3 obtained in this stud falls within normal limits. It is reasonable to assume that where a difference occurs, i.e. where a mare with a positive blood test fails to foal, the cause must be early foetal death.

The case of the mare OLIVE GROVE is of importance as it raises several interesting points. Her blood test remained positive for a considerable period after the foetus was no longer detectable by rectal palpation. The theory is advanced that the production of chorionic gonadotrophin is dependent upon the presence of the foetus, or in its absence upon chorionic tissue being present. It is not at all clear if it is not possible for chorionic gonadotrophin production to continue along its allotted span of time, once the endometrium has received the stimulus for the development of the endometrial 'cups' from the embryo, even if the latter should succumb after an early stage of development. Another possibility, which cannot be excluded, is that the presence of a certain amount of foetal debris and a persistent corpus luteum or corpora lutea, may provide the conditions suitable for the continuation of chorionic gonadotrophin production.

Very/.....

Very careful rectal palpation failed to establish the presence of any foetal matter in OLIVE GROVE after foetal disappearance had been diagnosed. The investigations of Day (1939) point to a similar conclusion. He found that there does not appear to be any correlation between the stage of pregnancy at which the foetus was removed and the resulting oestrous cycles. He removed the foetus between the 51st and 105th day of pregnancy in seven Welsh pony mares, when active gonadotrophin was at its highest level, and found that its presence did not affect in any way the maturation and ovulation of ovarian follicles a few days after the cessation of pregnancy.

These observations are regarded as incomplete as he does not record whether the gonadotrophic level was maintained for its normal length of time after the induced abortions, and if successful impregnation and gestation would follow matings during the heats following the abortions.

The case of OLIVE GROVE is not an isolated one as the incidence of this condition is relatively high in the Karroo Midlands. As many as 5 mares in a single stud of 30 mares, are known to have tested positive to the blood test during one season but they proved empty later on. Several of such positive testing mares have come into heat before the end of the breeding season. Some of them have been bred again but so far not a single instance is known of conception taking place. From the limited number of cases investigated it would appear impossible to impregnate a Thoroughbred mare again during the same season in which she has given a positive blood test followed by early foetal death.

K. HORMONE CONTROL OF THE OESTROUS CYCLE.

From the literature it is clear that much scattered but suggestive evidence exists on reproductive phenomena in the mare, but there remains a lack of a unifying principle. The confusion which exists is, to a large extent, due to the habit of physiologists of comparing reproductive behaviour of various unrelated species, even when it is a

well/.....

well known fact that certain conditions may have a stimulatory effect in certain species and yet have an inhibitory effect on the reproductive function of other species. So for instance there now seems to be overwhelming evidence that the length of day and night, and temperature have important influences on the regulation of the oestrous cycle and sexual behaviour in mammals. Many of these such as the horse, donkey, cat, ferret, etc., have "long-day" breeding seasons in the spring, whereas others, like the sheep, goat and deer, breed during the autumn or "short-day" season. Consequently if light be regarded as stimulatory to the former, then it is inhibitory to the latter. (Asdell, 1946).

All mammals have evolved to their present day status as a result of a series of adaptations. It must follow that the pattern of physiological responses of the various species cannot be divorced from external influences of climate, nutrition, etc., but bear upon them. In the case of domestic animals the additional factors introduced by selective breeding, artificial feeding and housing are capable of altering the reproductive behaviour and habits of a species from its counterpart still found in the wild state. Thus, while in most species an artificially lengthened day advances the breeding season, in others, for example, the guinea-pig (Dempsey et al. 1934), the ground-squirrel (Moore et al. 1934), the rabbit and cow, such treatment has, so far, failed to show any definite effect, suggesting that these species seem to have freed themselves wholly or partly from this environmental influence. (Amoroso, 1955).

In the final analysis of reproductive function it is imperative to pay attention to the origin and evolution of the species under investigation. In the case of horses sight cannot be lost of the fact that they were basically used for work, war and play. The mare remained useful for this purpose, even though she bred and produced a foal occasionally or not at all. As a result there has not been the tendency to improve fertility by selective breeding from only those mares which foaled regularly with the result that variations in fertility have

been/.....

allowed to continue unchecked.

The Thoroughbred is a horse specifically selected for speed which clearly represents an advance in neuro-muscular development and perfection. This nervous development is such that it forms a decided factor for consideration in the reproductive function of this breed. It is generally accepted (Dukes, 1947; Beach, 1948) that hormonal control or co-ordination in the body is the slower, apparently more primitive type; nervous regulation being regarded as the more efficient type and accepted as a more recent phylogenetic acquisition of the organism. The result of this one-sided selection for speed is that reproductive function in the Thoroughbred has failed to evolve into the more stable and rhythmic pattern encountered in other species of fully domesticated animals. More often than not the only constant feature of the oestrous cycle in the mare is its irregularity, and the retention to a great extent of all the characteristics of a rather primitive pattern of reproduction.

In the domesticated cow and sheep a highly specialised reproductive system functions with almost clockwork regularity when these animals are maintained under conditions of full domestication. This perfect co-ordination between component parts of the reproductive system is frequently absent in the Thoroughbred mare. Each of the parts may function independently, resulting in the dysfunction so frequently observed resulting in infertility. It will be difficult for a clinician to experience a breeding season on a large Thoroughbred stud without encountering abnormalities such as the fully grown maiden mare with normal heats but possessing infantile genitalia with failure to conceive; the mare with full development of the tubular genitalia and normal heats but having no ovulation, or the 'shy' mare which shows no external manifestation of sexual desire and consequently refuses to be bred although she has achieved unity of development between the ovaries and the genital tract.

One/.....

One feels that such phenomena of dysfunction cannot be regarded as pathological, but should be accepted as evidence of a rather primitive reproductive system struggling to achieve synchronization of all responsible organs to reach that unity of effort essential to successful reproduction - a process taken so much for granted in the domestic milk cow.

The semi-wild mare of Korea is monoestrus (Satoh and Hoshi, 1932), but the domestic mare is accepted as polyoestral, breeding as a rule seasonally during spring (Küpfer, 1928; Day, 1940; Asdell, 1946). Quinlan and others (1951) have shown that if mares are stabled, given an uniform ration throughout the year, and subjected to regular teasing, oestrous indications are evinced throughout the year although winter matings are sterile. Belonje (1956) reports that it is possible to bring anoestral mares in heat during midwinter by running them out with an operated stallion. The possibility hence exists that the presence and attentions of the stallion is a deciding factor in producing oestrous symptoms and not necessarily the stabling or the feeding.

Burkhardt (1948) induced oestrus and successful breeding in a group of mares by exposing them to artificial light during midwinter. The mares were examined rectally at short intervals to note ovarian response and were teased by a stallion to determine heat. It is difficult at this stage to assess the relative importance of the three factors involved in this experiment; i.e. light, rectal examination and the periodic attentions of the teaser stallion. From personal experience and observation it must be recorded that anoestral mares can be brought into season and successfully bred by periodic ractal massage of the genital organs accompanied by active teasing. The claim that artificial lighting is solely responsible for the phenomena observed, cannot be accepted without considerable reservation.

For these reasons I must concur with Lagerlöf (1936) and regard the variations in the oestrous behaviour of the mare as a

transition/.....

transition stage from the monoestrus to the polyoestrus, confined within a definite season, the outher limits of which vary according to environmental factors (Küpfer, 1928).

The importance of these environmental factors is indicated by the close correlation of reproductive function in many animals with the seasons of the year. Of the factors that influence reproduction and determine the breeding cycle, light, temperature and the environmental experiences derived from association of the sexes, are considered to be of the first importance. On the other hand, however, favourable the environment, one cannot agree but whole-heartedly with Beach's (1948) insistence that during the evolutionary process in the progress from lower mammals through those of intermediate phyletic status to man, there has been a reduction in the control of sexual behaviour by stereotyped anatomical and hormonal mechanism as a result of transfer of function to cortical brain mechanism.

Post-copulatory ovulation is normal in the rabbit (Hammond and Marshall, 1925), 13-lined ground squirrel (Foster, 1934), short-tailed shrew (Pearson, 1944), cat (Hansson, 1947), raccoon (Llewellyn & Enders, 1955), and it may be taken as established for the rabbit, and as a strong possibility for the other forms, that sexual excitement affects L.H. secretion by nervous reflex activation of the anterior pituitary. (Marshall and Verney, 1936). But, even in species in which ovulation is generally considered to be independent of mating, there is reason to believe that the secretory function of the pituitary is influenced by stimuli derived from copulatory activity and is dependent on a chronologically limited **nour**ohumoral stimulus to the hypo-physis that is qualitatively similar to that in the rabbit. Thus, Everett, Sawyer and Markee (1949) demonstrated that in cyclic rats ovulation can be blocked either by intravenous injection of Dibenamine or by subcutaneous injection of **atrophne** before 2.0 p.m. on the day of pro-oestrus (four-day cycle). Similar treatment at 4.0 p.m. does not usually interfere with ovulation. In the cow also, Quinlan,

Bisschop/....

Bisschop and Adelaar (1943) report that infertile coitus shortens the oestrous cycle, while copulation is said to hasten the occurrence of ovulation (Marion, Smith, Wiley and Barrett, 1950).

Other illustrations of the importance of nervous mechanisms to the endocrine control of the reproductive cycle of mammals are to be found in observations in the oestrous cycle of the cow. This animal has a relatively short heat period averaging about 13½ hours. According to Asdell (1946), when the threshold doses of oestrogens, not more than the amounts needed to induce heat, are injected daily into ovariectomised cows, the resulting oestrus is not continuous, but ceases at the usual time in spite of the continued injection. Evidently, the length of the heat period is curtailed by the induction of a refractory period in the brain and this causes sexual desire to cease.

This cortical brain influence has been observed in the Thoroughbred mare where a high nervous development has been attained by selective breeding for speed. This influence may be stimulatory or inhibitory e.g. the presence and attentions of a stallion may provoke sexual desire in the anoestral mare; severe pain consequent upon injury or operation may suppress oestrus or impregnation, and although ovulation is considered spontaneous there is reason to believe that the secretory function of the pituitary is influenced by stimuli derived from repeated copulatory activity, or cervical massage. There are many studmasters in the Karroo Midlands who firmly believe that daily and even twice daily services for mares, which refuse to settle in previous heats, will induce ovulation with conception. Anoestral mares are brought into season by placing them in a loose box from where they can see a stallion while the cervix is being massaged.

Under these circumstances it is difficult to gauge the relative importance of factors such as length of day and night and temperatures, when it is known that in the Karroo Midlands the days lengthen and the temperature rises during early spring, but that the highest

fertility/.....

fertility is obtained during summer after the rains have fallen with consequent improvement in natural grazing. It is generally accepted that maximum fertility is obtained in sheep on a rising plane of nutrition with a gradual increase in body weight starting from lean to fairly good condition. (Marshall and Hammond, 1949). It is probable that the ecological factors enumerated exert their effect through improved nutrition, and that the gradual improvement of the food intake constitutes the greatest single factor in the regulation of the oestrous cycle, sexual behaviour and impregnability of mares running out in the veld. When such mares are maintained under conditions of full domestication, i.e. stabling, feeding, etc., many seasonal influences may become considerably reduced or eliminated. This, in part, would explain the difference in sexual behaviour of non-pregnant mares run on the veld and subjected to the environmental and nutritional conditions prevailing, and the foaling mare which receives extra attention and additional feeding. Reproductive behaviour of the Thoroughbred mare in the Karroo Midlands cannot be regarded as independent of ecological and neurological phenomena.

It is now accepted that the internal secretions taking part in regulating the oestrous cycle are those of the ovary and the gonadotrophic hormones of the anterior pituitary, while other endocrine glands, e.g. the thyroid and adrenals, whose products are more directly concerned with the general metabolism of the body, exercise and indirect, though important, influence.

The gonadotrophic hormones of the anterior pituitary are three in number, namely the follicle stimulating hormone (F.S.H.), the luteinising hormone (L.H.), and the luteo trophic hormone (L.T.H.) or prolactin. Amoroso (1955) states that there is now a good deal of evidence in support of the suggestion that the secretion of F.S.H. and L.H. by the anterior pituitary are under separate control, and that the gonadotrophic potency of the anterior pituitary is regulated by a feedback mechanism in which the determining factor is the level at which

the/.....

the ovarian hormones are secreted. Thus, when its concentration in the blood rises, the oestrogen that is secreted by ovarian tissues under influence of F.S.H., inhibits the further secretion of F.S.H., and, provided that its concentration does not rise too far, stimulates the further release of L.H.

F.S.H. secretion may be envisaged as occurring initially in amounts sufficient to initiate follicular growth in the ovary. Under the increasing influence of L.H., follicular maturation is completed and oestrogen production continues. Ovulation is then induced followed by corpus luteum formation. At this stage the L.T.H. is responsible for maintenance of corpus luteum and secretion of progesterone. Ovulation thus occurs as a result of the combined action of oestrogen and progesterone on the follicle. The discharge of L.H. from the pituitary seems to be inhibited by high titres of progesterone. The corpus luteum remains functional for only a hosrt period unless pregnancy or pseudo-pregnancy supervenes. Regression of the corpus luteum may occur because of a self-limiting factor in itself, since there is no evidence of a cyclic change in pituitary luteotrophin production. Amoroso (1955) further maintains that since both F.S.H. and L.H. do not physiologically act as single entities at separate times, their individual actions are chiefly of academic and chemical interest. He states in addition, that the concept that secretion of progesterone begins during the period of follicular maturation has received further support from studies upon the fluctuations in the normal cycle. This effect is part of a more widespread pattern of change in water content which the hormone stimulates in most tissues of the body (Zuckerman, Palmer and Hanson, 1950).

In addition to the hyperaemia and cellular growth which it induces, another characteristic of oestrogen upon the reproductive organs of the female rat is to increase the amount of water in the tissue of the uterus, but this response is inhibited by the simultaneous action of progesterone. The water content normally reaches a maximum

shortly/.....

shortly before pro-oestrus and falls abruptly immediately before ovulation. (Astwood, 1939; Carroll, 1945), suggesting that oestrogen induces some reversible change either on the capillary wall, the lymphatics, or the extra-capillary tissue, which determines the retention or otherwise of extra-cellular water. The immediate cause of the pre-ovulatory dehydration is believed to be due to increased secretion of progesterone, which opposes the action of oestrogen upon the uterus. These facts suggest that secretion of progesterone by the follicle begins about the time of sexual receptivity. Amoroso (1955) draws attention that at this time luteal tissue as such has not yet appeared in the follicles, but certain early luteal changes have been detected in the follicular wall of pre-ovulatory follicles of the dog, and also of the cat, mouse, rat, mare and cow.

It is difficult to accept the simple endocrine interaction outlined above as a completely satisfactory explanation of sexual behaviour in the Thoroughbred mare as observed during 15 years of clinical experience gained in various parts of the Cape Province, including the Karroo Midlands and the following hypothesis is advanced and reflected diagrammatically in Fig. 13.

It is an accepted fact that horses normally breed seasonally in spring and summer, but the factors which control this periodicity are not well understood. That it may be an external one follows from the observation that when seasonal breeders are transferred from the Northern to the Southern hemisphere, they soon adjust to the reversal of the seasons and breed in that season to which they are now accustomed. In these studies the mare ORNAMENT 2nd was bred in France during May 1951, i.e. during their breeding season. She foaled om 21/4/52 but conceived again to a service on 21/10/52 in the Karroo Midlands which shows that she had adapted herself to the new breeding season.

Although it is suggested that an increasing gradient of light each day is the external factor involved, there is sufficient indication to suggest that other ecological, hormonal and neurological

factors/...

factors may play a considerable role in determining the onset, duration and cessation of the breeding season. The stimulus or stimuli so created stimulates the anterior pituitary to secrete increasing amounts of F.S.H. which sensitizes the body to produce oestrogens from various sources, of which the adrenal cortex is probably the most important. Seaborn (1925) found that the adrenals in some cases increase in weight during the oestrous period, by as much as 100 per cent.

Significant is the fact that the stallion secretes in his urine about 1,700,000 M.U. of oestrogenic sex hormones per diem, equivalent to 62 gramme of hormone in a year, a much larger amount than even the pregnant mare (Zondek, 1934). Mass excretion of oestrogenic hormone in the urine of the male is considered a peculiarity of equines. The titer varies being highest in spring and summer and is lowest during winter (Barulin, 1939). No correlation was found between the amount of oestrogenic substances in the urine and the volume of semen, its concentration, or the motility of the spermatozoa and the libido (Bielahsky & Ewy, 1951).

The level of blood oestrogens (oestrone and oestriol) in the mare rises and if excessive may produce symptoms of heat without follicular development of the ovary. This condition is frequently encountered in young maiden mares during early spring. The heat period is well-marked but the ovaries are hard and involuted.

Normally the cells of the theca interna utilise circulating blood oestrogens to secrete oestradiol into the Graafian follicle forming the liquor folliculi. The blood oestrogens under ordinary circumstances remain well below the threshold value at which oestrus is produced, and it is consequently only when the oestradiol content of the Graafian follicle rises above the threshold level that symptoms of sexual desire become evident.

A number of investigations have been carried out to determine the activity of the anterior pituitary in different species of

mammals/.....

mammals with the object of explaining the variations in reproductive behaviour shown by them. In the domestic animals an interesting chain of events has been found. In general it may be stated that the length of oestrus is directly related to the F.S.H. content of the anterior pituitary, the more F.S.H. content per unit weight of pituitary, the longer is the average heat period for the species. The threshold of oestrogens necessary to bring the females into heat follows the same pattern and so does the level of oestrogen secretion. The series in descending order is shown in Table 46.

TABLE NO. 46.

(After Eckstein, 1949)

The Hormone Content of the Anterior Pituitary in Different Species (in decreasing order).				The Duration of Oestrus in Different Species.	
Gonadotrophic Activity	Follicle Stimulating Hormone	Luteinising Hormone	Leuteotrophic Hormone (Prolactin)	Species	Length of Oestrus
(Chance et al, 1939)	(Witschi, 1940).	West & Fevold, 1940)	Chance et al., 1939)		
Horse	Horse			Mare	5-7 days
Pig	Pig	Sheep	Ox	Pig	2-3 days
Sheep	Sheep	Pig	Pig	Sheep	30 hours
Ox	Ox	Cattle	Horse	Cow	13-14 hours

The mare has considerable gonadotrophic activity of the anterior pituitary and secretes the greatest concentration of F.S.H. of all domestic animals, and the least L.H. and L.T.H., so that her heat period becomes correspondingly prolonged. It follows that the high level of F.S.H. output of the anterior pituitary requires a correspondingly high production of oestrogen.

Under the influence of F.S.H. and oestrogen the follicle rapidly grows and the cells of the membrana granulosa begin to luteinise and secrete progesterone. The possibility of progesterone secretion prior

to/.....

to rupture of the follicle has been discussed before. Edger (1953) by chemical assay methods found progesterone present in the fluid from the mature Graafian follicle of the cow and sow. Hammond (1938) states that if the Graafian follicle of the mare is ruptured artificially on the second day of heat, no corpus luteum is formed, and a new heat begins in a few days. On the other hand, artificial rupture on the fifth day is followed by corpus luteum formation, and the next heat occurs at the usual time. This may demonstrate the importance of the maturation process in preparing the granulosa cells to luteinise, or it may mean that the pituitary is not able to secrete L.H. early in oestrus. It would be reasonable to suppose that under the gradual increasing influence of progesterone and oestrogen the anterior pituitary secretes L.H. which promotes follicle maturation and at a certain level causes ovulation. Rupture of the Graafian follicle would therefore be the result of the synergetic action of progeaterone, oestrogen and L.H. Evidence obtained from the cow, in which the course of follicle growth can be followed by palpation of the ovary through the rectal wall, indicates that oestrogen does not cause a cessation of F.S.H. secretion, nor does it stimulate the secretion of L.H. It is much more probable that the small amount of progesterone secreted as the follicle matures causes the anterior pituitary to release L.H. and to cease secreting F.S.H. Hansel and Trimberger (1952) and Herrick (1953) have shown that the injection of small doses of progesterone at the beginning of oestrus hastens the ovulatory process in dairy heifers. Both the length of oestrus and the time from end of oestrus to ovulation are significantly reduced. This would explain the widely observed phenomena of prolonged heats early in the season, particularly in maiden Thoroughbred mares, where progesterone production is low or non-existent. On innumerable occasions has luteinising hormone been administered in the form of human pregnancy urine extract, either subcutaneously, intramuscularly or intravenously in doses ranging from 500 to 2,500 international units without causing follicular rupture in such cases. After the breeding season is well established and mares have

passed/.....

passed through several heat periods rupture of Graafian follicles can be brought about by relatively smaller doses of luteinising hormone. This can only be ascribed to the influence of a low residual progesterone content resulting from previous corpora lutea formation.

Small amounts of progesterone in combination with P.M.S. and uterine distension with Saline, were used in these studies on anoestral mares CALAMITY JANE and WYNDSONG. Both mares came on heat, the former having an ovulation with conception, the latter having an anovulatory heat. Several cases of persistent infertility have been encountered since 1952 in both maiden and non-pregnant mares, some of several years standing. In all these cases no abnormality could be detected and services had been performed within reasonable limits of ovulation. In these cases luteinising hormone was administered and simultaneously progesterone injected on the 3rd day of heat, with conception and successful pregnancy following. It is not unreasonable to assume that the progesterone output of the maturing Graafian follicle of such mares might have been insufficient to cause adequate development of the uterus for the reception and nourishment of the developing embryo.

The influence of progesterone in the preparation of the uterus is hence of paramount importance, although its action is only manifest after that organ has been previously stimulated by oestrogen. Many cases of sterile matings and early foetal deaths may be ascribed to inadequate endometrial development and maturation, resulting in starvation and death of the fertilised ovum.

Where nidation takes place either the endometrium the metabolic processes of the activity growing embryo, or a neurohumoral mechanism stimulates the anterior pituitary to secrete L.T.H., which in turn prolongs the functional life of the corpus luteum beyond its normal existence of about 8-10 days. A diagram of events during gestation in the mare is given in figure 14 and has been discussed under pregnancy. It is of interest to record that Short (1956) detected by a chemical

method/.....

method the presence of progesterone in the placenta of the mare. As the placenta of the mare is of the non-deciduate, epitheliochorial type and assumed to be composed of foetal tissue only, it is deducted that it is responsible for the production of progesterone or for its selective concentration from the maternal circulation.

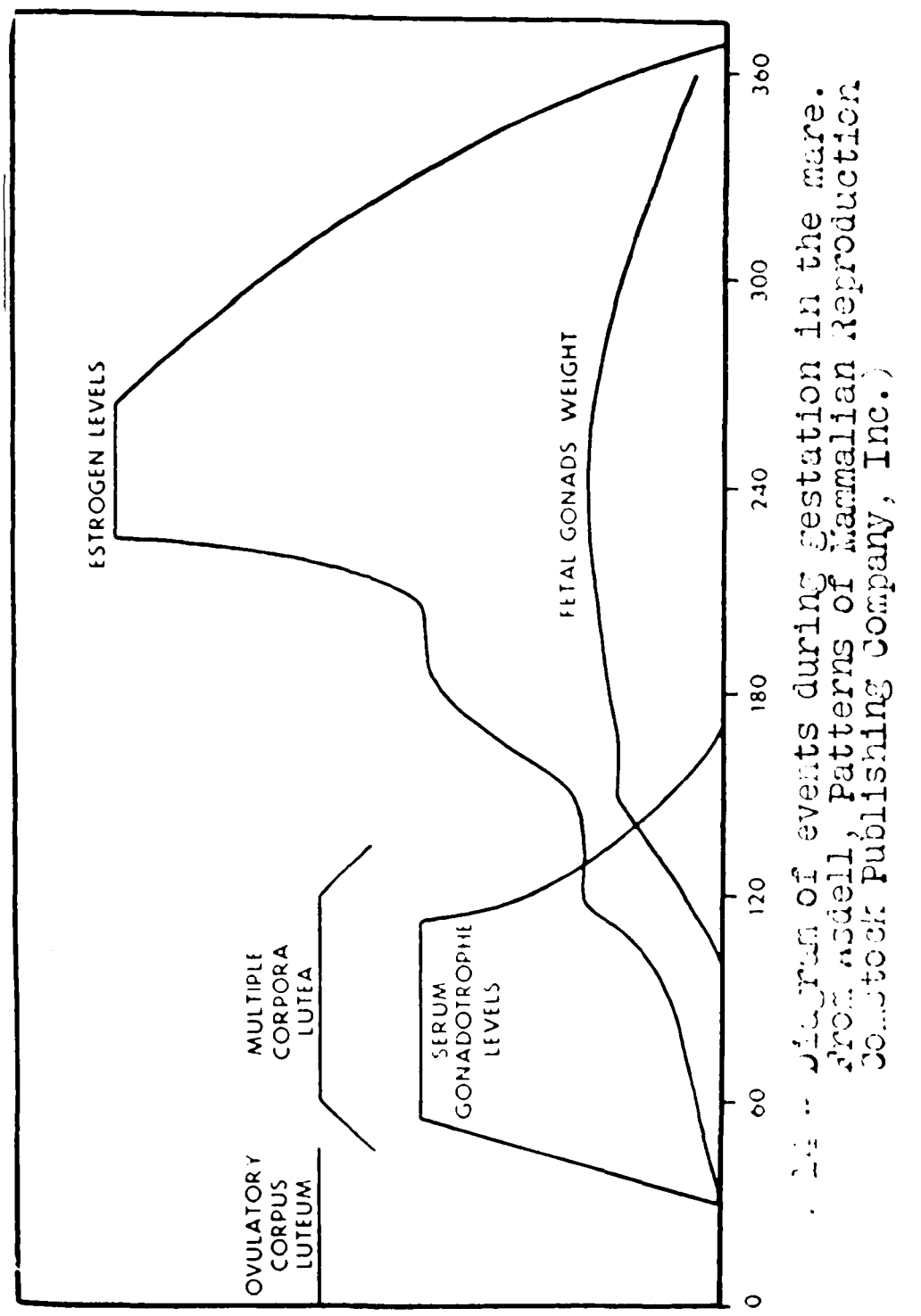


Fig. 24 - Diagram of events during gestation in the mare. From Asdell, Patterns of Mammalian Reproduction. Comstock Publishing Company, Inc.)

Another interesting point is that the excretion of oestrogens during pregnancy can first be detected at from 30 to 40 days, when it is about 250 R.U. per liter. It rises to 17,000 R.U. per liter, or more, at the 260th day, after which the quantity rapidly falls as

pregnancy/.....

pregnancy nears its end (Cole and Hart, 1942).

In women there is a progressive increase in the blood and urinary oestrogen, secreted by the placenta, which rises to its peak just before the onset of parturition after which it shows a remarkable drop (Robson, 1947). Oxytocin, of the post pituitary, has been shown to produce a more decided action on uterine muscle after the latter is sensitized with the hormone oestradiol. The hypothesis has been advanced that the synergistic action of these two hormones is instrumental in parturition. Another probable factor is that while progesterone is being produced uterine sensitivity to oxytocin is at a minimum. It is difficult, however, to see how pregnancy is maintained if oestrogen is regarded as the decisive factor as this hormone decreases to a low level in mares during the latter part of gestation.

Some factors are certainly at work that bring about parturition with such regularity, but their exact nature is still obscure. It is possible that foetal growth and its metabolic requirements, as well as an ageing placenta may play the decisive role in the termination of pregnancy.

It is accepted that the act of parturition is aided by active secretion of oxytocin of the posterior pituitary. There can be little doubt that is is accompanied by an active secretion of L.T.H. of the anterior pituitary resulting in milk production and the development of the maternal instinct. Should the L.T.H. hormone be excessive there will be suppression of F.S.H. production and the mare will not come on heat for a variable period extending for months or occurring only after weaning of her foal. This seems to be an individual characteristic and certain mares are known only to breed every other year (Burkhardt, 1948). The mare WYNDSONG appears to belong to this group. The L.T.H. output is further favourably influenced by the suckling reflex, which in all probability acts as a direct neuro-humoral stimulus to the anterior pituitary.

parturition/....

Parturition leads to the release of the anterior pituitary from the inhibiting influence of progesterone resulting in an intense secretion of F.S.H. and the appearance of foalheat shortly afterwards. As the ovaries are completely involuted and functionless during the last two-thirds of pregnancy it contains no progesterone. The chorionic production of progesterone is abruptly terminated during or shortly before birth, so that no residual progesterone is available in the body at the time of foalheat. This may explain the very high percentage of ovulatory failures (22.2 per cent) observed in this study, as well as by others (Jennings, 1941; Mahaffey, 1950), as it is only those follicles producing a sufficiently high concentration of progesterone, which will be capable of ovulating.

It is a well established fact that F.S.H., oestrogen and progesterone are secreted in considerable amounts in the mare. Reproductive function is consequently the result of a quantitative production of hormones concerned, and dysfunction the result of a disparity in the amounts secreted. Contrary to general view it would appear as if progesterone and not oestrogen plays a dominating role in the hormonal control of the oestrous cycle in the mare.

C O N C L U S I O N

1. The reason for the development of Thoroughbred breeding in the Karroo Midlands is traced primarily to the absence of Horsesickness and to the success attained in rearing large numbers of horses, for remount purposes, under veld conditions.

2. The growth and present development of the Thoroughbred industry is discussed. It is mentioned that over £1,000,000 in aggregate, is offered annually as stake money on the race tracks in South Africa, forming a powerful incentive to racing and breeding.

3. The detailed data on oestrus, ovulation, pregnancy and related phenomena in the Thoroughbred mare, are obtained from the Askania Nova Stud, Middelburg, Cape, between September 9th, 1952 and March 7th, 1953. They are the results of intensive observations carried out on 27 Thoroughbred mares. The management of the mares, the environmental factors of nutrition and climate, are discussed in detail, as well as the methods of clinical examination employed during the study.

4. The position of the ovary is found extremely variable and dependent upon bowel or bladder distention, on various stages of pregnancy and on the actual process of rectal examination.

5. The shape of the ovary is found to depend upon its functional activity. Where the ovary has returned to its resting stage by maximum contraction it assumes a kidney shape. Where follicular activity is taking place the organ becomes swollen and rounded. No standard shape is found.

6. The consistency of the ovary shows wide variation, dependent upon the stage of its functional development. If completely non-functional the organ is retracted to its minimum size, is usually flat and hard without any soft centres. The term "involuted" ovary is proposed to describe such an ovary. This condition occurs uni- or bi-laterally.

7/.....

7. The size of the ovary is found to be in direct relation to its functional activity. When completely involuted, whether uni- or bi-laterally, it reaches its minimum size which remains constant for a variable period. Where the ovary becomes active its shape alters from cycle to cycle depending upon the number of tertiary follicles formed. It cannot be accepted that the ovary begins to atrophy at 10-15 years, to become very small and fibrous as age advances. No such noticeable decrease in ovarian size is observed in these mares, 13 of whom are 10 years and older.

8. It is noticed that in the anoestral barren mare, Graafian follicles develop which either:-

   a. remain tense, regress and eventually disappear.
   b. become soft, ovulate and form a corpus luteum.
   c. become soft, fail to ovulate, regress and disappear.
   d. become soft, ovulate and form a corpus luteum during the following heat.

9. In the anoestral pregnant mare it is found that during early pregnancy follicles develop which become large, soft and watery, which either:-

   a. regress completely.
   b. ovulate to form a corpus luteum.
   c. Luteinise without rupturing.

10. Although several follicles reach the heat period in a soft and fluctuating state, the great majority are firm and tense at the beginning of oestrus, becoming softer as the time of ovulation approaches. The wall of the follicle in particular, becomes very thin and pliable, and there is a noticeable drop in intra-follicular pressure at or near the time of ovulation. The size of the follicle at commencement of oestrus varies from 1.5 cm. to 5 cm. and at or just precooding ovulation from 2.5 cm. to 5 cm. It is observed that the follicle grows larger as ovulation approaches but that this enlargement is by no means very marked.

11/.....

11. Ovulation is found to occur on the last day of heat or on the day preceeding it, in other words the mare goes out of heat 24-28 hours after ovulation. The only exception being two mares, who remained on heat up to 3 days after ovulation had taken place. After rupture of the normal sized follicle a distinct crater can be felt. Where the follicle is of large size and occupies the entire pole of the ovary the change taking place after ovulation is considerable, both in shape and size.

12. Six mares had anovulatory heats. Some follicles during such heats regress and disappear, one continued and ruptured only during the following heat, and the others luteinised without rupturing.

13. Two mares ovulated after cessation of heat, one mare ovulated prior to oestrus and two mares ovulated during early pregnancy.

14. One mare had a double ovulation during oestrus, one mare luteinised a follicle in one ovary and ovulated in the other during the same heat. Another mare ovulated once during her heat period and ovulated again the day after she went out of oestrus.

15. The frequency of ovulation in the right and left ovary is found identical, twenty ovulations occurring in the left and twenty in the right ovary.

16. The length of period during which the corpus luteum spurium can be detected in the non-pregnant mare ranges from 8-19 days with an average of 13.3 days.

17. Several mares develop and maintain only one corpus luteum after conception, and its presence can be detected for a period ranging from 49-86 days. The ovary after that period involutes and the presence of the corpus luteum can no longer be detected.

18. In other mares the primary corpus luteum slowly regresses and its place is taken by another corpus luteum, which is formed either in the same ovary or more usually in the opposite ovary. This second corpus luteum is formed either by spontaneous ovulation and subsequent luteinisation of the ruptured follicle, or by the luteinisation

of an/....

of an unruptured follicle. The presence of the first corpus luteum can be detected for a period varying from 15-66 days, and the second one from 21-80 days. The total period during which a corpus luteum is detectable varies from 41-123 days.

19. In two mares definite indications existed that the second corpus luteum of pregnancy receded and that its place was taken by a tertiary corpus luteum. The first corpus luteum in these cases could be palpated for a period varying from 9-17 days, the second from 23-67 days. The tertiary corpus luteum was detected in the ovary opposite to the one that contained the second one. The duration of the tertiary corpus luteum could not be ascertained.

20. After ovulation the newly formed corpus luteum can be detected by its distinctive feel. As a rule it is diffuse in nature, soft, elastic and crunches on pressure. Its outlines are as a rule indistinct making measurement impossible.

21. Where pregnancy takes place the presence of the corpus luteum can be detected with ease, but an estimation of its size, i.e. diamter can only be performed some time afterwards. This interval varies from 9-42 days, with the highest incidence between 9-18 days.

22. During the normal cycles of non-pregnant mares the corpus luteum is found invariably smaller and sometimes as large as the follicle which preceded it. In seven pregnant mares the corpus luteum of pregnancy exceeded the size of the follicle that preceded it, but they only reached their maximum size some considerable time after ovulation.

23. Rectal palpation of the uterine end of the Fallopian tubes failed to reveal any alterations in size, shape or consistency during the various phases of the sexual cycle in the non-pregnant or parturient mare.

24. No degenerative changes were detected in the ovaries of these mares. The only abnormality encounted is involution of the ovary,

either/.....

either uni- or bi-laterally, and cases of arrested development of the ovary called the static ovary. Their relationship to absence of heat, or during short or prolonged heat is discussed. The underlying causes of these conditions are regarded in all probability to be due to hormonal unbalance and are reversible, i.e. they are not of a permanent nature.

25. Involution of the uterine horns in the parturient mare was followed closely. Involution was complete in 3-4 weeks in three mares; 4 mares took 6-8 weeks and three mares 10-11 weeks and one mare 17 weeks. The influence of uterine infection in delaying uterine involution is discussed. Contraction of the non-pregnant horn continues for some time after conception has taken place in the opposite horn, because of the increased tonus of the uterine musculature during early pregnancy.

26. In the non-pregnant mare the cervix relaxes during oestrus to permit intra-uterine insemination by the stallion. After cessation of heat the cervix contracts again to a relatively firm consistency, usually of the type described by formula al. AI. It is observed that the cervix does not return completely to the quiescent state during the breeding season. The only exception being the mare that went into suckling anaphrodisia. The cervix reaches its maximum contraction on an average 8.5 days after ovulation and 7.6 days after heat in the non-pregnant mare.

27. The cervic relaxes to its maximal dilatation described by formula c3, $CIII_{a}$ from 1-5 days before ovulation, and continues until 1-2 days after ovulation.

28. It takes the cervix from 16-46 days, with an average of 29.7 days after cessation of heat to reach its contracted state and formula ao, AI, typical of pregnancy.

29. There is a definite tendency for the intensity of the colour of the vestibule to be greatest during oestrus and least during inter-oestrus. During oestrus there is a thin lubricating mucus and

the/.....

the vulvar lips become swollen, relaxed and the orifice elongated. Although individual variations are encountered, this method of determining the approximate time for service has found practical application.

30. The mean number of days from parturition to, and including, the 1st day of foalheat is 9.3 days. The mean duration of the foalheat is 4.6 days. Foalheat is taken as that heat occurring within 15 days after parturition.

31. Failure to ovulate during foalheat occurred in 22.2% of cases. In 66.6% of cases ovulation took place on the last day of heat or on the day preceding it, and in 11.2% it occurred 3 days before.

32. In 41.9% of instances the mare proved unfit for foalheat service because of a torn vulva, bruised vagina or purulent genital discharge. The remaining 58.1% were served of which 38.9% conceived.

33. The interval between parturition and oestrus following foalheat is found to range between 23-38 days with an average of 31 days.

34. The mean duration of oestrus during the breeding season is 5.9 days. The mean duration of the inter-oestral period is 18.2 days. If those cases where prenatal death occurred are excluded, the mean duration was 15.8 days, which is considered normal for this area.

35. The Jockey Club of South Africa has ruled that the ageing of Thoroughbre born South of the Equator shall take place from the 1st of August each year. The demand for well-grown 2 and 3 year old Thoroughbreds has resulted in the creation of a breeding season extending approximately from the 8th of September to about the 15th December.

36. The general fertility figures for Thoroughbreds in the Cape Province reveal an ascending incidence of conception closely related to rainfall, increase in the length of day light hours and warmth. The highest fertility percentage is found to extend from November to February.

37. It is noted that follicular development and consequent fertility can be favourably influenced by forcing barren mares to a higher nutritional activity by providing artificially grown green feeding

supplemented/.....

supplemented by concentrates during winter and early spring. It is observed that in this manner the natural breeding season can be considerably advanced and early spring mating made possible.

38. The intensity of oestrus was carefully followed and it is observed that in the Thoroughbred psychological heat is a distinct phenomenon. The process of coming in heat is not usually a gradual one, but immediately detectable, although the degree of receptivity varies considerably from mare to mare, and frequently from heat to heat in the same mare.

39. The reduction of oestrus by means of various hormones is discussed. There is no evidence that follicular growth is influenced by their use and considerable variation exist in the time of rupture of the follicle after injection, varying from 12-48 hours. In one mare the injection luteinising hormone (P.U.) was repeated after 48 hours with ovulation occurring within 24 hours afterwards. It is suggested that undue shortening of the prolonged heats early in the season might interfere with the normal maturation of the tubular genitalia and and contribute towards early foetal death. Because of instances of shock in other studs, the intramuscular administration of luteinising hormone is preferred to the intravenous route.

40. The various methods of inducing oestrus are compared. Uterine dilatation combined with Pregnant Mare Serum subcutaneously and the use of Progesterone intramuscularly is regarded as the most satisfactory in very obstinate cases of anoestrus.

41. The ovary during early pregnancy involutes to its minimum size. In 10 mares this onvolution was completed within a period ranging from 68-116 days, with an average of 83 days. The involuted ovaries are small, firm and contain no soft centres. It is surmised that at this stage they have no function.

42/.....

42. Uterine responsiveness is detected after a variable period after conception. This period varies considerably, in some mares it is detected immediately after conception, in others it is delayed up to 27 days later. This delay in responsiveness is ascribed to delayed involution of the uterine horns after recent foaling and the firmness of the wall of the parturient uterus masking the sensitivity of that organ to palpation. The time at which this responsiveness is lost varies from 38-60 days, with an average of 50 days after the last service.

43. After the sensitive stage the uterus enters the saccular stage characterised by the disappearance of the contraction reflex and the change within the uterus as a result of the growing foetus. The relative sizes of the foetus during early pregnancy are given.

44. All pregnancies during the 1952 breeding season are the result of ovulations occurring within 30 hours after service, and in 2 cases from services taking place within 6 hours after ovulation.

45. One pregnant mare gave oestral indications 17 days after service, another 37 days after service. The psychological manifestations of heat were distinct, but, not excessive, and disappeared by the second day in both instances.

46. Foetal migration is found of common occurrence. In 5 out of 9 mares where ovulation occurred in the left ovary, implantation took place in the right horn of the uterus. In 4 out of 9 mares where ovulation occurred in the right ovary implantation took place in the left horn of the uterus. Out of a total of 20 conceptions implantation is found to occur in 12 cases in the right horn of the uterus and 8 in the left horn of the uterus.

47. The average length of gestation is found to be 337 days with a variation from 316-357 days. The length of gestation in relation to the month of foaling shows a tendency to differ,

early/.....

early spring foaling having a shorter gestational period than summer foaling. No conclusion is possible as the number of mares is too small and other factors cannot be excluded. The length of gestation in relation to the sex of the foal proved identical and is on the average 337 days.

48. The value of the Caslick operation is discussed. It is employed after intra-uterine treatment has been applied in the non-pregnant mare, as well as during early pregnancy. There is no doubt that it is of value in treating certain cases of infertility.

49. Prenatal death was diagnosed in several mares. In one mare the foetus had developed sufficiently to stimulate gonadotrophin production. After the 78th day of pregnancy no trace of the conceptus could be detected by rectal palpation, but the Ascheim-Zondek blood test remained positive to the 130th day and became suspicious on the 144th day.

50. Two mares had a palpable foetus 46-50 days after service before losing it. They failed to develop serum gonadotrophin and were negative to the blood test. One of these mares, brought back to oestrus with hormone treatment, conceived and carried her foal successfully. The diagnosis of early foetal death in the other mare was done after the breeding season had closed, and she was consequently not bred.

51. Two mares failed to indicate any foetal development in the uterus, but had all the other signs of pregnancy. The blood test performed on the 46th and 48th day respectively proved negative. Both mares were returned to oestrus with hormone treatment and served. One mare conceived and carried her foal successfully.

52. Early foetal death is a recognised phenomenon in the Karroo Midlands and several factors are suggested which may play a role in its causation. Defective germ plasma, faulty nutritional environment either by sub-involution of the uterus or failure of endometrial secretions, genital or systemic infections or ingestions

of/.....

of poisons may all contribute to very early foetal death. High oestrogen content of the vegetation and its abortifacient action during certain stages of pregnancy, is a possibility that cannot be ignored. Failure of the foetus to cause or stimulate the production of gonadotrophin may play a role, as well as the transition period when the gonadotrophin disappear from the blood and the oestrogen level rises. Habitual abortion and threatened abortion have been checked by the use of progesterone.

53. The modified Ascheim-Zondek test performed on blood collected between the 40th and 52nd day after the last service proved 100% accurate in 27 samples collected from 24 mares, making allowance for the knowledge of the foetal death in one mare. If this positive test be regarded as an error in the test, the percentage accuracy becomes 96.3%. It is suggested that where the test gives a positive reading and the mare subsequently proves barren that early foetal death has occurred.

54. Out of 24 mares mated 19 became pregnant and carried their foals giving a fertility figure of 79.2%. Three mares died from Horsesickness during March, 1953. Two of these mares were in foal.

55. It is concluded that the variations in the oestrous behaviour of the Thoroughbred mares are to be regarded as indicating a transition stage from the monoestrus to the polyoestrus, confined within a definite season, the outer limits of which vary according to ecological, neurological and hormonal factors.

56. The usual theories on endocrine interactions are discussed. It is concluded that they do not constitute a completely satisfactory explanation of the sexual behaviour of the Thoroughbred mare. Another hypothesis on hormonal control of the oestrous cycle is advanced which incorporates the various phenomena observed. It would appear as if the hormone Progesterone plays a dominant role in the regulation and control of the reproductive cycle.

S U M M A R Y

The history, growth and present development of the Thoroughbred industry of South Africa are described. The reasons for the establishment of Thoroughbred studs in the Karroo Midlands are discussed.

A study is made of various psychological, physiological and ecological factors in relation to breeding results. The data on oestrus, ovulation, pregnancy and related phenomena were obtained at the Askania Nova Stud, Middelburg, Cape, between 9th September, 1952 and 7th March, 1953, and are the results of observations combined with consistent rectal and vaginal examinations carried out on 27 Thoroughbred mares.

Management of the stud is described and data are presented recording observations on the oestrous cycle and its hormonal control, with details on the application of various endocrine substance, treatments and surgical interventions in the correction of irregularities of the cycle. The hormonal control of the oestrous cycle is reveiwed and another theory proposed.

Information is also presented on some aspects of pregnancy, including the occurrence of foetal migration and foetal death. These findings are discussed.

A C K N O W L E D G E M E N T S

The author is greatly indebted to the Director of Veterinary Services (and animal Industry), Dr. R.A. Alexander, for the many facilities granted in conducting these investigations, and to Dr. S.W.J. van Rensburg, and Dr. N.C. Starke for constant advice and guidance in all phases of the study.

Sincere appreciation is expressed to Mr. G.A. Kramer, owner of Askania Nova Stud, Middelburg, Cape, for authorising the investigations on his extremely valuable Thoroughbred Stud during the breeding season of 1952. To Mr. W. Lister, Manager and Studmaster of Askania Nova grateful thanks are due for his co-operation and assistance during the performance of the work.

Thanks are extended to the Jockey Club and Thoroughbred Breeders Association of South African for the granting of an overseas Scholarship during 1950, which made this study possible, and to Dr. G. Pfaff, Secretary of the Jockey Club of South Africa for his unfailing interest and assistance at all times.

In conclusion the author wishes to convey his particular indebtness and thanks to Dr. John Quinlan, formerly Professor of Surgery and Gynaecology, Onderstepoort, for his stimulating and constructive guidance in the presentation of this work.

R E F E R E N C E S.

Acocks, J.P.H. (1953). Veld Types of South African Botanical Survey of S.A. Memoir No. 28, Govt. Printer, pp. 1-192.

Acocks, J.P.H. (1947). Personal communication.

Aehnelt, E., and Plas, J. (1946). Zeitpunkt der ersten Ovulation bei Fohlen Stuten. Dtch. tierärztl. Wschr., Vol. 53, pp. 10-14.

Aehnelt, E., and Plas, J. (1946). Der Einfluss der Jahreszeit auf Rosse. Ovulation und Befruchtung. Dtch. Tierärztl. Wschr., Vol. 84. Quoted Götze, 1949.

Aehnelt, E., and Plas, J. (1946). Ovulation und Befruchtung bei Stuten. Dtch. tierärztl. Wschr. Vol. 53, pp. 52-57.

Aehnelt, E., and Plas, J. (1946). Mehrzystische Veränderungen an den Eierstöcken von Stuten. Dtsch. tierärztl. Wschr., Vol. 34.

Aitken. W.A. (1927). Some observations on the Oestrus Cycle and Reproductive Phenomena of the Mare. Am. J. Vet. Assoc., Vol. 70, No. 23, pp. 481-491.

Andrews, F.N., and McKenzie, F. (1939). The Estrual Cycle of the Mare. Proc. Am. Soc. An. Prod., Vol. 32, pp. 365-369.

Andrews, F.N., and McKenzie, F. (1941). Estrus, Ovulation and Related Phenomena in the Mare. Res. Bull. 329. Univ. Missouri.

Amoroso, E.G., Hancock, J.L., and Rowlands, I.W. (1948). Ovarian Activity in the Pregnant Mare. Nature, Vol. 161, p. 355.

Amoroso, E.C., and Rowlands, I.W. (1951). Hormonal effects in the pregnant mare and foetal foal. J. Endocrin. Vol. 7, No. 4, pp. L-Llll.

Amoroso, E.C. (1955). Hormone Control of the Oestrous Cycle. Vet. Rec., Vol. 67, No. 50. pp. 1072-1084.

Anderson, J. (1941). Report on the Biological Urine Test for the Diagnosis of Pregnancy in the Mare. Vet, Rec., Vol. 53, pp. 251-252.

Ascheim and Zondek (1928). Schwangerschafts-diagnose aus dem Harn. Arch. f. Gynäkol CXXX, 1. Quoted by Cole and Hart (1930).

Asdell, S.A. (1946). Patterns of Mammalian Reproduction. Comstock Publishing Co., Inc. Ithaca, N.Y.

Astwood, E.B. (1939). Amer. J. Physiol., Vol. 126, p. 162. Quoted Amoroso, 1955.

Barulin, K., Burcenko, E., and Popov, A. (1936). The Vaginal Method of Pregnancy Diagnosis. Probl. Zevotu. Vol. 8, pp 42-53 An. Breed Abstr. (1937), Vol. 5, No. 9.

Barulin, K.I. (1939). Racion. Kornil. Ispoljz Provizvod, s-h. Zitvorn, pp. 95-100. Quoted Asdell, 1946.

Basov, A.F./.....

Basov, A.F. (1935). The influence of acclimatisation on fertility of imported mares. Trud. Sevkavkaz. Stanc Knonevod., Vol. 3, pp. 38-45. An. Breed. Abstr. (1936). Vol. 4, pp. 283.

Beach, F.A. (1948). Hormones and Behaviour. Paul B. Hoeber, Inc., New York.

Bekker, J.I. (1932). Studies in Mineral Metabolism XXIII. Phosphorous and Iodine Supplements in Field Experiments with Sheep. 18th Rept. Dir. of Vet, and An. Ind., Union of South Africa.

Belonje, C.W.A. (1949). Observations on Reproduction in the Thoroughbred in Middelburg and Colesberg Districts. S.A. Bloodstock Breeders Review 1949. A.P.B. Bookstore, Johannesburg.

Belonje, C.W.A. (1949). Observations on Reproduction in the Thoroughbred Mare. Jl. S.A.V.M.A., Vol. 20, No. 1 pp 21-32.

Belonje, C.W.A. (1951). Some Diseases Associated with Breeding of Horses. Part I. Jl. S.A.V.M.A., Vol. 22, No. 4, pp. 203-207.

Belonje, C.W.A. (1952). Some Diseases Associated with Breeding of Horses. Part II. Jl. S.A.V.M.A., Vol. 23, No. 1 pp. 27-42.

Belonje, C.W.A. (1956). The Influence of Running a Stallion with non-pregnant Thoroughbred Mares. Jl. S.A.V.M.A. Vol. 27, No. 1, pp. 57-60.

Berliner, V.R., and Scales, J.W. (1944). Effects of Stilboestrol on Estrus of Mares. J. Anim. Sci., Vol. 3, pp. 431-432.

Berliner, V. (1945). The Artificial Insemination of Farm Animals. Rutger Univ. Press. New Brunswick.

Berthelon, M., and Tournut, J. (1948). Abortion provoked by Oestrogens. Rev. Med. Vet., Lyons et Toulouse. Vol. 99, pp. 49-67.

Bielánsky, W., and Ewy, Z. (1951). The effect of Oestrogens on the reproductive functions of the Stallion. Acta endocrinol, Vol. 6, pp. 272-284.

Blakeslee, L.H., and Hudson, R.S. (1942). Twinning in Horses. J. Anim. Sci. Vol. 1, pp. 155-158.

Bloodstock Breeders Review (1950). Fertility of Stallions 1948/49. S.A. Bloodstock Breeders Review (1950). A.P.B. Bookstore, Johannesburg.

Bloodstock Breeders Review (1951). Fertility of Stallions 1949/50. S.A. Bloodstock Breeders Review (1951). A.P.B. Bookstore, Johannesburg.

Bloodstock Breeders Review (1951). Value of Stakes 1904-1951. S.A. Bloodstock Breeders Review 1951. A.P.B. Bookstore, Johannesburg.

Botha, J.P. (1938). The digestibility and nutritive value of Karroo pasture plants. Farming in S.A., No. 8.

Boyd, J.D., Hamilton, W.J., and J. Hammond, Jr. (1944). Trans-uterine migration of the ovum. J. Anat. Vol. 78, pp.5-14.

Burkhardt, J. (1947). Anoestrus in the mare and its treatment with oestrogen. Vet. Rec. Vol. 59, No. 26, pp. 341-342.

Burkhardt, J./.....

Burkhardt, J. (1947). Transition from anoestrus in the mare and the effects of artificial lighting. J. Agric. Sci. Vol. 37, pp. 64-68.

Burkhardt, J. (1948). Some Clinical Problems of Horse Breeding. Vet. Rec. Vol. 60, No. 21, pp. 243-248.

Burkhardt, J. (1948). Sperm Survival in the Genital Tract. of the Mare. J. Agric. Sci. Vol. 39, No. 2, pp. 201-203.

Burrows (1945). Biological Action of Sex Hormones. Cambridge Univ. Press.

Cape Times (1952). South Africa's £4,000,000 Stud Farming Industry 17.10.52.

Carroll, W.B. (1945). J. Endocrin. Vol. 36, p. 266. Quoted Amoroso, 1955.

Caslick, E.A. (1937). The Sexual Cycle of the Mare. Cornell Vet. Vol. 27, No. 2, pp. 187-206.

Caslick, E.A. (1937). The Vulva and the Vulvo-vaginal orifice and its relation to genital health of the Thoroughbred Mare. Cornell Vet. Vol. 27, No. 2, pp. 178-187.

Catchpole, H.R. and Lyons, W.R. (1934). The gonadstimulating hormone of pregnant mares. Am. J. Anat. Vol. 55, p. 167.

Clark, R. (1949). Results abtained with the modified Ascheim-Zondek Pregnancy Test on Mares. Jl. S.A.V.M.A., Vol. 20, No. 1, pp. 39-41.

Cole, H.H., and Hart, G.H. (1930). The potency of blood serum of mares in progressive stages of pregnancy in effecting the sexual maturity of the immature rat. Am. J. Phys. Vol. 93, pp. 57-68.

Cole, H.H., Howell, C.E., and Hart, G.H. (1931). The Changes occurring in the Ovary of the mare during pregnancy. Anat. Rec. Vol. 49, No. 3, pp. 199-209.

Cole, H.H., Hart, G.H. Lyons, W.R., and Catchpole, H.R. (1933). The development and hormonal content of fetal horse gonads. Anat. Rec. Vol. 56, pp. 275-293.

Cole, H.H., and Saunders, F.J. (1935). The concentration of Gonad stimulating Hormone in Blood serum and of Oestrin in the Urine throughout pregnancy in the Mare. J. Endocrin. Vol. 19, pp. 199-208.

Cole, H.H. (1938). High Gonadotropic hormone concentration in Pregnant Ponies. Proc. Soc. Expt. Biol. and Med. Vol. 38, pp. 193-194.

Cole, H.H., and Hart, G.H. (1942). Diagnoses of pregnancy in the mare by Hormonal means. J.A.V.M.A. Vol. 101, p. 124.

Cole, H.H., and Goss, H. (1943). The Source of equine gonadotrophin. Essays in biology in honour of Herbert M. Evans. Berkely and Los Angeles. Univ. of Calif. Press, pp. 105-119.

Cole, H.H. Pencharz, R.I., and Goss, H. (1940). On the biological properties of highly purified gonadotrophin from pregnant mare serum. J. Endocrin. Vol. 27, pp. 548-553.

Constantinescu, G.K./...

Constantinescu, G.K., and Mauch, A. (1936). Untersuchungen über das Sexual leben der Stuten. Annals de l' Institute National Zootechnique de Roumanie. Vol. 5, pp. 9-82.

Courrier, R. (1930). Structure et histophysiologie de l' appareil génital femelle. Encyc. Méd. Chirurg. 2nd ed. 6, Cap. 2 (17-42). Quoted Hammond and Wodzicki (1941).

Cronin, M.T.I. (1952). The Characters of Streptococci isolated from the uteri of Thoroughbred Mares in Ireland. J. Comp. Path. and Therap. Vol. 62, No. 4, pp. 260-265.

Crowhurst, R.C., and Caslick, W. (1946). Some observations on Equine Practice and its Relation to the Breeding of Thoroughbred Mares. North. Am. Vet. Vol. 27, pp. 761-766.

Cummings, J.N. (1942). A Study of Estrus and Ovulation in the Mare. J. Animal Sci. Vol. 1, pp. 309-313.

Davison, W.F. (1947). The Control of Ovulation in the Mare, with reference to insemination with Stored Semen. J. Agric. Sci. Vol. 37, No. 4, pp. 287-290.

Day, F.T. (1939). Sterility in the Mare associated with Irregularities of the Oestrus Cycle. Vet. Rec. Vol. 36, No. 51, pp. 1113-1119.

Day, F.T. (1939). The oestroes cycle of the Mare following removal of the Foetus at various stages of Pregnancy. J. Agric. Sci. Vol. 29, No. 3, pp. 470-475.

Day, F.T. (1939). Ovulation and the descent of the Ovum in the fallopian tube of the mare after treatment with gonadotrophic hormones. J. Agric. Sci. Vol. 29, No. 3, pp. 459-469.

Day, F.T. (1940). Clinical and Experimental Observations on Reproduction in the Mare. J. Agric. Sci. Vol. 30, No. 2, pp. 244-261.

Day, F.T. and Rowlands, I.W. (1940). The time and rate of appearance of gonadotrophin in the serum of pregnant mares. J. Endocrin. Vol. 2, pp. 255-261.

Day, F.T. and W.M. C. Miller (1940). A comparison of the efficiency of methods of diagnosing equine pregnancy, with special reference to the mucin test. Vet. Rec. Vol. 52, No. 40, pp. 711-716.

Dempsey, E.W., Meyers, H.J., Young, W.C., and Jennison, D.B. (1934) Amer. J. Physiol. Vol. 109, p. 307.

Dempsey, E.W., Rioch, D. McK. (1939). J. Neurophysiol. Vol. 2, p. 9 Quoted Amoroso, 1955.

De Croutte. (1937). Practical methods of Combatting Sterility in the Mare. Rev. Zootech. Vol. 8, pp. 99-109.

Deubler, M.J. (1952). Observations of the Routine Use of Cervical Cultures in Mares. Vet. Med. Vol. XLVII, No. 5, pp. 182-184.

Dimock, W.W., and Good, E.S. (1927). Studies on Abortion in Mares. Am. Vet. Med. Ass. J., Vol. 7, No. 25.

Dimock, W.W., and Edwards, P.R. (1928). Pathology and Bacteriology of the Reproductive Organs of Mares in Relation to Sterility. Kentucky. Agric. exp, Sta. Bull. 286.

Dimock, W.W./.....

Dimock, W.W., and Edwards, P.R. (1932). Infections of Fetuses and Foals. Kentucky Agric. exp. Sta. Bull. 333.

Dimock, W.W., Edwards, P.R. and Bruner, D.W. (1942). Equine Abortion Virus. Kentucky Agric. exp. Sta. Bull. 426.

Dimock, W.W. and Bruner, D.W. (1949). Barren Broodmares. Kentucky Agric. exp. Sta. Cir. 63.

Dimock, W.W. (1947). Early Clinical Examination of Mares for Pregnancy. Kentucky Agric. exp. Sta. Cir. 61.

Dukes, H.H. (1947). The Physiology of Domestic Animals. Ithaca, N.Y. 6th ed.

Du Toit, P.J. and Bisschop, J.H.R. (1929). The Breeding of Cattle on Phosphorus Deficient Veld. 15th Rept. Dir. Vet. Serv. Union of South Africa, pp. 1059-1166.

Du Toit, P.J., Malan, A.I., Louw, J.G., Holzapfel, C.R. and Roets, G.C.S. A study of the Mineral Content and Feeding Value of Natural Pastures in the Union of South Africa. 1st Report (1932) 18th Rept. Dir. Vet. Serv. and An. Ind., pp. 525-577. 2nd Report (1934) Onderstepoort Jour. Vet. Sci and An. Ind., Vol. 2, No. 2 pp. 607-648. 3rd Report (1935) Onderstepoort Jour. Vet. Sci. and An. Ind., Vol. 5, No. 1, pp. 201-214.

Du Toit, P.J., Louw, J.G. and Malan, A.I. (1935). 4th Report (1935). The influence of season and frequency of cutting on the yield, persistency and chemical composition of grass species, Onderstepoort Journ. Vet. Sci. and An. Ind. Vol. 5, No. 1, pp. 215-270.

Du Toit, P.J., Louw, J.G. and Malan, A.I. (1940). Final Report. A Study on the Mineral Content and Feeding Value of Natural Pastures in the Union of South Africa. Onderstepoort Jour. Vet. Sci. and An. Ind. Vol. 14, No. 1 and 2, pp. 123-327.

Dutt, R.H. (1953). Induction of Estrus and Ovulation in anestrual ewes by use of progesterone and pregnant mare serum. J. Anim. Sci. Vol. 12, pp. 515-523.

Edgar, D.G. (1953). The Progesterone content of body fluids and tissues. J. Endocrin. Vol. 10, p. 54.

Ellenberger und Baum (1932). Handbuch der Vergleichende Anatomie der Haustiere. Hanover.

Errington, B.J. (1942). Equine Twin Placentation. Cornell Vet. Vol. 32, pp. 367-380.

Everett, J.W., Sawyer, C.H. and Markee, J.E. (1949). J. Endocrin. Vol. 44, p. 234. Quoted Amoroso, 1955.

Ewart, J.G. (1915). Studies on the development of the Horse. 1. Development during the third week. Trans. Roy. Soc. Edinburgh, Vol. 51, p. 287. Quoted Catchpole and Lyons 1934.

Easterbrooks, H.L. and Plastridge, W.N. (1950). Intra-uterine antibiotic treatment of vibrionic sterility in Dairy Cows. J.S.A.V.M.A. Vol. 117, p. 388.

Foster/.....

Foster, M.A. (1934). Amer. J. Anat. Vol. 54, p. 487. Quoted Amoroso, 1955.

Ganz, O. (1939). Untersuchungen über den Zyklus der Stuten v. Beitrag: Eierstöcke und Gebärmutter. Diss Hanover. Dtsch. tierärztl. Wschr. (1940). Vol. 48, No. 30.

Gonzaga, A.C., and Ebora, P.M. (1936). The occurrence of estrum in pregnant mares. Phillipp. J. Anim. Industr. Vol. 3, pp. 19-23. An. Breed. Abstr. (1936). Vol. 4, p. 284.

Götze, R. (1935). Rosse und Unfruchtbarkeit der Stuten. Dtsch. tierärztl. Wschr. Vol. 43, pp. 161-163.

Götze, R. (1949). Besamung und Unfruchtbarkeit der Haus säugetiere. Hanover.

Groenewald, J.W. (1951). Mineral and Trace Element Requirements of Animals in South Africa. J.l. S.A.V.M.A. Vol. 22, No. 2, pp. 53-61.

Groenewald, J.W. (1952). Die Voer van Plaasvee. Onderstepoort, Suid-Afrika.

Haard, J. (1946). Die pappilla uterina des Pferdes ausserhalb und während der Rosse. Dias Hanover. Quoted Götze 1949.

Hamilton, W.J. and Day, F.T. (1945). Cleavage Stages of the ova of the Horse with notes on ovulation. J. Anat. Vol. 79, No. 127.

Hammond, J., and Marshall, F.H.A. (1925). Reproduction in the Rabbit. Oliver and Boyd, Ltd., London.

Hammond, J., and Marshall, F.H.A. (1930). Proc. Roy. Soc., Ser. B. Vol. 105, p. 607.

Hammond, J. (1938). Proc. Physiol. Congr., Moscow. In Sechenov. J. Physiol. U.S.S.R., Vol. 21, pp. 193-194. Quoted Asdell, 1946.

Hammond, J. (1938). Recent Scientific Research on Horse Breeding Problems. Trans. Yorks. Agric. Soc., Vol. 95, No. 11.

Hammond, J., and Wodzicki, K. (1941). Anatomical and Histological Changes during the Oestrus Cycle in the Mare. Proc. of Royal Soc. of London Series B. Vol. 858, No. 130, pp. 1-23.

Hancock, J.L. (1948). Notes on Oestrus, Ovulation and Pregnancy in the Mare. Vet. Rec. Vol. 60, No. 52, pp. 679-682.

Hansel, W. and Trimberger, G.W. (1952). The effect of progesterone on ovulation time in dairy heifers. J. Dairy Sci. Vol. 35, pp. 65-70.

Hansson, A. (1947). Acta. Zool. Vol. 28. Quoted Amoroso, 1955.

Harada, N., and Nishikawa, Y. (1951). Studies on the Artificial Induction of Ovulation in the Horse. On the Effect of the injection of Stilboestrol on ovulation in rabbits and horses. An. Breed. Abstr. Vol. 20, No. 1, p. 56.

Harrison, R.J. (1946). Early development of corpis luteum in Mare. J. Anat. Vol. 80, pp. 160-166. Quoted Rowlands 1949.

Hart/.....

Hart, G.H., and Cole, H.H. (1934). The Source of Oestrin in the Mare. An. J. Phys. Vol. 109, pp. 320-323.

Heape, W. (1900). The Sexual Season of Mammals and the Relation of the Pro-estrum to Menstruation. Quar. J. Micr. Sc. No. 183, pp. 1-70.

Heer, R. (1939). Untersuchungen über der Zyklus der Stute II. Eierstöcke und Gebärmutter. Diss. Hanover. Dtsch. tierärztl. Wschr. (1940). Vol. 48, p. 173.

Henning, M.W. Keppel, J.J.G. and Flight, C.H. (1943). Equine abortion. J.l. S.A.V.M.A. Vol. 14, No. 2, pp. 59-66.

Henning, M.W. (1945). On the Etiology of Epizootic or Infectious Equine Abortion. Onderstepoort Jl. of Vet. Sci. An. Ind. Vol. 21, No. 1, pp. 17-40.

Henning, M.W., and McIntosh, B.M. (1946). An Outbrek of Tendo-Vaginitis and Bursitis due to Salmonella Abortus-Equi. Jl. S.A.V.M.A. Vol. 17, No. 2, pp. 88-91.

Henning, M.W. (1949). Animal Diseases in South Africa. Central News Agency, South Africa.

Henning, M.W. (1953). Personal communication.

Henrici, M. (1928). The phosphorus content of the grasses of Bechuanaland in the course of their development. 13th and 14th Repts. Dir. Vet. Ed. and Res. pp. 1077-1028.

Henrici, M. (1932). An investigation of the content of phosphorus, calcium and protein of grasses in the coastal region of Natal and Southern Zululand. Agri. Sci. Bull. No. 115, South Africa.

Henrici, M. (1935). Fodder Plants of the Broken Veld. Part I. Agric. Sci. Bull. No. 142, South Africa.

Henrici, M. (1940). Fodder Plants of the Broken Veld. Part II. Agric. Sci. Bull. No. 213, South Africa.

Henrici, M. (1945). Digestion experiments with fresh Karroo Plants. South African Jl. Sci. Vol. 41, pp. 213-217.

Herrick, J.B. (1953). Clinical Observation of Progesterone therapy in repeat breeding heifers. Vet. Med. Vol. 48, pp. 489-490.

Hoshi, H. (1939). Studies on the ovaries of the Mare. I. The Anatomical investigation of the ovarian changes in Sexual Cycles. Jap. J. Vet. Sci. Vol. 1, pp. 349-375. An. Breed. Abstr. 1940, Vol. 8.

Hesse, E. (1939). Über den Hormon gehalte der Hohlraumflüssigkeit in Ovarien nymphomaner Stuten. Berl. Münch. tierärztl. Wschr, p. 609.

Hetzel, H. (1938). Die Numphomanie der Stuten. Tierärztl. Rdsch. Vol. 44, pp. 681-685 and pp. 697-702.

Jennings, Wm. E. (1941). Some Common Problems in Horsebreeding. Cornell. Vet. Vol. 31, pp. 197-216.

Jockey Club of South Africa. (1949). The General Stud Book of S.A. Rules and Procedure. June, 1949.

Jockey Club/.....

Jockey Club of South Africa. (1952). The General Stud Book Vol. 16.

Jordão, L.P., De Camargo, M.X., and Gouveia, P.F. (1950). Reproductive efficiency of the Mangalarga Stock at the são Paulo State Stud. Bol. Industr. Anim. 11 (¾), No. 52, p. 80.

Kedrov, V.K. (1939). Activity of Ovaries and frequency of Pregnancy in the Uterine Horns of the Mare (Russian) Dokl. Akad. selzskohoz, Nank. 2/3, pp. 65-67. An. Breed. Abstr. 1939, Vol. 7, pp. 101.

Kedrov, V.K. (1944). Insemination of Mares after Ovulation. Sovhoz. Proizyod 3: 33-35. An. Breed. Abstr. 1945, Vol. 13, No. 131.

Kimura, J., and Lyons,W.R. (1937). Progestin in the Pregnant Mare. Proc. Soc. Exp. Biol. N.Y. Vol. 37, p. 423.

Köber, S. (1938). Über die Auscheidung deur Oestrogene Stoffe im Harn trächtiger Stute. Arch. int. Pharmacodyn 59: 61-67. Anim. Breed. Abstr. 1939, Vol. 7 pp. 211-212.

Kolster, R. (1901-2). Anatomische-Hefte. Band 18: Heft 2, 457. Quoted Cole and Hart (1930).

Krampe, A. (1936). The Unfruchtbarkeit bei Stuten und ihre Bekämpfung in der Landesbauern Schaft. Sachsium-Anhalt. Dtsch. Landw. Tierz. Vol. 40, pp. 21-23.

Kurosawa, R. (1931). Uber die Früh diagnose der Trächtigkeit bei der Stute durch Vaginale Untersuching ins besondere durch Untersuchung von Scheiden schleim.
(a) Tierarztl. Rundschau, Vol. 37, No. 20, pp. 345 - 349 Teil I;
(b) Tierarztl. " No. 21, pp. 361-365. Teil II.

Küpfer, M. (1928). The ovarian changes and the periodicity of oestrum in donkey and horse. 13th and 14th Rept. Vet. Res. S. Afri. Part 2, pp. 1211-1270.

Koroljkov, A.G. (1951). Twins in horsebreeding. Konevodstvo 1951 (3) 20-22. Anim. Abstr. Vol. 19, No. 4, p. 1559.

Lagerlöf, N. (1936). Notes on heat, ovulation and mating in the mare. Svenak. Vet. Tidskr. 41: 173- An. Breed. Abstr. 1938, Vol. 6, No. 6.

Legg, S.P., Curnow, D.H., and Simpson, S.A. (1950). The Seasonal and Species Distribution of Oestrogen in British Pasture Plants. Biochem. J. Vol. 46, No. 4, pp. 19-20.

Lehndorff, Graf (1925). Handbuch für Pferde züchter. 7, Auflage, Berlin.

Lichtenstein, H. Reisen in Südlichen Afrika. 1798-1806. Quoted Schreuder 1915.

Louw, J.G. (1938). The influence of frequency of cutting on the Yield, chemical composition, digestibility and nutritive value of some grass species. Onderstepoort Jl. Vet. Sci. and An. Ind. Vol II, pp. 163-244.

Louw, J.G. (1941). Digestibility of the Constituents of the Carbohydrate Complex of Grasses. Onderstepoort Jl. Vet. Sci. and An. Ind. Vol. 17, No. 1 and 2, pp. 165-179.

Llewellyn, L.M./.....

Llewellyn, L.M. and Enders, R.K. (1954). J. Mammal. Vol. 30, p. 440. Quoted Amoroso, 1955.

Mahaffey, L.W. (1950). Studies on Fertility in the Thoroughbred Mare. I. Aust. Vet. Jnl. Vol. 26, No. 11, pp. 295-300.

Mahaffey, L. (1952). Studies on Fertility in the Thoroughbred Mare. II. Aust. Vet, Jl. Vol. 28. No. 3, pp. 53-71.

Marrion, G.G., Smith, Y.R., Wiley, T.E., and Barratt, G.R. (1950). J. Dairy Sci. Vol. 33, p. 391.

Marshall, F.H.A. and Hammond, J. (1949). Fertility and Animal Breeding. Ministry of Agric. and Fishery. Bull. 39, 6th ed.

Marshall, F.H.A., and Verney, E.B. (1936). J. Physiol. Vol. 86, p. 327.

Mauch, A. (1937). Untersuchungen über die Trachtigkeitsdauer der Stuten Z. Zucht. Vol. 39, pp. 31-42.

McKenzie, F.F. and Andrews, F.N. (1937). Estrus and Ovulation in the Mare. Proc. Am. Soc. An. Prod. Vol. 30. pp. 64-70.

McKenzie, F.F., and Andrews, F.N. (1938). Variation in Estrus and Ovulation in the Mare. Proc. Am. Soc. Anim. Prod.

McKenzie, F.F. (1940). Recent reproductive studies on Equines. Proc. Am. Soc. Anim. Prod. 33rd Ann. Meet. pp. 98-102.

Millar, R. (1952). Forces observed during coitus in Thoroughbreds. Aust. Vet. Jl. Vol. 28, No. 5, p. 127.

Millar, R. (1952). Observations on the Bacterial Flora of the Vulvo-Vaginal Tract of Mares. Aust. Vet. Jl. Vol. 28, No. 7, pp. 171-173.

Miller, Wm. C., and Day, F.T. (1939). The Diagnosis of Equine Pregnancy. J. Roy. Army Vet. Corps. May, 1939, pp. 95-105.

Mirskaya, L.M., and Salzmann, A.A. (1935). Heat and ovulation in the Mare (Russian). Usp. zootch. Nank. 1, pp. 157-168. An. Breed. Abstr. (1936). Vol. 4, No. 285.

Mirskaya, L.M., Kedrov, V.K., and Lihacev, A.M. (1936). Probl. Zivotu 3: 66-76. An. Breed. Abstr. 1940, Vol. 8, No. 15.

Mirskaya, L.M., and Petroplavlovsky, V.V. (1938). Reduction of the normal duration of heat in the Mare by aid of Prolan. Cornell. Vet. Vol. 28, pp. 58-61.

Moore, W.W. and Nalbandov, A.Y. (1953). Neurogenic effects of uterine distention on the estrous cycle of the ewe. Jl. Endocrin. Vol. 53, pp. 1-11.

Moore, G.R. (1954). Infections of the Bovine Tubular Genitalia. Vet. Med. Vol. XLIX, No. 2, pp. 63-65.

Morrison, F.B. (1950). Feeds and Feeding 21st Ed., Ithaca, N.Y.

Nishikawa, Y. Harada, N., and Sugi, T. (1952). Studies on the Effect of Continuous Injections of Stilboestrol on the functions of Ovaries in Mares. Rept. Int. Congr. Phys. and Path. An. Prod. Vol. 1m pp. 173-179.

Oettingen B./.....

Oettingen, B. von (1918). Die Pferdezucht. Berlin.

Pearson, O.P. (1944). Amer. J. Anat. Vol. 75, p. 39. Quoted Amoroso, 1955.

Peck, K.G. (1952). Infertility in Mares. Vet. Med. Vol. XLVII, No. 9 pp. 359-363.

Petropavlovskii, V. (1938). Prolan as a means of reducing the duration of heat in Mares. Konevodstvo 3, pp. 21-26. (Russian). An. Breed. Abstr. (1941). Vol. 9, p. 206.

Pfaff, G. (1953). Incidence of Conception of the Thoroughbred Mare in S.A. Personal communication.

Quinlan, J., Maré, G.S. and Roux, L.L. (1932). The Vitality of the Spermatozoon in the Genital Tract of the Merino Ewe. 18th Rept. Dir. of Vet. Serv. and An. Ind. No. 2, pp. 831-870.

Quinlan, J., and Roux, L.L. (1936). Researches into Sterility of Cows in S.A. Onderstepoort J. Vet. Sci. An. Ind. Vol. 6, No. 2, pp. 719 - 772.

Quinlan, J. and Riemerschmid, G. (1941). A preliminary note on the Temperature of the Scrotal Skin of the Bull. Onderstepoort Jour., Vol. 16, No. 1 and 2, pp. 299-312.

Quinlan, J., Bisschop, J.H.R. and Adelaar, T.V. (1941).. The ovarian cycle of heifers during Summer. Onderstepoort J. Vet. Sci. and Anim. Ind., Vol. 16, No. 1 and 2, pp. 213-235.

Quinlan, J. (1946). The Mating of Mares. South African Bloodstock Breeders Review, A.P.D. Bookstore, Johannesburg.

Quinlan, J. van Rensburg, S.W.J., Steyn, H.P. (1951). The oestrus cycle of the mare when maintained under stable conditions with restricted exercise at Onderstepoort. Onderstepoort J. Vet. Sci. An. Ind. Vol. 25, No. 1, pp. 105-119.

Quinlan, J. (1952). Racing and Breeding. Classic Publishers (Pty) Ltd., Cape Times Ltd., Cape Town.

Quinlan, J. (1956). Personal communication.

Riemerschmid, G. and Quinlan, J. (1941). Scrotal Skin Temperature of the Bull. Onderstepoort Jl. Vol. 17, No. 1 and 2, pp. 123-140.

Robertson, A.L. (1945). Historical Survey of the Turf in South Africa. S.A. Bloodstock Breeders Review 1945 A.P.B. Bookstore, Johannesburg.

Robertson, J.B. (1912). Fertility in the Thoroughbred Horse. The Bloodstock Breeders Review. The British Bloodstock Agency Ltd., London.

Robson, J.M. (1947). Recent Advamces in Sex and Reproductive Physiology 3rd ed. The Blakeston Co., Philadelphia, Toronto.

Robson, J.M. and Adler, J. (1940). Site of Action of Oestrogens. Nature, Vol. 146, p. 60.

Roux, L.L. (1936). Sex Physiology of Sheep. Onderstepport J. Vet. Sci. An. Ind., Vol. 6, No. 2, pp. 465-717.

Rowlands/.....

Rowlands, I.W. (1949). Serum gonadotrophin and Ovarian Activity in the Pregnant Mare. J. Endocrin. Vol. 6, pp. 184-191.

Rowson, L.E.A., Lamming, G.E., and Fry, R.M. (1953). The relationship between ovarian hormones and uterine infections. Vet. Rec. Vol. 65, p. 335.

Salzmann, A.A. (1936). Studies on the Sexual Cycle of the Mare (Russian). Konevodstvo 6: 28-33. An. Breed. Abstr. Vol. 4, No. 4. pp. 405-406.

Salzmann, A.A. (1939). Insemination of Mares after Ovulation (Russian). Sovetsk. Zootch. 4: 77-80. An. Breed. Abstr. 1940, Vol. 8.

Samodelkin, P.A. (1939). Service of Mares with reference to Ovarian Changes (Russian). Voprosy. Plodov. Rabotosp Lösad. Moscow: Selzhozgiz 22-28. An. Breed. Abstr., 1940, Vol. 8.

Satoh, S., and Hoshi, S. (1932). A study of Reproduction in the Mare. 1. J. Jap. Soc. Vet. Sci. Vol. 11, p. 257.

Satoh, S., and Hoshi, S. (1933). A study of Reproduction in the Mare. 2. J. Jap. Soc. Vet. Sci. Vol. 12, pp. 200-223.

Satoh, S., and Hoshi, S. (1934). Studies on the Reproduction in the Mare. 3. The Oestrus duration and Oestrus Cycle. J. Jap. Soc. Vet. Sci. Vol. 13, pp. 237-250.

Satoh, S., and Hoshi, S. (1938). Researches on Reproduction in Mares. 4. Periodic changes in vulva, vagina and cervix. J. Jap. Soc. Vet. Sci. Vol. 17, pp. 89-109.

Satoh, S. and Hoshi, S. (1939). Studies on the reproduction in the Mare. 4. On the Act of Mating. Jap. J. Vet. Sci. Vol. 1, pp. 489-511. An. Breed. Abstr., 1940, Vol. 8.

Schmaltz, R. (1911). Die struktur der Geschlechts organe Haussäugetiere. Berlin.

Schweitzer, F.L. (1949). Gonadotropin Concentration in presence of twins. Rev. Soc. Argent. Biol. Vol. 25, pp. 240-249. An. Breed. Abstr. Vol. 19. No. 3, p.1056.

Schreuder, P.J. v.d. H. (1915). The Cape Horse. Thesis Ph. D., Cornell Univ. Ithaca, N.Y.

Seaborn, E. (1925). The Oestrus Cycle in the Mare and some associated phenomena. Anat. Rec. Vol. 30, pp. 277-287.

Sharpe, H. (1930). The Practical Studgroom. 2nd ed. British Blood-stock Agency, London.

Short, R.V. (1956). Progesterone in the placentae of domestic animals. Nature, Vol. 178, pp. 743-744.

Sisson, S. (1938). The Anatomy of the Domestic Animals, 3rd ed. Saunders, Philadelphia, London.

Tidmarsh, C.E.M. (1951). Veld Management Studies 1934-1950. Pas. Res. S.A. Prog. Rept. III. Govt. Printer, Pretoria.

Theiler, A., Green, H.H., du Toit, P.J. (1927). Minimum Mineral Requirements in Cattle. Jl. Agr. Sc. Vol. 17, No. 3, pp. 291-314.

Topp, H./.....

Topp, H. (1937). Beitrag zur Frage der Rosse und Ovulation bei Stuten. Diss. Hanover. An. Breed. Abstr. (1938), Vol. 6, p. 193.

Trum, B.F. (1950). The Estrous Cycle of the Mare. Cornell. Vet. Vol. 40, pp. 17-23.

Uppenborn, W. (1933). Untersuchungen über die trachtigkeitsdauer der Stuten, mit einem Anhang: Untersuchungen über die Zwillingsgeburten beim Pferd. Z. Zucht. Vol. 28, pp. 1-27.

Van Rensburg, S.W.J., and van Heerden, J.S. (1953). Infertility in Mares caused by Ovarian Dysfunction. Onderstepoort J. Vet. Res. Vol. 26, No. 2, pp. 285-313.

Van Wyk, D.J.R. (1933). Die seisoenverskil in Voedingswaarde van sekere ondersoorte grasse van die spesies Digitaria. Wetenskaplike Pamflet No. 126, Suid Afrika.

Van Wyk, H.P.D., Oosthuizen, S.A. and Fourie, S. (1948). Lucerne Hay. Agri. Sci. Bull. No. 269, South Africa.

Voloskov, P.A. (1936). Heat in mares and methods of ascertaining ovulation. (Russian). Konevodstve 10, pp. 47-54. An. Breed. Abstr. Vol. 5, No. 2, pp. 126-127.

Von Korff, K. (1939). Untersuchungen über den Zyklus der Stute IV. Aussere Rosse und Scheidenbildung. Diss. Hanover. Dtsch. tierärztl. Wschr. (1940). Vol. 48, pp. 172-173.

Von Oettingen, B. (1909). Horsebreeding. Sampson Low, Marston & Co., London.

Wagner, H. (1934). Ein beitrag zur zwillings trächtigkeit der Stute. Dtsch. tierärztl. Wschr. Vol. 42, pp. 610-613.

Wagner, H. (1935). Wege zur Erziehung einer höhoner Trächtigkeitsziffer bei der Stute. Dtsch. tierärztl. Wschr. Vol. 43, pp. 257-260.

Williams, W.L. (1943). The Diseases of the Genital Organs of Domestic Animals. Ithaca, N.Y.

Wyndham, H.A. The Rt. Hon. (1924). The Early History of the Thoroughbred Horse in South Africa. Oxford Univ. Press.

Zavadovsky, B.M., and Goldberg, M.B. (1937). The effect of prolan upon the sexual activity of mares. Bull. Biol. Med. exp. U.R.S.S., Vol. 3, pp. 357-359. Animal Breed. Abstr., 1939, Vol. 7, pp. 102.

Zivotkov, H.I. (1933-34). Artificial insemination of horses in Army Studs. (Russian). 1st All. Union Conf. Artif. Insem. (1936) pp. 85-90. An. Breed. Abstr., Vol. 3, No. 3, pp. 246.

Zivotkov, H.I. (1951). Does resorbtion of embryos occur in Pregnant Mares (Russian). Konevodstvo 2, pp. 26-29. An. Breed. Abstr. Vol. 19, No. 3, p. 1059.

Zivotkov, H.I., Gongarenko, K.S., and Krivoseckov, A.G. (1936). On the Study of Ovulation in the Mare (Russian). Probl. Zhivotu 3, pp. 71-76. An. Breed. Abstr. (1936). p. 286.

Zondek, B. (1934). Mass Excretion of Oestrogenic Hormone in the Urine of the Stallion. Nature, Vol. 133, p. 209.

Zuckerman, S., Palmer, A. and Hanson, D.A. (1950). J. Endocrin. Vol. 6, p. 261. Quoted Amoroso, 1955.