STUDIES ON REPRODUCTION IN EQUINES

by

RAVINDRA LAL ARORA,
B.V.Sc. & A.H.,
Post Graduate College of Animal Sciences,
Indian Veterinary Research Institute,
IZATNAGAR (U.P.)

THESIS

Submitted to the Agra University in partial fulfilment
of the requirements for the degree of
MASTER OF VETERINARY SCIENCE (A. H.)
IN
ANIMAL GENETICS AND BREEDING

1970

STUDIES ON REPRODUCTION IN EQUINES

by

RAVINDRA LAL ARORA,
B.V.Sc. & A.H.,

Post Graduate College of Animal Sciences,
Indian Veterinary Research Institute,
IZATNAGAR (U.P.)

THESIS

Submitted to the Agra University in partial fulfilment of the requirements for the degree of

MASTER OF VETERINARY SCIENCE (A. H.)

IN

ANIMAL GENETICS AND BREEDING

1970

S.N. Luktuke, G.B.V.C., Assoc. IVRI, F.R.V.C.S.,
Animal Gynaecologist

Division of Animal Genetics,
Indian Veterinary Research Institute,
Izatnagar, U.P.

February 12 , 1970.

This is to certify that the entire research work contained in this thesis entitled "Studies on Reproduction in Equines" has been authentically carried out by Shri Ravindra Lal Arora, under my supervision and guidance.

S.N. Luktuke

(S.N. LUKTUKE)

ACKNOWLEDGEMENT

With great pleasure the author records his deep sense of gratitude and indebtedness to his guide Shri S.N. Luktuke, G.B.V.Sc., Assoc. IVRI, F.R.V.C.S., Animal Gynaecologist for his keen interest, valuable guidance, constructive criticism and constant encouragement for carrying out this research work and in the preparation of this thesis.

Grateful acknowledgements are also due to the Director of Remounts and Veterinary Corps, Army Headquarters, New Delhi for his kind permission to carry out studies pertaining to the animals of Equine Breeding Stud, Babugarh and make the relevent data available.

He also acknowledges his sincere thanks to Comdt. Equine Breeding Stud, Babugarh, Lt. Col. Chandgi Ram, Capt. A.P. Saxena and Capt. R.N. Kakkar for their help and cooperation in collecting necessary informations from the Stud and make the data available.

The author sincerely thanks Shri B.S. Sharma, M.Sc., Assistant Statistician, for his help in statistical analysis of the data.

Thanks are also due to Dr. C.M. Singh, M.S., Ph.D., Director, Indian Veterinary Research Institute, Izatnagar, U.P. for his kind interest in this study and for providing all necessary facilities to carry out the present work.

C O N T E N T S

INTRODUCTION

Evolution of the horse took a period of approximately fifty-eight million years but it was hunted by man only 25,000 years ago. Probably horses have been domesticated first in Central Asia or Persia more than 3,000 years B.C. They spread Westward through Southern Europe in the time of the Lake Dwellers and were reported in Babylonia as early as 2000 B.C. (Ensminger, 1963).

Attention to equine breeding was greatly paid in Europe for several centuries past as horse was used as a farm animal for agricultural operations and for transport purposes. Many other countries in the world also had been using horse in agriculture and transport. Horse racing was also very popular in the European continent and special care was being taken in raising certain breeds of horses for this sport. After the World War II, agriculture in developed countries and in many of the developing ones rapidly got mechanised and this animal which was of great practical utility on farms, got almost ousted. With the increasing use of automobiles the animal has also lost his value as a transport animal. Until the end of last century during wars the horses were in great demand. With the advent of newer nuclear weapons and great technical advance in 'war material' this animal has been absolutely pushed in to the background.

From very ancient times, at least, from 322 B.C. King Chandra Gupta Maurya's era, saddle horses were used perhaps in greater numbers in India than in any other part of the world. In the annals of Indian History it is stated that Chandra Gupta's army included 80,000 cavalry and 8,000 four or two horsed chariots. At the third battle of Panipat in 1761, 1,00,000 cavalry were engaged. Hyder Ali of Mysore had a force of 40,000 cavalry in 1780.

Owing to incessant and intensive warfare in India from Emperor Aurangzeb's reign onwards for 150 years and the chaotic conditions which existed, horses had become scarce and scattered and the previous good breeds had degenerated, except for a few remnants, by the beginning of last century when the East India Company set to work to re-establish horse-breeding for army purposes. Unfortunately their efforts were confined at first to the comparatively unsuitable Province of Bihar. Before much progress could be made, horses began to be imported firstly from South Africa and lately from Australia. With every encouragement given to horse breeding in those British colonies, which competed eagerly to capture the Indian market, the quality of horses they exported to India rapidly improved and the import was on the increase. This caused discouragement to horse breeding in India. Thus imported horses came to be the main source of supply not only for the army but also for the

Indian States which had virtually abandoned their efforts to breed their requirements with the cessation of interne-cine war (Government of India Memorandum, 1933). The end of the war against Mysore in 1782 found British cavalry almost useless owing to lack of horses and Lieutenant Evans of the Madras Native Infantry decided to attempt to breed remounts as a private enterprise. The stud was located at Ganjam. The Company developed the stud with unusual generosity but due to discouragement and repeated criticisms by the authorities in London the fate of the Ganjam stud was sealed in 1808 (Matross, 1936).

Between 1899-1902 army horse breeding operations were handed over to the control of the Army Remount Department and operations extended to the very favourable Punjab Canal Colonies then being established. That was a most fortunate measure, because the Army Remount Department had been able to prove that India is as capable as she used to be in former times of producing excellent horses (Government of India Memorandum, 1933). From time to time some efforts had been made to give protection to Indian bred race horses by Royal Western India Turf Club, Royal Calcutta Turf Club and Horse Breeding and Show Society of India. Practical help to small breeder was assured by the scheme submitted to the stewards of the Royal Western India Turf Club by Sir Victor Sassoon sometimes in 1933.

In India great need of the horse was felt during the two recent foreign aggressions by neighbouring countries on her northern frontiers. In the North Eastern Frontier, transport of war equipments to higher altitudes was greatly handled with the help of strong sturdy mules. Attention of our defence department was concentrated on increased production of mules. They already had equine studs for such production and their activities were further enlarged.

Researches in physiology of reproduction in farm animals in India are of recent origin. The studies were accentuated in bovines with the introduction of artificial insemination about 25 years back. Uptil now attention was not paid to organise studies on various processes of reproduction in equines. With a view to assist horse and mule breeding programme, of the defence department it was intended to initiate investigations on equine reproduction. It was also considered that these studies would be of great help for horse breeders interested in raising stock for horse racing. We have very few stud farms in the country. It was considered worthwhile to initiate the investigation with the existing data already available in one of the old stud farms at Babugarh near Meerut. An attempt has been made to present in this thesis information on foal heat, its onset after parturition and duration, time and occurrence of subsequent heat, conception rates at these heats and the incidence of physiological and pathological termination of pregnancies.

REVIEW OF LITERATURE

FOAL HEAT

Though breeding in equines has been going on in several countries in the world since long, it is amazing to note that there are conflicting opinions concerning the breeding efficiency at foal heat. Hirt (1943) in an extensive review of literature emphasized that no uniform picture can be drawn of the oestrous cycle of the mare. The length, intensity and reappearance of oestrus are subject to great individual variation as a result of domestication and the influence of climate, breed (primitive or improved), and soil. However, most authorities agree that the first oestrus following normal parturition is the most favourable time for conception in mares.

Williams (1945) recorded a mare whose first foal was born when she was 8 years old and who subsequently bore a foal each year until she was 24. The author, from the data available to him, concluded that when mated unsuccessfully at first post-partum heat the foal produced in the following pregnancy is more likely to be a colt than a filly. He questioned the increase of reproductive efficiency due to mating of mares during foal heat. Contrary to the common belief that a mare if not mated at 1st heat cannot foal annually, the author has found that pregnancy duration in a

really healthy mare will be less than 335 days, and her second heat will occur at 30 days post-partum, if then mated with a healthy stallion she will probably foal in under 330 days.

Mahaffey (1950) concluded, "Although a fertility rate of over 50 per cent cannot be expected at foal heat in large groups of mares, with appropriate selection of mares following ovarian palpation and examination of genital tract some 70 per cent of these served will conceive. In view of the short Thoroughbred breeding season mating at early post-partum oestrus is recommended".

Deskur (1964) pointed out that the practice of mating mares on the 9th day after parturition would probably have given 20 per cent of pregnancies in the mares investigated by him.

OCCURRENCE

Lipping (1933) found that the first oestrus after foaling usually occurs on the 7th-12th day. It is usually greatly delayed if it does not appear on the 15th day.

Constantinescu and Mauch (1936) reported that heat after foaling usually sets in after 4-17 days (7-11 days in 90 per cent).

McKenzie and Andrews (1937) found the interval between

parturition and foal heat to be from 2-12 days with a mean of 7.25 days.

According to Berliner et al. (1938) foal heat began 2-8 days after foaling.

Svecin (1939) cited that after foaling, heat usually sets in 17 to 18 days (6-69).

Kedrov and Lihacev (1940) studied 600 working mares belonging to 23 collective farms in the Krasnodar region. In 85.6 per cent of the cases foal heat occurred within 4-13 days (average 8.59 days).

Satalov (1940) observed that oestrus began 9-38 days post-partum in 25 post-parturient draft mares.

Williams (1943) stated that foal heat usually occurs within 8th or 9th day or even earlier.

Tutt (1944) revealed that in 39 out of 42 mares oestrus commenced within 8-13 days after foaling.

Robin and Petrov (1945) in their studies on 54 pure Arab and 11 Barb mares observed that in majority of cases heat occurred 5-12 days after parturition but in some cases the delay was as much as 27 days.

Britton and Howel (1945) in a herd of 36 Arab mares recorded over 40 days' delay in the onset of foal heat a total of 32 times for 18 mares. Onset of foal heat which was found to have taken place from the 5th to the 15th day post-partum, tended to be early in the summer months, and later in the winter months.

Aehnelt and Plas (1946) observed that in 37 out of 44 mares, the external signs of oestrus began between the 5th and the 13th day after parturition. Nine of the mares showed the first signs on the 8th and 16 on the 9th day.

In Bielanski's studies in 1946 on 14 females, heat appeared on an average within 9-14 days after foaling.

In Østland mares the first cycle begins on the 9th day post-partum (Aas, 1948).

Bain (1948) conducted studies simultaneously at the Claiborne stud in Kentucky and the Alton Lodge stud in NewZealand. In 44 mares the first oestrus appeared 6-27 days post-partum.

Skatkin (1948) investigated further on 450 saddle mares and 150 Vladimir mares that on an average mares come in heat on the 9th day after foaling; 80-90 per cent came on heat on the 5th-12th day post-partum.

In the same year Burri noticed foal heat on the 5th-13th day post-partum in the majority of 25 foaling Jura mares.

Grigorjev (1949) noted a significant difference in the onset of heat in all age groups (3-15 years and older). None came on heat before the 5th day, 37.8 per cent 6-10 days after foaling and a decreasing percentage during the next 1½ months.

According to McManamny (1949) the average time for the appearance of the first oestrus was 7.9 days after foaling in 135 'wet mares'.

Mahaffey (1950) revealed considerable individual variation in the day of onset of post-partum oestrus and ovulation from the data of Andrews and McKenzie, as well as from data collected at Parringa stud in 1948 and 1949. He concluded that the averages for onset of first post-partum oestrus and ovulation cannot be used to calculate an optimum time of service; mares must be considered individually.

Trum (1950) recorded foaling heat in 93 per cent of the mares 5-8 days post-partum; 77 per cent showed heat between the 7th and 10th day.

Redon and Fayolle (1957) calculated the period between parturition and post-partum oestrus to be 11.3 and 8.8 days in 18 local mares and 6 Arab-Barb mares respectively at the Breeding Centre at Dahra, Senegal.

Lipczynski and Deskur (1958) recorded foal heat on the 9th day after foaling.

Sattar-Zade (1958) found that Karabakh mares come on heat 20-40 days after foaling.

Detkens (1961) noted 4-14 days post-partum interval.

Chieffi et al. (1962) carried out studies on 277 post-partum oestruses in 93 Mangalarga mares at a stud in Sao Paulo. 75.1 per cent of the oestruses appeared within 8 days of parturition with 45.5 per cent beginning on the 7th day.

Matassino (1962) estimated average interval from foaling to first service as 27.4 ± 19.3 days. Average service period (foaling to conception) was 33.3 ± 23.0 days.

Du Plessis (1964) investigated on 336 oestrous cycles of 182 Thoroughbred mares. Sixty per cent of mares were found to exhibit oestrus within 14 days of foaling. Of the 72 mares which did not exhibit a foaling heat, 57 came into oestrus

20-30 days after parturition and 15 developed anoestrum.

Deskur (1964) made studies on 172 Poznan, 100 Mazury (East Prussian) and 31 English Thoroughbred mares. Sixty nine per cent of Poznan, 65 per cent of Mazury, and 44 per cent of the Thoroughbred mares showed oestrus not later than 20th day after parturition; 70-80 per cent of all mares showed oestrus by the 30th day. The earliest oestrus occurred on the 4th day in a Poznan mare, the 5th day in a Thoroughbred and the 6th day in a Mazury mare. The closer the date of foaling was to May the shorter was the period between foaling and first oestrus.

Hadi (1966) analysed data from 1947-1964 on 27 mares of the Hingoli Stud breed in Maharashtra State in India. Oestrus occurred within 14 days of foaling in 77.2 per cent of 136 foalings.

Parfenov (1966) found in 115 Kabarda mares that post-partum oestrus occurred in 12.1 days after foaling; the interval decreased to 9.4 days for Anglo Kabarda females with ¼ Kabarda blood.

Jaworowska (1967) said that mares often come on heat 5 days after foaling.

Matthews et al. (1967) found that 369 (86.21 per cent) of 428 foaling mares exhibited oestrus within 18 days of foaling; the onset of oestrus occurred on an average 8 days post-partum although there were significant differences between years. He defined foal heat in the mare as "oestrus that occurs within 8 days after foaling, and usually commences 6-10 days post-partum".

Popov et al. (1968) elaborately investigated from the data for 1954-1965 in the Animal Breeding Institute at Kostinbrod and the State Farm "G. Dimitrov". He found that of 1514 mares, 6.4, 15.5 and 14.6 per cent came on heat 5-14, 15-30 and 31-60 days respectively after foaling.

Hendrikse (1968) reported that the percentages of mares first 3-8, 9-11, 12-20, 21-29, 30-39 and more than 40 days after parturition were 15.7, 46.8, 13.6, 7.0, 9.4 and 6.6 respectively.

Data and observations by different workers reviewed above have been summarised in Table 1.

Table 1

Interval in days between parturition and foal heat or first post-partum heat as reported by different authors

Name of the author	Year	Place of work	Type of material taken for study	Interval in days between parturition and foal heat or 1st post-partum heat
1. Lipping	1933	-	-	7-12
2. Constantinescu and Mauch	1936	-	1506 oestrous cycles	4-17 and 7-11 in 90%
3. McKenzie and Andrews	1937	Bozeman	-	7.25 (2-12)
4. Berliner et al.	1938	-	10 Jennets	2-8
5. Svecin	1939	-	100 females	17-18 (6-69)
6. Kedrov and Lihacev	1940	Krasnodar region	600 working mares	8.59 (4-13) in 85.6%
7. Satalov	1940	-	25 draft mares	9-38
8. Williams	1943	-	-	Within 8th or 9th or even earlier.
9. Tutt	1944	-	42 mares	Within 8-13 in 39 mares
10. Robin and Petrov	1945	-	54 Pure Arab and 11 Barb mares	5-12 (5-27)

Table 1 (contd)

Name of the author	Year	Place of work	Type of material taken for study	Interval in days between parturition and foal heat or 1st post-partum heat
11. Britton and Howel	1945	-	36 Arab mares	5-15; over 40 in 18 mares
12. Aehnelt and Plas	1946	Hannover	44 mares	5-13 in 37 mares 8 in 9 mares 9 in 16 mares
13. Bielanski	1946	Cracow	14 females	9-14
14. Aas	1948	-	Ostland mares	9
15. Bain	1948	NewZealand and Kentucky	44 mares	6-27
16. Skatkin	1948	-	450 Saddle mares) 150 Vladimir mares)	9, 5-12 in 80-90%
17. Burri	1948	Bern	25 Jura mares	5-13
18. Grigorjev	1949	-	-	6-10 in 37.8%
19. McManamny	1949	-	135 wet mares	7.9
20. Trum	1950	Bolivia	-	5-8 in 93% and 7-10 in 77%
21. Redon and Fayolle	1957	Senegal	18 local mares 6 Arab Barb mares	11.3 8.8

Table 1 (contd)

Name of the author	Year	Place of work	Type of material taken for study	Interval in days between parturition and foal heat or 1st post-partum heat
22. Lipczynski and Deskur	1958	-	93 mares	9
23. Sattar-Zade	1958	-	Karabakh mares	20-40
24. Detkens	1961	-	-	4-14
25. Chieffi et al.	1962	Sao Paulo	93 Mangalarga mares	Within 8 in 75.1% of oestruses and 45.5% begin on the 7th day
26. Matassino	1962	Italy	-	27.4 ± 19.3
27. Du Plessis	1964	Onderstepoort	182 Thoroughbred mares	Within 14 in 60%
28. Deskur	1964	Cracow	172 Poznan mares	Below 20) and in 69%) below
			100 Mazury mares	Below 20) 30 in in 65%) 70-80%
			31 English Thoroughbred mares	Below 20) of all in 44%) mares
29. Hadi	1966	India	27 Hingoli Stud breed mares	Below 14 in 77.2% of foalings
30. Parfenov	1966	Russia	115 Kabarda mares	12.1
			Anglo-Kabarda females with ¼ Kabarda blood	9.4

Table 1 (contd)

Name of the author	Year	Place of work	Type of material taken for study	Interval in days between parturition and foal heat or 1st post-partum heat
31. Jaworowska	1967	Poland	-	5
32. Matthews et al.	1967	-	428 foaling mares	8, below 18 in 369 (86.21%)
33. Popov et al.	1968	Kostinbrod and G. Dimitrov	1514 mares	5-14 in 6.4% 15-30 in 15.5% 31-60 in 14.6%
34. Hendrikse	1968	-	-	3-8 in 15.7% 9-11 in 46.8% 12-20 in 13.6% 21-29 in 7.0% 30-39 in 9.4% 40 and above in 6.6%

DURATION OF FOAL HEAT AND OVULATION

Foal heat has been often referred in literature by many workers as first post-partum oestrus. The review on studies pertaining to the duration of first post-partum oestrus in mares is given below.

Berliner et al. (1938) found that foal heat lasted 2-6 days in 10 Jennets.

Satalov (1940) reported that post-partum heat lasted 2-9 days and 1 to 4 days following ovulation in 25 post-parturient draft mares.

Tutt (1944) mentioned 2-4 days as duration of foal heat in 39 out of 42 mares.

Gotze and Rosenberger (1944) reported that the first ovulation occurs 8-13 days after foaling. This interval to first post-partum ovulation may even be longer.

Aehnelt and Plas (1946) found that foal heat lasted 2-13 days (average 4 days). In 21 cases the end of oestrous period came one day after ovulation, and in 19 cases, two days after ovulation. Ovulation took place between the 8th and 21st day after parturition in 37 out of 44 mares examined. In 38 mares ovulation took place after the 9th day, the time commonly choosen by breeders for the first service post-partum. On an average ovulation occurred 12th day after foaling.

Foal heat was found to last 4-9 days (average 7.3) in 11 mares in Bielanski's studies in 1946.

Bain (1948) revealed the duration of oestrus to be 1-15 days in 44 mares.

According to Skatkin (1948) oestrus lasted on an average 6-8 days (2-13) and in the majority of mares 4-9 days,

its duration was 4 days in 63 per cent of the 450 saddle mares, 7 days in 54 per cent of the 150 trotter mares and 6-9 days in 63.3 per cent of the 150 Vladimir mares. The onset of ovulation was on an average on the 6th-8th day of oestrus (3rd-15th day and later in a few cases). It was on the 3rd to 10th day in 84-92 per cent, and on the 11th to 15th day in 7-16 per cent of the mares. He found out from the data on 93 mares at Zimovnikov that oestrus duration was the same in successive cycles in 18.3 per cent of the mares; there was a difference of one or two days in 51.7 per cent of the mares, and a difference of 3-8 days in 30 per cent of the mares. On an average 2.1 days difference was noted.

According to Grigorjev (1949) the duration of heat increased in proportion to the interval between parturition and the onset of heat. There was considerable individual variation in the duration of heat.

McManamny (1949) observed that the average duration of foal heat was 2.5 days in 135 wet mares.

Mahaffey (1950) observed that the duration of oestrus varied from 1-10 days ($M = 4.4 \pm 0.47$), from 1-8 days ($M = 4 \pm 0.31$) and from 9-12 days ($M = 5 \pm 0.45$) from Andrews and McKenzie's data as well as from data collected at Parringa stud respectively.

Trum (1950) noticed extreme variation in the time of ovulation. Of the 30 mares examined for ovulation 40 per cent ovulated one day before the end of oestrus and 77 per cent during the last three days.

According to Lipczynski and Deskur (1958) the first ovulation usually occurred on 11th or 13th day.

Sattar-Zade (1958) found that foal heat lasted five days in Karabakh mares.

According to Chieffi et al. (1962) the length of first post-partum oestrous period averaged 8.5 days.

Deskur (1964) found that earliest ovulation in Poznan mares was on the 7th day after parturition v. the 9th day in Mazury and Thoroughbred mares.

Du Plessis (1964) observed the average duration of foal heat to be 3.8 days (2-13) in 182 Thoroughbred mares.

Foal heat was found to last 3-9 days in Jaworowska's studies in 1967.

Studies reviewed above are summarised in Table 2.

Table 2

Duration of foal heat and ovulation as reported by different authors

Name of the author	Year	Place	Type of material taken for study	Duration of foal heat in days	Time of ovulation
1. Berliner et al.	1938	-	10 Jennets	2-6	-
2. Satalov	1940	-	25 draft mares	2-9	Ovulation occurred 1-4 days before the end of oestrus
3. Tutt	1944	-	42 mares	2-4 in 39 mares	-
4. Gotze and Rosenberger	1944	Hannover	-		Ovulation occurred 8-13 days post-partum or even longer
5. Aehnelt and Plas	1946	Hannover	44 mares	4 (2-13)	12 (8-21) days post-partum
6. Bielanski	1946	Cracow	14 females	7.3 (4-9)	-
7. Bain	1948	NewZealand and Kentucky	44 mares	1-15	-
8. Skatkin	1948	-	450 Saddle mares and 150 Vladimir mares	2-13	3-10 days post-partum
9. McManamny	1949	-	135 wet mares	2.5	-

Table 2 (contd)

Name of the author	Year	Place	Type of material taken for study	Duration of foal heat in days	Time of ovulation
10. Mahaffey	1950	-	-	1-12	-
11. Trum	1950	Bolivia	-	-	1-3 days before the end of oestrus in 77%
12. Lipczynski and Deskur	1958	-	93 mares	-	11th or 13th day post-partum
13. Sattar-Zade	1958	-	Karabakh mares	5	-
14. Chieffi et al.	1962	Sao Paulo	93 Mangalarya mares	8.5	-
15. Du Plessis	1964	Onder-stepoort	182 Thoroughbred mares	3.8 (2-13)	-
16. Deskur	1964	Cracow	172 Poznam 100 Mazury 31 English Thoroughbred		Ovulation occurred 7th-9th day after parturition
17. Jaworowska	1967	Poland	-	3-9	-

BREEDING EFFICIENCY AT FOAL HEAT

Williams (1926) recorded 30 per cent conception rate in 120 ninth day breeding in a famous thoroughbred stud of high repute fertility.

According to Williams (1943) conception rate was 43.7 per cent with one service while it was 67.3 per cent in mares bred at later heats. He presumed the failures to be due to introduction of infection in the uterus by mating and unfavourable defence mechanism of the uterus at foal heat.

Stevenson (1945) did not observe any significant difference in the percentage of conception or in percentage of healthy foals born to a group of mares bred within 8-14 days after parturition and a similar group bred during 'non-foal' heats in an above average maintained and managed stud.

According to Britton and Howell (1945) the results of mating on various days of foal heat showed a trend towards an increase in conception percentage when the last mating approached the 12th-13th day. Of 130 mares mated at the foal heat 68 failed to conceive. Conception rate works out to be 47.69 per cent.

Robles (1947) while reporting observations on mares in Philippines found that the percentage of mares which became pregnant as a result of insemination during foal heat was as high as 48 per cent for Bureau mares bred at Alabang and 9 per cent only for private mares bred at Sariaya Breeding

Station. According to him the poor results at the later station may be ascribed partly to service at the wrong time and partly to lack of proper care of the mares before and after breeding.

Aas (1948) suggested that service should be 9-12 days post-partum.

According to Bain (1948) in NewZealand 33-36 per cent of mares served at the foal heat conceived v. 63 per cent of mares served at the second heat.

Mahaffey (1950) observed that in the year 1948, out of 27 mares exhibiting foal heat 18 were served and 14 (77 per cent) of these conceived; in 1949 out of 31 mares 20 were served and 14 (70 per cent) of these conceived.

Jennings (1950) recorded 43.8 per cent conception rate for foaling mares bred during the foal heat (9th day breeding). When only a few mares were bred during foal heat, a higher conception rate for all the mares was observed. He suggested that 9th day breeding should take place as infrequent as possible.

Nyborg (1953) proved from data on 94 Belgian mares that 9th-10th day after foaling is the optimum mating period but service should be repeated on 11th-12th, 14th-15th and

28th-29th days.

Jordao et al. (1954) observed that, of the pregnant mares in three groups viz. 397 purebred mares of various European breeds, in 390 crossbred mares with Breton Post-horse blood, and in 202 Mangalarga mares 61.4, 53.5 and 58.0 per cent respectively conceived during first post-partum oestrus.

In India Kohli and Suri (1957) found conception rate for the foal heat to be lower than for the later heats in 128 donkey females with a total of 694 foalings over a period of 38 years in donkey breeding stud at the Government Livestock Farm, Hissar. 198 cases were mated within 16 days after foaling. They observed 27.1, 31.2, and 34.2 per cent fertility in 48.4 per cent cases served below 11 days, 32.4 per cent between 11 to 13 days and 19.2 per cent between 14 to 16 days after foaling respectively. The conception rate for the first service during foal heat period of 10 days' breeding was 27.1 per cent as compared with 50.1 per cent for those bred during non-foal heats. The difference of fertility rate between the two was significant.

Chieffi et al. (1962) observed that of the 277 matings during foal heat 27.8 per cent resulted in conception v. 61.8 per cent in 322 matings during the subsequent oestrus and

64 per cent in matings of primiparous females. In females mated during foal heat 3.6 services were required per conception v. 1.7 for females mated during subsequent oestrous period and 1.6 for primiparae. He concluded that further studies would be necessary to predict any advantage of mating females during first post-partum oestrus.

Cannas Simoes and Nunes Duarte (1963) indicated conception rate for females mated to stallions or jacks during foal heat (within 8 days of foaling) to be 30.7 per cent v. 44.1 per cent for females mated more than 24 days post-partum. Total number of services required per conception was 2.12 and 1.64 respectively for females in 2 groups. At matings carried out less than 6 days post-partum, the conception rate was only 8.1 per cent.

Du Plessis (1964) recorded 46 per cent conception rate among mares bred during foal heat.

68.6 per cent of the mares mated at the first oestrus became pregnant (Deskur, 1964).

Cannas Simoes and Nunes Durate (1966) said that conception rate of mares mated during foal heat seemed to be most affected by management methods.

Hadi (1966) calculated conception rate at the foal heat

as 22.6 per cent on 27 mares of Hingoli stud breed in India.

Popov et al. (1968) found that conception rate was highest (61.5 per cent) for 932 mares coming on heat 5-14 days after foaling.

Hendrikse (1968) reported that as a result of replies (80 per cent of 15,610) to a department of Agriculture (Health Committee of Horse Breeding Section) questionaire covering the 1958, 1959 and 1960 mating seasons, it was concluded that best results are not obtained by mating mares at the first oestrus after foaling. The conception rates were 37.7, 45.0, 43.3, 52.5, 57.0 and 51.3 per cent for 3-8, 9-11, 12-20, 21-29, 30-39 and more than 40 days after parturition. In general the results of mating were better than those of the first service, indicating that the first service frequently took place too early.

The results of breeding efficiency at foal heat reported above by various workers are tabulated in Table 3.

Table 3

Conception rate at foal heat and its comparison with that of breeding at later heat as reported by different authors

Name of the author	Year	Type of material taken for study	Conception rate at foal heat and its comparison with that of later heat breeding
1. Williams	1926	120 ninth day breeding	30%
2. Williams	1943	-	43.7% v. 67.3% by later heats
3. Stevenson	1945	-	No significant difference was noted
4. Robles	1947	Bureau mares Private mares	48% 9%
5. Bain	1948	44 mares	33-36% v. 63% by later heats
6. Mahaffey	1950	18 mares 20 mares	77% in the year 1948 70% in the year 1949
7. Trum	1950	-	Less than that of later heats
8. Jennings	1950	-	43.8%
9. Jordao et al.	1954	397 purebred mares 390 crossbred mares 202 Mangalarga mares	61.4% 53.5% 58.0%

Table 3 (contd)

Name of the author	Year	Type of material taken for study	Conception rate at foal heat and its comparison with that of later heat breeding
10. Kohli and Suri	1957	128 Donkey mares	Lower than that of later heats
11. Chieffi et al.	1962	93 Mangalarga mares	27.8% v. 61.8% by later heats
12. Cannas Simoes and Nunes Duarte	1963	202 mares	30.7% by mating within 8 days of foaling 44.1% by mating more than 24 days of foaling 8.1% by mating less than 6 days post-partum
13. Du Plessis	1964	182 Thoroughbred mares	46%
14. Deskur	1964	172 Poznan, 100 Mazury and 31 English Thoroughbred mares	68.6%
15. Hadi	1966	27 Hingoli stud breed mares	22.6%
16. Cannas Simoes and Nunes Duarte	1966	275 mares	Most affected by management methods
17. Popov et al.	1968	932 mares	61.5% by mating 5-14 days post-partum
18. Hendrikse	1968	-	37.7% by mating 3-8 days post-partum 45.0% by mating 9-11 days post-partum 43.3% by mating 12-20 days post-partum 52.5% by mating 21-29 days post-partum 57.0% by mating 30-39 days post-partum 51.3% by mating 40 or more days post-partum

PATHOLOGICAL TERMINATION OF PREGNANCY AND OTHER CONSEQUENCES AS A RESULT OF BREEDING AT FOAL HEAT

Williams (1926) reported that the mares conceived by breeding on 9th day showed 11.1 per cent abortions and non-viable foals while the pregnancies from breeding at later heats were followed by 4.1 per cent abortions and non-viables.

Jennings (1941) in the United States Remount Station at Front Royal found undesirable results. He gathered following information from foaling mares bred on 9th day.

1. Abortion was 12.8 per cent which was four times of those bred at subsequent heats after foaling.

2. Percentage of dystocia was 15 per cent in mares bred on 9th day and no case of dystocia was noticed in those bred at later dates.

3. Still-births were 7.5 per cent being six times that of later breeding.

4. Retained placenta occurred in 29.1 per cent v. 21.0 per cent in those bred at later oestruses.

Britton and Howell (1945) showed 5 of 17 dead or diseased foals in 13 mares following foal heat matings.

According to findings obtained by Aehnelt and Plas (1946) a considerable percentage of infertility in mares is

probably due to the practice of forcing service on the 9th day after parturition.

According to Trum (1950), mating during foal heat results in fewer pregnancies than during subsequent heat and there was high rate of abortion and non-viable foals.

Jordao et al. (1954) found that of all the foals born as a result of conception during first post-partum oestrus 83.1 per cent survived until weaning v. 81.4 per cent of all foals born as a result of conception at heats other than first post-partum.

Chieffi et al. (1962) reported that of the mares which were mated during the post-partum oestrus but did not conceive, 74.3 per cent did not come on heat again until after weaning.

According to studies made by Du Plessis (1964) 21 per cent of the mares which did not conceive at foal heat subsequently developed anoestrus which was significantly more common in lactating than in dry mares. Of the 72 mares which did not exhibit foal heat, 57 came into oestrus 20-30 days after parturition and 15 (20.83 per cent) developed anoestrum.

Merkt (1966) compared the consequences of mating during foal heat and those of subsequent heats. He observed embryonal resorption during the 2nd month of pregnancy in 17 per cent of

271 suckling Thoroughbred mares which had conceived in their first oestrus after foaling, it occurred in 11 per cent of 56 mares which had become pregnant by breeding during the oestrus following foal heat, and in 7 per cent of 192 mares which had not conceived until after several oestrous periods.

Hadi (1966) stated that 18.5 per cent pregnancies terminated in abortion, or the birth of a weak or dead foal as a result of breeding at foal heat.

Results of the investigations reviewed above as reported by different authors have been briefly mentioned in Table 4.

Table 4

Pathological termination of pregnancy and other consequences as a result of breeding at foal heat as reported by different workers

Name of the author	Year	Pathological termination of pregnancy and other consequences
1. Williams	1926	11.1% abortions by 9th day breeding v. 4.1% abortions by breeding at later heats. Heat greatly delayed if it does not appear on 15th day after foaling.
2. Jennings	1941	12.8% abortions by 9th day breeding v. ¼th of it by breeding at later heats, 15% dystocia by 9th day breeding v. none by later breeding, 7.5% stillbirths by 9th day breeding v. 1/6 of it by later breeding and 29.1% retained placenta by 9th day breeding v. 21.0% by later breeding.

Table 4 (contd)

Name of the author	Year	Pathological termination of pregnancy and other consequences
3. Britton and Howel	1945	5 of the 17 dead or diseased foals were following foal heat matings.
4. Trum	1950	High rate of abortion.
5. Jordao et al.	1954	83.1% survived until weaning by foal heat breeding v. 81.4% by later heat breeding.
6. Chieffi et al.	1962	Of the mares unconceived on foal heat 74.3% did not come on heat again until after weaning.
7. Du Plessis	1964	Of 72 mares which did not exhibit a foaling heat 57 came into oestrus 20-30 days after foaling and 15 developed anoestrus. 21% of those failed to conceive at foal heat also developed anoestrus.
8. Merkt	1966	17% embryonic resorption during 2nd month of gestation following foal heat breeding v. 11% at the same stage by later heat breeding.
9. Hadi	1966	18.5% abortion, weak or dead foals.

INTERVAL BETWEEN FOAL HEAT AND FIRST SUBSEQUENT HEAT AND BREEDING EFFICIENCY AT THE LATTER

Constantinescu and Mauch (1936) found that if the first cycle after foaling was missed, the best results were obtained when the mares were mated 30-37 days after foaling. The

highest conception rate of 56.3-57.1 per cent was obtained when the first mating was carried out on 1st or 2nd day and 2nd mating on 4th or 5th day of heat.

Bielanski (1946) pointed out that in 42 females which were not settled during the foal heat the next one appeared after 22.2 days.

Bain (1948) reported that 63% of the mares served at the 2nd heat (subsequent to foal heat) conceived.

Chieffi et al. (1962) found 61.8 per cent conception rate in 322 matings during the subsequent oestrus.

OVERALL CONCEPTION RATE

Videla (1944) collected data from Argentine stud books or from stud farms on about 3000 Thoroughbred mares for the period 1908-1941. Annual average conception rate was 62.75. The conception rates in Australia (1936-39), U.S.A. (1940), NewZealand (1938), England (1935-39) and Italy (1930-33) were 73.67, 72.15, 69.54, 68.82 and 67 per cent respectively.

Berge (1944-45) found that mating of association stallions of the Vestland breed with 33,255 mares resulted in 65.54 per cent becoming pregnant and 64.72 per cent of 33,991 mares with those of the Ostland breed.

Robin and Petrov (1945) reported that in Algeria conception rate was 67 per cent in 1942 and 65 per cent in 1943.

According to Bain (1948) 79.7 per cent of 1978 mares became pregnant at Claiborne stud in Kentucky.

Fey and Thomann (1948) found conception rate to be 56.43 per cent in 1233 mares served by 3 'cold blood' stallions of the Thurgau Horse Breeding Association at Weinfelden.

Jordao and Gouveia (1948) pointed out that conception rate was 53.7 per cent and 55.4 per cent in Brazilian born and imported mares respectively in Sao Paulo.

According to studies by McManamny (1949) a conception rate of not less than 80 per cent had been maintained.

Kern (1949) reported that the conception rate was 50.43 per cent among 6290 mares in 1946 and 57.57 per cent among 6277 mares in 1947.

Kern (1950) noted conception rate as 76.6 per cent and 70.3 per cent by different stallions.

Jordao and Furtado Gouveia (1950) reported 54.7 per cent conception rate in 471 English Thoroughbred mares in Sao Paulo.

According to Jordao et al. (1951) average conception

rate was 57.1 per cent varying from 23.8 to 85.7 per cent over the period 1939-1949 in 43 she-asses of a stud at Colina in Sao Paulo, Brazil.

Jordao et al. (1952) found an average conception rate of 60.6 per cent in Anglo-Arab mares at State Stud in Sao Paulo. Further in the same year they found 49.2 per cent conception rate in Thoroughbreds. In 1954 they reported 54.2, 36.9 and 49.5 per cent conception rate in 397 purebred mares of various European breeds, in 390 crossbred mares with Breton Post-horse blood, and in 202 Mangalarga mares respectively.

In 1954, they observed 35.9 per cent conception rate during the period 1937-1950 in 259 native and crossbred mares served by Brazilian and Italian jacks. It averaged 49.3 per cent in 69 of these mares served by stallions.

Pozo Lora (1956) reported that average conception rate was 62.9 and 53.6 per cent in 874 Spanish and 1207 Arab mares respectively.

Wussow and Hartwig (1956) calculated fertility of 8783 cold blood mares with a total of 66,960 services in Saxony and Anhalt. It varied from 59.9 to 84.9 per cent according to age at services.

Kohli and Suri (1957) investigated 47.2 per cent average fertility rate among 128 donkey females.

Du Plessis (1964) reported 72 per cent as an overall conception rate.

Jaworowska (1967) based his observations on mares in the reserve of the experiment station of the Polish Academy of Sciences in Popielno. He found that conception rate was usually 100 per cent.

Popov et al. (1968) investigated overall conception rate as 83.8 per cent.

Hutton and Meacham (1968) reported that conception rate averaged 79.5, 72.5 and 78.6 per cent in lactating, barren and maiden mares respectively. The study was made on breeding records for 1960-1964 on 14 farms and 6 breeds.

Above findings pertaining to overall conception rate as reported by different authors are summarised in Table 5.

Table 5

Overall conception rate reported by different workers

Name of the worker	Year	Type of material taken for study	Overall conception rate
1. Videla	1944	About 3000 Thoroughbred mares	62.75% in Argentina 73.67% in Australia 72.15% in U.S.A. 69.54% in NewZealand 68.82% in England 67.00% in Italy
2. Berge	1944-45	33255 mares of Vestland breed 33991 mares of Ostland breed	65.54% 64.72%
3. Robin and Petrov	1945	54 pure Arabs and 11 Barb mares	67% in 1942 65% in 1943
4. Bain	1948	1978 mares	79.7%
5. Fey and Thomann	1948	1233 mares	56.43%
6. Jordao and Gouveia	1948	Brazilian born mares Imported mares	53.7% 55.4%
7. McManamny	1949	-	Not less than 80%
8. Kern	1949	6290 mares 6277 mares	50.43% 57.57%
9. Kern	1950	78 mares 64 mares	76.6% 70.3%
10. Jordao and Furtado Gouveia	1950	471 English Thoroughbreds	54.7%

Table 5 (contd)

Name of the worker	Year	Type of material taken for study	Overall conception rate
11. Jordao et al.	1951	43 she-asses	57.1% (23.8-85.7%)
12. Jordao et al.	1952	381 matings of Anglo-Arab mares	60.6%
13. Jordao et al.	1952	288 Thoroughbred matings	49.2%
14. Jordao et al.	1954	397 Purebred mares	54.2%
		390 crossbred mares	36.9%
		202 Mangalarga mares	49.5%
15. Jordao et al.	1954	259 Native and crossbred mares	35.9%
		69 Native and crossbred mares	49.3%
16. Pozo Lora	1956	874 Spanish mares	62.9%
		1207 Arab mares	53.6%
17. Wussow and Hartwig	1956	8783 Cold blood mares	59.9-84.9%
18. Kohli and Suri	1957	128 Donkey mares	47.2%
19. Du Plessis	1964	182 Thoroughbred mares	72%
20. Jaworowska	1967	-	Usually 100%
21. Popov et al.	1968	-	83.8%
22. Hutton and Meacham	1968	Lactating mares	79.5%
		Barren mares	72.5%
		Maiden mares	78.6%

OVERALL ABORTION RATE

According to Fey and Thomann (1948) the percentage of overall abortions and stillbirths was 15.44 in 1233 mares at Weinfelden.

Halasz (1954) reported that abortion rates were 17 and 11 per cent in autumn and spring respectively in 249 mares of Kisber and Babolua Studs in Budapest.

Jordao et al. (1954) noted 5.4 per cent abortions and stillbirths in 259 native and crossbred mares in Sao Paulo Stud.

Wussow and Hartwig (1956) observed an overall average of 6.91 per cent abortions among fertile mares.

Du Plessis (1964) reported 14 per cent overall abortions in 182 Thoroughbred mares.

SEASONAL INFLUENCE ON OCCURRENCE OF FOALING

According to Koroljkov (1952) majority of the foalings took place from March to May, the range being from March to July in the Northern Caucasus.

Wussow and Hartwig (1953) found that foalings occurred mainly in April and May. Their findings were based on 19,169 births which took place between 1922 and 1952.

Lukomski (1954) reported that in pre-war years over 90 per cent of the foalings of Halfbred English mares took place during the period January to May as recorded in the Poznan Pomeranian stud book. The peak was in the first half of April. In the post-war period foalings took place mainly from March to May with a tendency for peak to occur in the second half of March. In summer and autumn, no foaling was recorded.

Zwolinski (1960) made extensive investigations on 4063 foalings of 867 mares between 1946 and 1958 (twelve breeding seasons). Maximum number of foalings (23.5 per cent) took place in the month of April. 84.1 per cent of the foalings took place in the period, January to May. No foaling occurred in July and August. During the years 1955-58, more than 20 per cent of the foals were born from September to December.

According to Matassino's study in 1962 on 490 breeding seasons of 88 mares, 44 per cent of the foalings took place in April and 27 per cent in May. In the month of March, June and February, the occurrence of foaling was 23 per cent, 4 per cent and 2 per cent respectively.

References regarding the work on foaling seasons in India were not traceable.

MATERIAL AND METHOD

Military authorities were approached for collecting data maintained at Equine Breeding Stud, Babugarh for over a period of 16 years from 1949 to 1965. Records pertaining to 1372 foalings of 572 mares were available for this study. Details concerning 1241 foal heats were also available. The mares were of the following four types :

1. GS (General Service Mule Breeding) : These are Indian mares crossed with imported donkey stallions for the production of general service mules.

2. MA (Mountain Artillery Mule Breeding) : These are heavy draught type imported mares crossed with imported donkey stallions for the production of Mountain Artillery mules.

3. HB (Horse Breeding) : These are Indian and imported mares crossed with imported stallions for the production of horses.

4. DM (Donkey Mare Breeding) : These are imported donkey mares crossed with imported donkey stallions for the production of donkeys.

The above animals were of different age group and were in good condition of health. As per routine of the stud, the mares were frequently examined and teased daily soon after

parturition for detection of foal heat. The intensity of foal heat was judged by the behaviour and response of the mare towards the stallion i.e. the attitude of the mare for allowing stallion to make sexual advances.

Heats starting later than 18 days of post-partum were considered to be regular cyclic oestruses and not foal heats. The day subsequent to parturition was considered to be the first day after parturition, the next day as second day and and so on. Few mares started showing foal heat on the day of foaling. These were not taken into account for finding out interval to foal heat and foal heat duration. All the mares were bred at intense foal heat when they were very receptive. They were served during foal heat 1 to 3 times depending on duration of foal heat but for purpose of calculating breeding efficiency only one service was counted as is being practiced for cattle where reinseminations are made during one oestrus. The teasing and examination were also continued thereafter on 14th, 15th, 18th, 21st, 28th, 31st, 35th and 42nd day after parturition for checking onset of oestrus in cases of mares which would not settle at foal heat. At this oestrus following foal heat, mares were also served, once or more times depending on the duration of oestrus. Only natural service was allowed and no artificial insemination was practiced.

Pregnancy diagnosis was done about two months after

service. Observations pertaining to normal and abnormal termination of pregnancies were recorded. Heats occurring after pathological termination of pregnancy (abortion or stillbirth) were also recorded and the animals were bred at this heat. But these heats were not taken into consideration.

Weaning of the young foals was done mostly at the age of about six months.

In the present study the following factors pertaining to foal heat were taken for investigations.

1. Occurrence of foal heat.
2. Interval between foaling and foal heat.
3. Influence of sex of foal on the interval to foal heat.
4. Duration of foal heat.
5. Influence of sex of foal on foal heat duration.
6. Breeding efficiency at foal heat.
7. Pathological termination of pregnancy after breeding at foal heat.
8. Interval between foal heat and first subsequent heat.
9. Breeding efficiency at first subsequent heat.
10. Pathological termination of pregnancy after breeding at first subsequent heat.
11. Overall conception rate.
12. Overall abortion and stillbirths.

13. Comparison of conception rate at foal heat with that at first subsequent heat.
14. Seasonal influence on occurrence of foaling.

Study of the above factors was made by considering all the animals in three groups viz. (i) horse producing mares, (ii) mule producing mares and (iii) donkey mares. Comparisons of the different factors among the three groups of mares were also made by different statistical methods.

Following data were recorded for each mare and analysed.

1. Number and type of mare.
2. Date of foaling.
3. Sex of foal.
4. Date of commencement of foal heat.
5. Date of breeding.
6. Date of end of foal heat.
7. Pregnancy diagnosis.
8. Date of pathological termination of pregnancy i.e. abortion or stillbirth if any.
9. Date of normal physiological termination of pregnancy.
10. Date of first subsequent heat, if any.
11. Date of oestrus occurring within 18 days in cases of pathological terminations of pregnancy.

The desired items of study were considered as follows :

Occurrence of foal heat : It was taken as the percentage of foalings followed by oestrus starting within 18 days of foaling.

Interval between foaling and foal heat : The period in days between the date of foaling and the date of commencement of foal heat was taken to be the interval between foaling and foal heat.

Influence of sex of foal on the interval to foal heat : Interval between foaling and foal heat of those mares which foaled male foals was compared with that of mares which foaled female foals. The difference was considered to be due to the influence of sex of foal on the interval to foal heat.

Duration of foal heat : It was taken as the interval between the date the foal heat started and date of cessations of foal heat.

Influence of sex of foal on foal heat duration : Duration of foal heat of those mares which foaled male foals was compared with that of mares which foaled female foals and the difference was taken as due to the influence of sex of foal on the foal heat duration.

Breeding efficiency at foal heat : Conception rate of matings at foal heat was calculated.

Pathological termination of pregnancy : All the pregnancies which did not terminate normally, namely abortions and still-births were considered as pathological. These cases were separately recorded and incidences were worked out for those bred at foal heat and also for those bred at first subsequent heat.

Interval between foal heat and first subsequent heat and breeding efficiency at the latter : The interval between commencement of foal heat and commencement of first subsequent heat was found out. For breeding efficiency, conception rate at first subsequent heat was found out.

Overall conception rate : It was taken as conception rate of matings irrespective of foal heat mating or mating at subsequent heats.

Overall abortion and stillbirths : An overall incidence of abortion and stillbirth irrespective of conceptions at foal heat or at subsequent heats was found out in all the three groups of mares.

Seasonal influence on occurrence of foaling : All the foalings were distributed in all the twelve months of the year and were

tested statistically for equal distribution. For studying seasonal influence on occurrence of foaling, percentage of foalings was found out in five seasons which were considered as described by Ahuja (1958). These are given below :

(i) Summer (dry)	:	May and June
(ii) Summer (wet)	:	July, August and September
(iii) Autumn	:	October and November
(iv) Winter	:	December, January and February
(v) Spring	:	March and April

For statistical analysis of the data standard statistical procedures (Snedecor and Cochran, 1967) were followed.

RESULTS

OCCURRENCE OF FOAL HEAT

Occurrence of foal heat was studied by considering observations on mares which had foaled at least once. In mares 90.88 per cent of the foalings were followed by foal heat. Occurrence of foal heat was 92.38 per cent in mule producing mares and 81.91 per cent in horse producing mares whereas in donkey mares 80.36 per cent of the foalings were followed by foal heat. Table 6 details number of mares studied, number of foalings, number of foal heats observed and the percentage of foalings followed by foal heat.

Table 6

Occurrence of foal heat

Type of mares	No. of mares studied	No. of foalings	No. of foal heats	Percentage of foalings followed by foal heats
Mares	552	1316	1196	90.88
1. Horse producing mares	89	188	154	81.91
2. Mule producing mares	463	1128	1042	92.38
Donkey mares	20	56	45	80.36

It can be seen from the above table that the occurrence of foal heat ranged from 80.36 to 92.38 per cent.

Comparisons of the occurrence of foal heat among the three groups of mares were made by 'normal deviate test for proportions' and 'corrected chi-square test (with Yates correction)' and the values are indicated in Table 7.

Table 7

Differences in the incidence of foal heat between different groups of mares, and their respective values of normal deviate and corrected chi-square showing significance of the difference

	Mule producing mares and horse producing mares	Horse producing mares and donkey mares	Mule producing mares and donkey mares
Difference in percentage	10.47**	1.55 NS	12.02**
Value of normal deviate	4.612	0.263	-
Value of corrected chi-square	-	-	8.711

** = Significant at 1 per cent probability level
NS = Not significant

The incidence of foal heat in mule producing mares was 10.47 per cent higher than that of horse producing mares and

12.02 per cent higher than that of donkey mares. The differences were found to be highly significant. Occurrence of foal heat in donkey mares was 1.55 per cent lower than that of horse producing mares but the difference was statistically not significant.

INTERVAL BETWEEN FOALING AND FOAL HEAT

Average interval between foaling and foal heat, its standard error and range in three groups of mares have been shown in Table 8.

Table 8

Interval between foaling and foal heat

Type of mares	Average interval in days between foaling and foal heat		
	Average	S.E.	Range
Mares	6.286	±0.085	1-18
1. Horse producing mares	6.952	±0.133	1-14
2. Mule producing mares	6.104	±0.100	1-18
Donkey mares	8.579	±0.863	1-16

SE = Standard error.

Interval between foaling and foal heat was 6.286 ± 0.085 days, 6.952 ± 0.133 days, 6.104 ± 0.100 days and 8.579 ± 0.863 days in mares, horse producing mares, mule producing mares and donkey mares respectively.

Comparisons of the interval to foal heat among the three groups of mares were made by 't' test and the differences along with their values of 't' are presented in Table 9.

Table 9

Differences in interval to foal heat between different groups of mares and their respective values of 't' showing significance of the difference

	Horse producing mares and mule producing mares	Donkey mares and horse producing mares	Donkey mares and mule producing mares
Difference in days	0.848**	1.627 NS	2.475*
Value of 't'	5.078	1.864	2.848

* = Significant at 5 per cent probability level
** = Significant at 1 per cent probability level
NS = Not significant

The interval was 1.627 days longer in donkey mares than that of horse producing mares but the difference was statistically not significant. The interval between foaling and foal heat was 0.848 days longer in horse producing mares than that of mule producing mares, the difference being highly significant. Mule producing mares showed 2.475 days shorter interval than that of donkey mares. This difference was found significant at 0.05 probability level.

Distribution of interval between foaling and foal heat was studied and the interval was found to vary from 1 to 18 days in three groups of mares. 83.56 per cent of the horse producing mares, 79.85 per cent of the mule producing mares and 47.38 per cent of the donkey mares came in oestrus from 5 to 8 days of foaling. 4.11 per cent horse producing mares, 13.81 per cent mule producing mares and 5.26 per cent donkey mares came into heat within 4 days of foaling. Foal heat was found to occur from 9 to 18 days of foaling in 12.33 per cent horse producing mares, 6.34 per cent mule producing mares and 47.36 per cent donkey mares. Details regarding the distribution of the interval to foal heat are given in Table 10 and also shown diagrametically by bar diagrams in Fig. 1.

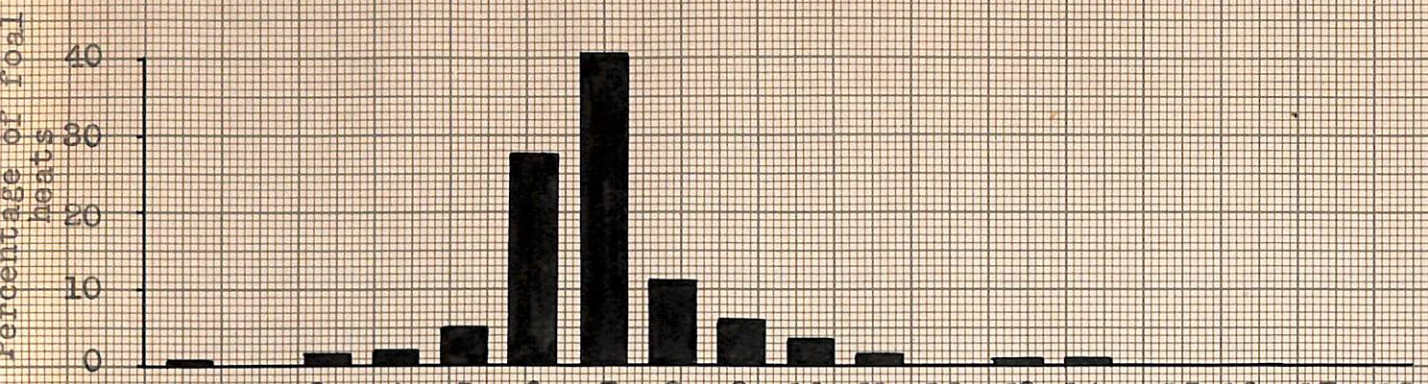
INFLUENCE OF SEX OF FOAL ON THE INTERVAL TO FOAL HEAT

Interval between foaling and foal heat of the mares

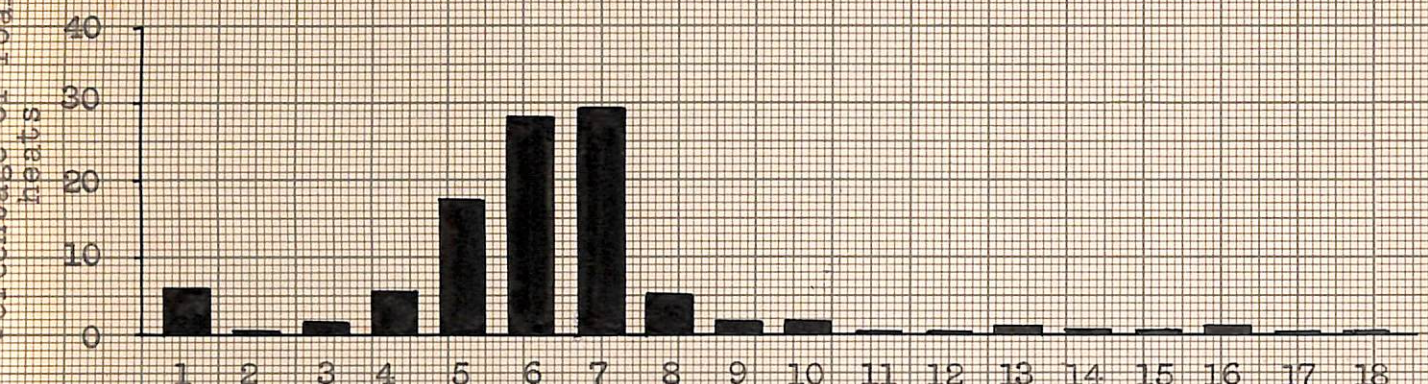
Table 10

Distribution of interval between foaling and foal heat in different groups of mares

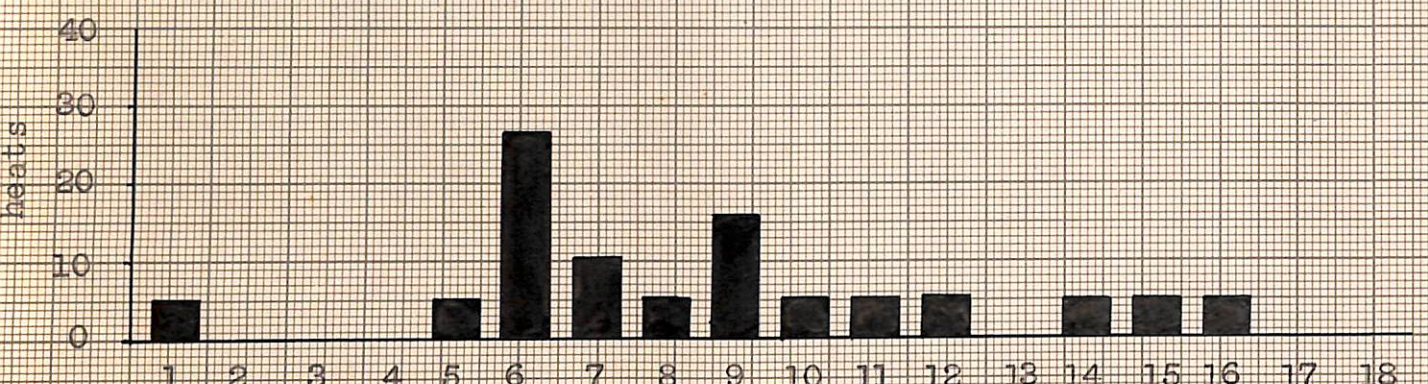
	Interval between foaling and foal heat in days																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
HORSE PRODUCING MARES																			
No. of heats	1	-	2	3	7	40	59	16	9	5	2	-	1	1	-	-	-	-	146
Percentage	0.69	-	1.37	2.05	4.79	27.40	40.41	10.96	6.16	3.42	1.37	-	0.69	0.69	-	-	-	-	100.06
Total		4.11%				83.56%								12.33%					100.00
MULE PRODUCING MARES																			
No. of heats	33	3	8	30	94	151	156	27	8	8	3	1	4	3	1	4	1	1	536
Percentage	6.16	0.56	1.49	5.60	17.54	28.17	29.10	5.04	1.49	1.49	0.56	0.19	0.74	0.56	0.19	0.74	0.19	0.19	100.00
Total		13.81%				79.85%								6.34%					100.00
DONKEY MARES																			
No. of heats	1	-	-	-	1	5	2	1	3	1	1	1	-	1	1	1	-	-	19
Percentage	5.26	-	-	-	5.26	26.32	10.54	5.26	15.80	5.26	5.26	5.26	-	5.26	5.26	5.26	-	-	100.00
Total		5.26%				47.38%								47.36%					100.00



Horse Producing Mares



Mule Producing Mares



Donkey Mares

Fig. 1. Diagrametical presentation of distribution of interval between foaling and foal heat

producing male foals was compared with that of mares producing female foals by 't' test. Statistically no significant difference was found in three groups of mares i.e. horse producing mares, mule producing mares and donkey mares.

Average interval between foaling and foal heat, its standard error, range for both the groups (one producing male foals and the other producing female foals) of mares and the difference of the averages along with value of 't' showing its insignificance have been presented in Table 11.

DURATION OF FOAL HEAT

Average foal heat duration, its standard error and range have been shown in Table 12.

Foal heat duration was 5.595 ± 0.068 days, 5.269 ± 0.127 days, 5.684 ± 0.079 days and 5.842 ± 0.503 days in mares, horse producing mares, mule producing mares and donkey mares respectively.

Table 11

Influence of sex of foal on interval between foaling and foal heat

Type of mares	When the sex of foal is male			When the sex of foal is female			Difference in average interval to foal heat (in days) between those of two sexes	Value of 't'
	Average	S.E.	Range	Average	S.E.	Range		
Mares	6.305	±0.117	1-18	6.266	±0.122	1-17	0.039 NS	0.231
1. Horse producing mares	6.833	±0.203	1-13	7.050	±0.177	3-14	0.217 NS	0.810
2. Mule producing mares	6.182	±0.136	1-18	6.016	±0.147	1-17	0.166 NS	0.830
Donkey mares	8.800	±0.929	5-14	8.333	±1.563	1-16	0.467 NS	0.263

SE = Standard error
NS = Not significant

Table 12

Duration of foal heat

Type of mares	Average duration of foal heat in days		
	Average	S.E.	Range
Mares	5.595	±0.068	2-13
1. Horse producing mares	5.269	±0.127	2-13
2. Mule producing mares	5.684	±0.079	2-13
Donkey mares	5.842	±0.503	2-11

SE = Standard error

Comparisons of the foal heat duration were made among the three groups of mares by 't' test. Differences of the averages and the values of 't' showing their significance have been presented in Table 13.

Table 13

Differences in foal heat duration between different groups of mares and their respective values of 't' showing significance of the difference

	Mule producing mares and horse producing mares	Donkey mares and horse producing mares	Donkey mares and mule producing mares
Difference in days	0.415**	0.573 NS	0.158 NS
Value of 't'	2.774	1.104	0.310

** = Significant at 1 per cent probability level
NS = Not significant

Foal heat duration was 0.415 days longer in mule producing mares than that of horse producing mares and the difference was highly significant. In donkey mares the duration was 0.573 days longer than that of horse producing mares and 0.158 days longer than that of mule producing mares. But in both the cases the difference was not significant.

Distribution of foal heat duration was studied and the oestrus duration was found to vary from 2 to 13 days in the three groups of mares. The duration was 3 to 7 days in 93.10 per cent horse producing mares, 88.20 per cent mule producing

mares and 84.21 per cent donkey mares. It was 2 days in 0.69 per cent horse producing mares, 0.56 per cent mule producing mares and 5.26 per cent donkey mares. 6.21 per cent horse producing mares, 11.24 per cent mule producing mares and 10.53 per cent donkey mares showed foal heat of 8 to 13 days duration. Details regarding the distribution of foal heat duration are presented in Table 14 and also shown diagrametically by bar diagrams in Fig. 2.

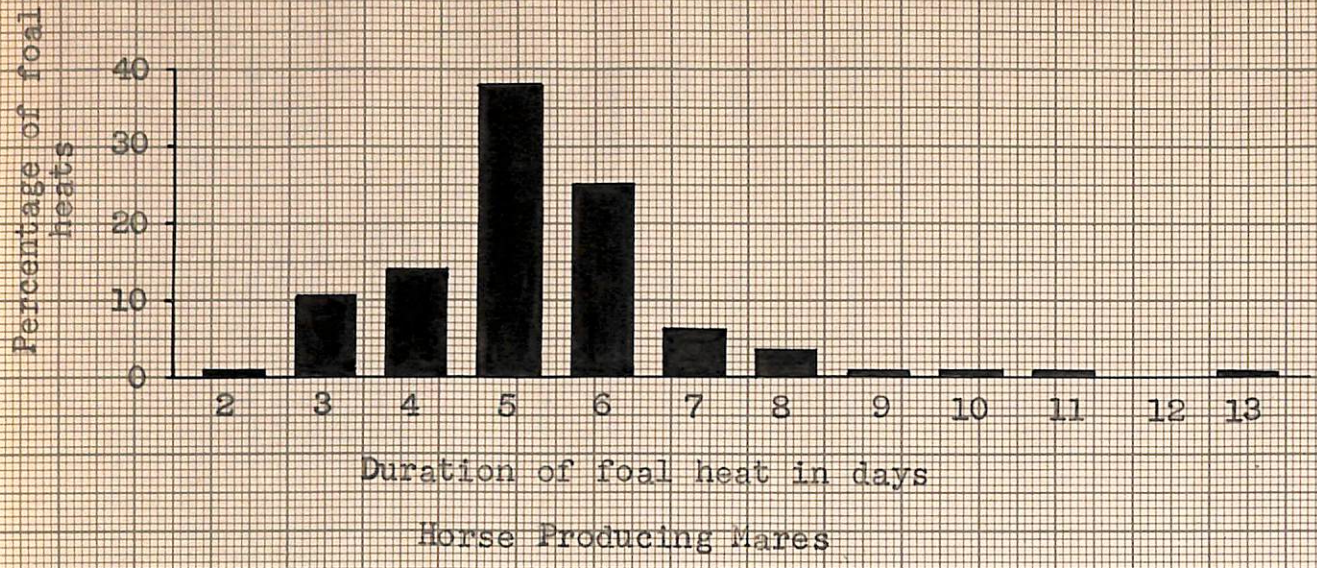
INFLUENCE OF SEX OF FOAL ON FOAL HEAT DURATION

Average duration of foal heat, its standard error and range for mares giving birth to male foals and for those giving birth to female foals were found out separately in three groups of mares. Difference of average foal heat durations was tested by 't' test. No significant difference was found in horse producing mares, mule producing mares as well as donkey mares. Detailed figures are presented in Table 15.

Table 14

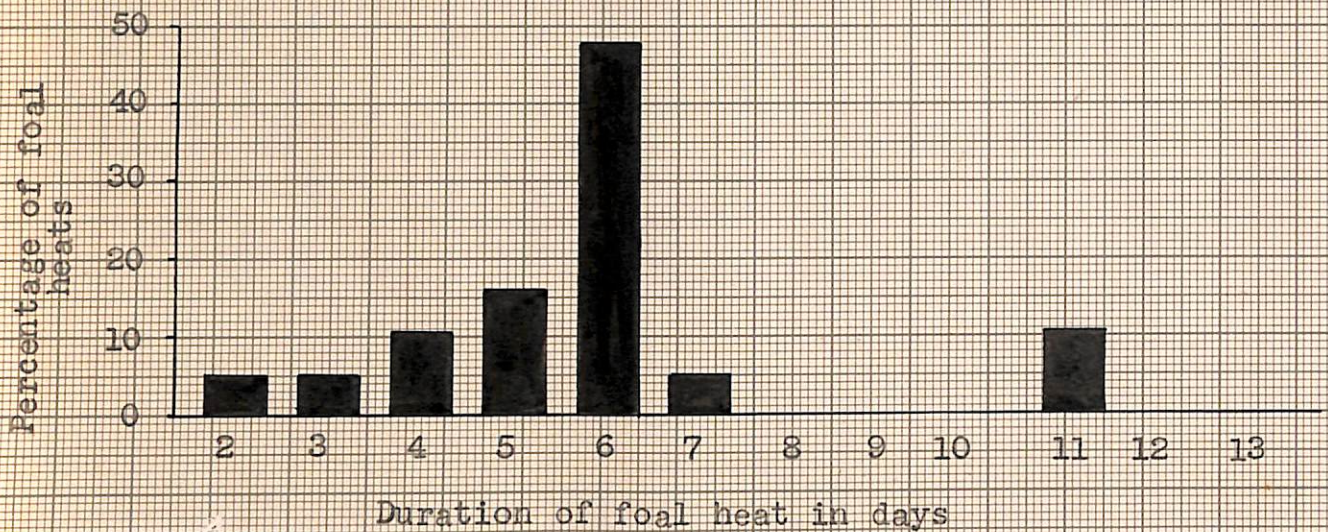
Distribution of foal heat duration in different groups of mares

	Duration of foal heat in days												
	2	3	4	5	6	7	8	9	10	11	12	13	Total
HORSE PRODUCING MARES													
No. of heats	1	15	20	55	36	9	5	1	1	1	-	1	145
Percentage	0.69	10.34	13.79	37.93	24.83	6.21	3.45	0.69	0.69	0.69	-	0.69	100.00
Total	0.69%	93.10%					6.21%						100.00
MULE PRODUCING MARES													
No. of heats	3	50	58	180	101	82	25	7	11	11	5	1	534
Percentage	0.56	9.36	10.86	33.71	18.91	15.36	4.68	1.31	2.06	2.06	0.94	0.19	100.00
Total	0.56%	88.20%					11.24%						100.00
DONKEY MARES													
No. of heats	1	1	2	3	9	1	-	-	-	2	-	-	19
Percentage	5.26	5.26	10.53	15.79	47.37	5.26	-	-	-	10.53	-	-	100.00
Total	5.26%	84.21%					10.53%						100.00



Horse Producing Mares

Mule Producing Mares



Donkey Mares

Fig. 2. Diagrametical presentation of distribution of foal heat duration

Table 15

Influence of sex of foal on duration of foal heat

Type of mares	When the sex of foal is male			When the sex of foal is female			Difference in average foal heat duration (in days) between those of two sexes	Value of 't'
	Average	S.E.	Range	Average	S.E.	Range		
Mares	5.570	±0.091	2-12	5.621	±0.102	2-13	0.051 NS	0.372
1. Horse producing mares	5.369	±0.204	2-11	5.188	±0.160	3-13	0.181 NS	0.708
2. Mule producing mares	5.616	±0.102	3-12	5.760	±0.123	2-13	0.144 NS	0.900
Donkey mares	5.700	±0.716	2-11	6.000	±0.745	3-11	0.300 NS	0.290

SE = Standard error
NS = Not significant

CONCEPTION RATE AT FOAL HEAT

Conception rate at foal heat was calculated. Table 16 shows total number of matings at foal heat, total number of conceptions by mating at foal heat and per cent conception rate, in horse producing mares, mule producing mares and donkey mares.

Table 16

Conception rate at foal heat

Type of mares	Total No. of matings at foal heat	Total No. of conceptions by mating at foal heat	Per cent conception rate
Mares			
1. Horse producing mares	154	52	33.77
2. Mule producing mares	1042	342	32.82
Donkey mares	45	19	42.22

In mule producing mares, conception rate was 32.82 per cent while in horse producing mares it was 33.77 per cent. Conception rate was found to be 42.22 per cent in donkey mares. Comparisons of conception rate among the three groups of mares were made by 'normal deviate test for proportions' and the values of normal deviate along with the differences are

mentioned in Table 17.

Table 17

Differences in conception rate at foal heat between different groups of mares and their respective values of normal deviate showing significance of the difference

	Horse producing mares and mule producing mares	Donkey mares and horse producing mares	Donkey mares and mule producing mares
Difference in percentage	0.95 NS	8.45 NS	9.40 NS
Value of normal deviate	0.234	1.041	1.311

NS = Not significant

Mule producing mares showed 0.95 per cent lesser conception rate than that of horse producing mares. In donkey mares, conception rate was 9.40 per cent higher than that of mule producing mares and 8.45 per cent higher than that of horse producing mares. The differences among these groups were found to be insignificant.

PATHOLOGICAL TERMINATION OF PREGNANCY AFTER BREEDING AT FOAL HEAT

The incidence of abortion and stillbirth was worked out in the mares conceived as a result of mating during foal heat.

Number of pregnancies by foal heat breeding, number of abortions, number of stillbirths and their percentages in all the three groups of mares are given in Table 18.

Table 18

Pathological termination of pregnancy (abortion and stillbirth) after breeding at foal heat

Type of mares	No. of pregnancies as a result of breeding at foal heat	Abortions		Stillbirths	
		No.	Percentage	No.	Percentage
Mares					
1. Horse producing mares	27	2	7.407	0	0.000
2. Mule producing mares	256	22	8.594	3	1.172
Donkey mares	18	0	0.000	0	0.000

In mule producing mares the incidence of abortion was 8.594 per cent being slightly higher than that of horse producing mares in which it was 7.407 per cent. No abortion took place in donkey mares. Comparison of the incidence of abortion among the three groups of mares was made by 'corrected chi-square test (with Yates correction)' and Fisher's exact method of calculating probability. Values of chi-square and probability are presented in Table 19.

Table 19

Differences in the incidence of abortion and stillbirth between different groups of mares, and their respective values of corrected chi-square and probability showing significance of the difference

	Mule producing mares and horse producing mares	Horse producing mares and donkey mares	Mule producing mares and donkey mares
ABORTION			
Difference in percentage	1.187 NS	7.407 NS	8.594 NS
Value of corrected chi-square	0.023	-	0.719
Value of probability	-	0.35	-
STILLBIRTH			
Difference in percentage	1.172 NS	0.000	1.172 NS
Value of corrected chi-square	0.178	-	0.504

NS = Not significant

The differences in the incidence of abortion were statistically insignificant among all the three groups of mares.

In mule producing mares 1.172 per cent of the pregnancies terminated in stillbirths while no case of stillbirth was recorded in horse producing mares as well as in donkey mares. The differences in the incidence of stillbirth among the three groups of mares were not significant.

INTERVAL BETWEEN FOAL HEAT AND FIRST SUBSEQUENT HEAT

Average interval between foal heat and first subsequent heat, its standard error and range in horse producing mares, mule producing mares and donkey mares are presented in Table 20.

Table 20

Interval between foal heat and first subsequent heat

Type of mares	No. of observations	Interval in days between foal heat and first subsequent heat		
		Average	S.E.	Range
Mares				
1. Horse producing mares	90	88.544	±7.889	13-293
2. Mule producing mares	225	80.827	±4.637	14-294
Donkey mares	12	51.000	±15.236	16-202

SE = Standard error

In horse producing mares the interval was 88.544 ± 7.889 days while in mule producing mares it was 80.827 ± 4.637 days. In donkey mares the interval was 51.000 ± 15.236 days. Comparison for the significance of the differences among the average intervals of the three groups of mares was made by 't' test and its values are presented in Table 21.

Table 21

Differences in the average interval between foal heat and first subsequent heat in different groups of mares and their respective values of 't' showing significance of the difference

	Horse producing mares and mule producing mares	Horse producing mares and donkey mares	Mule producing mares and donkey mares
Difference in days	7.717 NS	37.544*	29.827 NS
Value of 't'	0.843	2.188	1.873

* = Significant at 5 per cent probability level
NS = Not significant

In horse producing mares the interval was longer by 7.717 days than that of mule producing mares but the difference was statistically insignificant. In donkey mares the interval

was less than that of horse producing mares by 37.544 days, the difference being significant at 5 per cent probability level. The difference between the interval of mule producing mares and that of donkey mares was 29.827 days being insignificant statistically.

CONCEPTION RATE AT FIRST SUBSEQUENT HEAT

Conception rate at the first heats subsequent to foal heats was calculated. Number of matings, number of conceptions and per cent conception rate at first subsequent heat are listed in Table 22.

Table 22

Conception rate at first subsequent heat

Type of mares	Total No. of matings at first subsequent heat	Total No. of conceptions by mating at first subsequent heat	Per cent conception rate
Mares			
1. Horse producing mares	100	34	34.00
2. Mule producing mares	559	160	28.62
Donkey mares	21	7	33.33

Conception rates were 34.00%, 28.62% and 33.33% in horse producing mares, mule producing mares and donkey mares respectively.

Comparisons of conception rate among different groups of mares were made by normal deviate test for proportions and the values of normal deviate along with differences are mentioned in Table 23.

Table 23

Differences in conception rate at first subsequent heat between different groups of mares and their respective values of normal deviate showing significance of the difference

	Horse producing mares and mule producing mares	Horse producing mares and donkey mares	Donkey mares and mule producing mares
Difference in percentage	5.38 NS	0.67 NS	4.71 NS
Value of normal deviate	1.087	0.059	0.468

NS = Not significant

Conception rate in mule producing mares was 5.38 per cent lower than that of horse producing mares and

4.71 per cent lower than that of donkey mares. Horse producing mares showed 0.67 per cent higher conception rate than that of donkey mares. All these differences were not found to be significant among the three groups of mares.

PATHOLOGICAL TERMINATION OF PREGNANCY AFTER BREEDING AT FIRST SUBSEQUENT HEAT

The incidence of abortion and stillbirth was found out in mares mated at first subsequent oestrus following foal heat. Total number of pregnancies as a result of breeding at first subsequent heat, number of abortions, number of stillbirths and their percentages in three groups of mares are presented in Table 24.

Table 24

Pathological termination of pregnancy (abortion and stillbirth) after breeding at first subsequent heat

Type of mares	Total No. of pregnancies as a result of breeding at first subsequent heat	Abortions		Stillbirths	
		No.	Percentage	No.	Percentage
Mares					
1. Horse producing mares	16	0	0.000	0	0.000
2. Mule producing mares	127	6	4.724	1	0.787
Donkey mares	6	1	16.667	0	0.000

In mule producing mares 4.724 per cent and in donkey mares 16.667 per cent of the pregnancies terminated in abortion. No case of abortion was noticed in horse producing mares.

In mule producing mares 0.787 per cent of the pregnancies terminated in stillbirths. In horse producing mares and in donkey mares, no case of stillbirth was recorded.

Comparisons of the incidence of abortion and stillbirth among three groups of mares are given in Table 25. These were made by Fisher's exact method of calculating probability. The differences were statistically not significant though donkey mares showed higher percentage of abortion than that of mule producing mares.

Table 25

Differences in the incidence of abortion and stillbirth after breeding at first subsequent heat, between different groups of mares and their respective values of probability showing significance of the difference

	Mule producing mares and horse producing mares	Donkey mares and horse producing mares	Donkey mares and mule producing mares
ABORTION			
Difference in percentage	4.724 NS	16.667 NS	11.943 NS
Value of probability	0.48	0.27	0.97
STILLBIRTH			
Difference in percentage	0.787 NS	-	0.787 NS
Value of probability	0.89	-	0.95

NS = Not significant

OVERALL CONCEPTION RATE

Overall number of matings, number of conceptions and per cent conception rate in three groups of mares are presented in Table 26.

Table 26

Overall conception rate

Type of mares	Overall No. of matings	Overall No. of conceptions	Per cent conception rate
Mares			
1. Horse producing mares	783	282	36.02
2. Mule producing mares	6046	1530	25.31
Donkey mares	245	69	28.16

Conception rates were 36.02 per cent, 25.31 per cent and 28.16 per cent in horse producing mares, mule producing mares and donkey mares respectively.

Comparisons of conception rate in three groups of mares were made by 'normal deviate test for proportions'. Table 27 shows differences of overall conception rate and values of normal deviate among the three groups.

Table 27

Differences in overall conception rate between different groups of mares and their respective values of normal deviate showing significance of the difference

	Horse producing mares and mule producing mares	Horse producing mares and donkey mares	Donkey mares and mule producing mares
Difference in percentage	10.71**	7.86*	2.85 NS
Value of normal deviate	6.375	2.265	1.004

* = Significant at 5 per cent probability level
** = Significant at 1 per cent probability level
NS = Not significant

In horse producing mares conception rate was 10.71 per cent more than that of mule producing mares and statistically the difference was highly significant. In donkey mares the conception rate was lower than that of horse producing mares by 7.86 per cent, the difference being significant only at 0.05 probability level. Mule producing mares showed 2.85 per cent lower conception rate than that of donkey mares but the difference was statistically insignificant.

OVERALL ABORTION AND STILLBIRTHS

Overall incidence of abortion and stillbirth was worked out by taking into consideration all the pregnancies irrespective of those resulting by foal heat breeding, breeding at first subsequent heat and by breeding thereafter. In horse producing mares 9.135 per cent, in mule producing mares 8.629 per cent and in donkey mares 6.667 per cent of the pregnancies terminated in abortion. Detailed figures are listed in Table 28.

Table 28

Overall abortions and stillbirths

Type of mares	Overall total No. of pregnancies	Abortions		Stillbirths	
		No.	Percentage	No.	Percentage
Mares					
1. Horse producing mares	208	19	9.135	1	0.481
2. Mule producing mares	1240	107	8.629	5	0.403
Donkey mares	60	4	6.667	0	0.000

Comparisons of the incidence of abortion among the three groups of mares were made by normal deviate test for

proportions. Incidence of abortion in horse producing mares was 0.51 per cent higher than that of mule producing mares and 2.47 per cent higher than that of donkey mares. Mule producing mares showed 1.96 per cent more abortions than that of donkey mares. Differences were found to be insignificant statistically.

The incidence of stillbirth was 0.481 per cent in horse producing mares and 0.403 per cent in mule producing mares. No case of stillbirth was recorded in donkey mares.

Comparisons of the incidence of stillbirth were made by 'corrected chi-square test (with Yates correction)' among the three groups of mares. The differences were not significant statistically, though horse producing mares showed slightly higher percentage of stillbirth than that of mule producing mares.

Differences in the incidence of abortion and stillbirth, values of normal deviate and values of corrected chi-square are presented in Table 29.

Table 29

Differences in overall incidence of abortion and stillbirth between different groups of mares, and their respective values of normal deviate and corrected chi-square showing significance of the difference

	Horse producing mares and mule producing mares	Horse producing mares and donkey mares	Mule producing mares and donkey mares
ABORTION			
Difference in percentage	0.51 NS	2.47 NS	1.96 NS
Value of normal deviate	0.242	0.602	0.531
STILLBIRTH			
Difference in percentage	0.78 NS	0.481 NS	0.403 NS
Value of corrected chi-square	0.178	0.440	0.331

NS = Not significant

COMPARISON OF CONCEPTION RATE AT FOAL HEAT WITH THAT AT FIRST SUBSEQUENT HEAT

Conception rate at foal heat was compared with that at first subsequent heat in three groups of mares. In horse producing mares conception rate at foal heat was found to be 0.23 per cent lower than that at first subsequent heat. But

conception rate at foal heat was found to be 4.20 per cent higher in mule producing mares and 8.89 per cent higher in donkey mares than that at first subsequent heat in the same groups of mares. However the differences were not found to be significant statistically. Conception rate at foal heat, conception rate at first subsequent heat, differences between the two and their values of normal deviate showing insignificance of the differences, in three groups of mares are presented in Table 30.

Table 30

Differences between conception rate at foal heat and that at first subsequent heat, and their respective values of normal deviate showing insignificance of the difference in different groups of mares

	Per cent conception rate at foal heat	Per cent conception rate at first subsequent heat	Difference	Value of normal deviate
Mares				
1. Horse producing mares	33.77	34.00	0.23 NS	0.038
2. Mule producing mares	32.82	28.62	4.20 NS	1.728
Donkey mares	42.22	33.33	8.89 NS	0.689

NS = Not significant

SEASONAL INFLUENCE ON OCCURRENCE OF FOALING

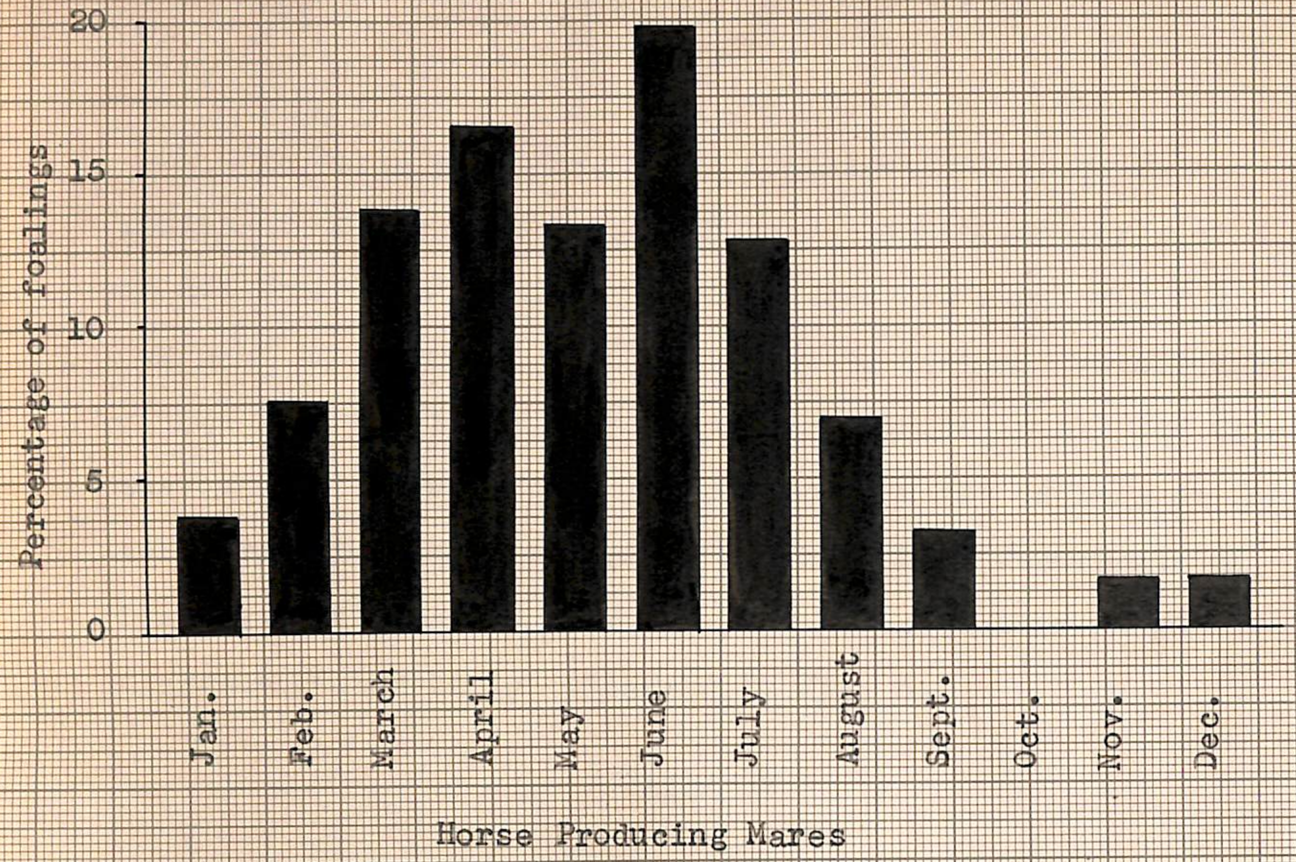
Monthwise distribution of foalings was done in horse producing mares and in mule producing mares. In horse producing mares foalings occurred from 1.60 per cent in November and December to 19.68 per cent in the month of June. In mule producing mares foalings took place from 1.33 per cent in the month of November to 19.15 per cent in the month of April. However 76.06 per cent of the foalings in horse producing mares and 75.18 per cent of the foalings in mule producing mares occurred from March to July. Only 23.94 per cent of the foalings in horse producing mares and 24.82 per cent of the foalings in mule producing mares took place from August to next February. Number of foalings and their percentages in all the twelve months of the year in horse producing mares as well as in mule producing mares are detailed in Table 31. Monthwise distribution of foalings in two groups of mares has also been shown diagrametically by bar diagrams in Fig. 3.

Chi-square test of goodness of fit was applied for testing equal distribution of foalings in different months of the year. Highly significant values of chi-square (108.785 for horse producing mares and 620.702 for mule producing mares) at 0.001 probability level indicated that occurrence of foaling was significantly different in different months of the year.

Table 31

Monthwise distribution of foalings in two groups of mares

	Month of foalings												
	January	February	March	April	May	June	July	August	September	October	November	December	Total
HORSE PRODUCING MARES													
No. of foalings	7	14	26	31	25	37	24	12	6	-	3	3	188
Percentage	3.72	7.45	13.83	16.49	13.30	19.68	12.76	6.38	3.19	-	1.60	1.60	100.00
Total	11.17%		76.06%						12.77%				100.00
MULE PRODUCING MARES													
No. of foalings	27	50	143	216	203	132	154	82	61	25	15	20	1128
Percentage	2.39	4.43	12.68	19.15	18.00	11.70	13.65	7.27	5.41	2.22	1.33	1.77	100.00
Total	6.82%		75.18%						18.00%				100.00



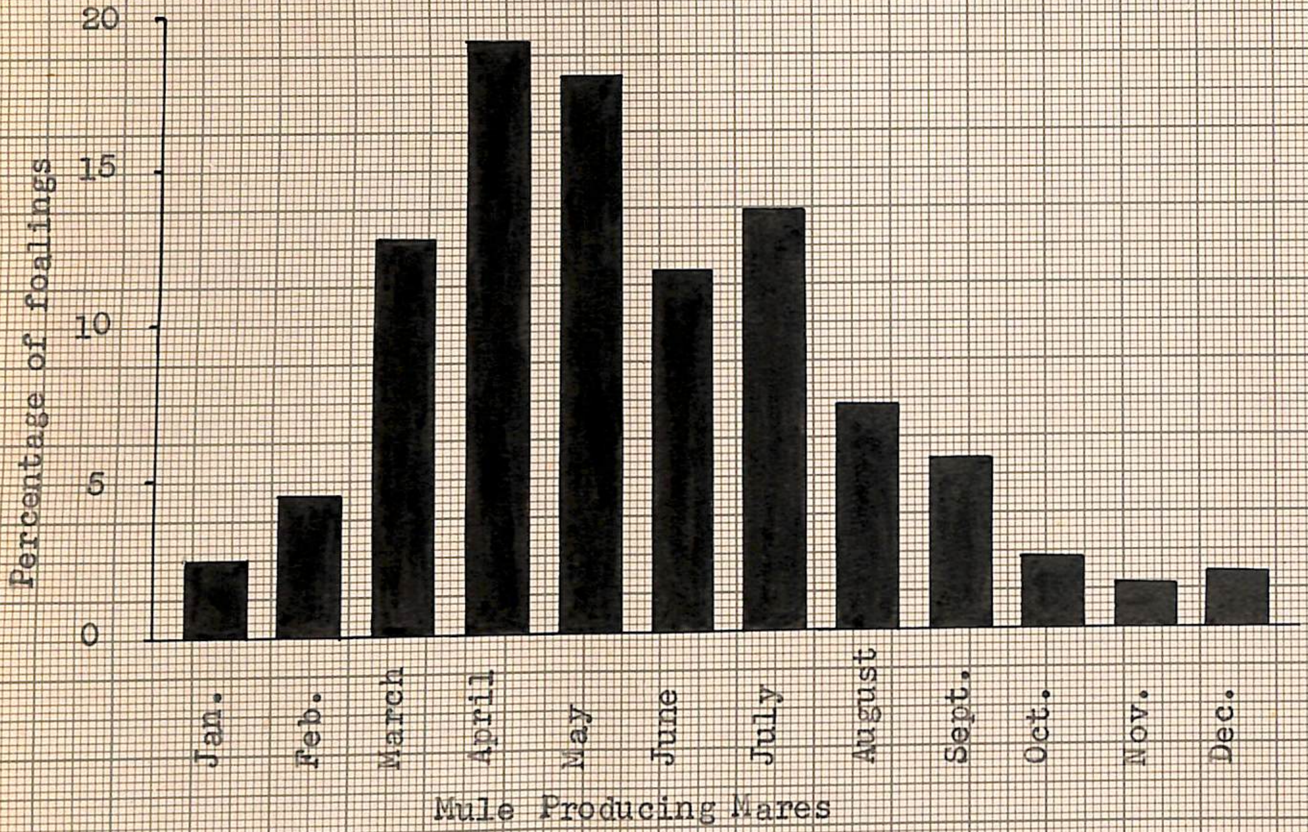


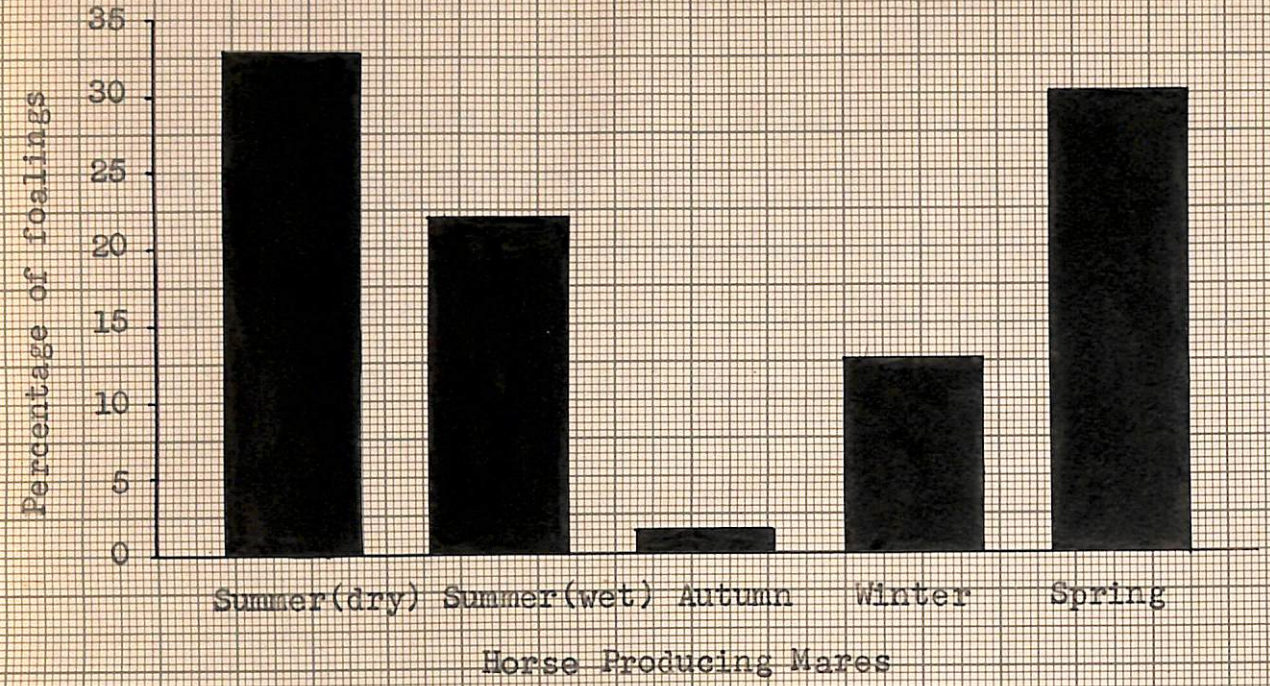
Fig. 3. Diagrametical presentation of monthwise distribution of foalings

In horse producing mares foalings took place from minimum 1.60 per cent in autumn to maximum 32.98 per cent in dry summer. In mule producing mares the range was 3.55 per cent in autumn to 31.83 per cent in spring. Total number of foalings and their respective percentages in all the five seasons of the year for horse producing mares as well as for mule producing mares are given in Table 32. Occurrence of foaling in five seasons of the year has also been shown diagrametically by bar diagrams in Fig. 4.

Table 32

Occurrence of foaling in different seasons of the year

	Season of foalings					
	Summer (dry)	Summer (wet)	Autumn	Winter	Spring	Total
			HORSE PRODUCING MARES			
No. of foalings	62	42	3	24	57	188
Percentage	32.98	22.33	1.60	12.77	30.32	100.00
			MULE PRODUCING MARES			
No. of foalings	335	297	40	97	359	1128
Percentage	29.70	26.33	3.55	8.59	31.83	100.00



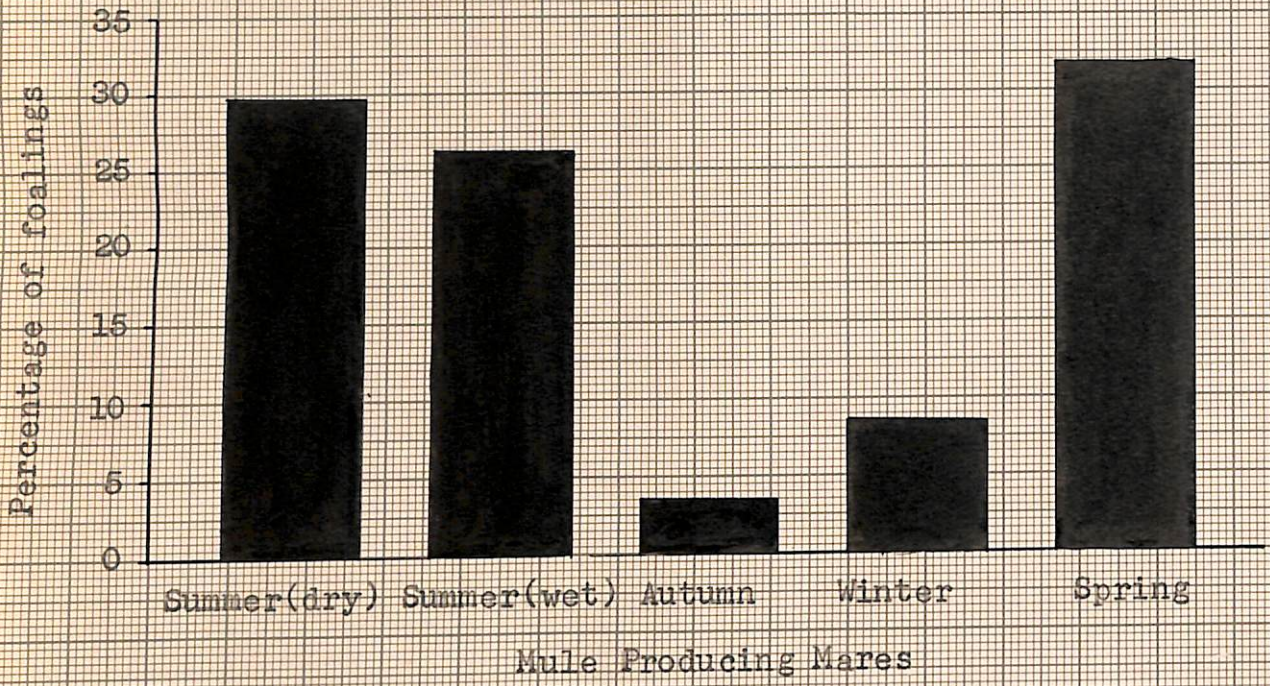


Fig. 4. Diagrametical presentation of occurrence of foaling in different seasons

Comparison of horse producing mares was made with mule producing mares in regard to the effect of season on occurrence of foalings by chi-square test for proportions. The value of chi-square was 21.037. The effect of season on occurrence of foaling in horse producing mares was not significantly different from that in mule producing mares.

DISCUSSION

The efficiency of rate of reproduction is the first basis of economic production. This was stated by Heape (1898). With a view to augment the livestock production it is imperative that all the farm animals should have high efficiency in reproduction. In India several schemes are already in progress for overall improvement of livestock sponsored by Central Government, various State Governments, semi-government and private organisations, and there are also some projects with foreign collaboration. Artificial insemination which was started about 25 years back has now been widely accepted as a tool for rapid improvement of our bovine stock. Simultaneously researches have been in progress concerning various reproductive processes in both cattle and buffaloes during the past 25 years. Good information is now available for the pattern of oestrous cycle for various breeds in different parts of the country. The oestrus in all mammals is a very vulnerable stage during which pregnancy can occur provided there is optimum endocrine balance which should help ovulation in right time and prepare uterus for the reception and nidation of fertilized ovum. The main problem of bovine reproduction in India is the aberration in the manifestation of oestrus, buffaloes in particular. In many animals the intensity of heat is so weak that external

symptoms are seldom noticed and this is a major hurdle in artificial insemination organisation. Basically bovines have a low level of FSH (Follicular Stimulating Hormone) and in comparison, the LH (Luteinizing hormone) circulation in the circulatory system is at a higher level. Bovines are the only species of farm animals where ovulation occurs much later after the end of heat and as already mentioned above in buffaloes the artificial insemination worker faces the problem of silent heat. Such buffaloes in an artificial insemination organisation go unserved as the heat is not detected (though possibly they can become pregnant if left with bulls in natural service) and as a result the calf crop drops down.

In equines the pattern of oestrous cycle is rather much different than that observed in bovines and other farm stock. The level of FSH is considerably very high and there is no problem of evincing of heat. The duration of oestrous in equine is also comparatively much longer, about 3 to 7 days or more, than in bovines where the duration of oestrous is very short about a day or so. The clinical symptoms of oestrus in mares are also much more intense as exhibited by changes in the external genitalia, stringy or wiry mucus though sometimes not very copius and a peculiar behaviour of the females with intense sexual excitement as evidenced by movements of the clitoris and the vulvar labia. The main

problem really is that the oestrus sometimes may last for very long time, even for a month and not followed by ovulation. This is due to basically low level of LH. Histological structure of hypophysis in equine is much different than that in bovines.

Equines though are polyoestrous animals do not come into heat throughout all the seasons as they are largely influenced by seasonal factors. They show polyoestrous pattern of oestrous cycle during particular seasons only and during other times a large number of them remain anoestrus. For the horse breeder, therefore, it becomes very difficult to organise his breeding programme because he cannot expect foals all the year round as a dairy breeder producing calves through all the seasons. In equines during the last month of pregnancy the graafian follicle starts developing and soon after foaling this growth is accelerated and the animal shows oestrus within a very short time after parturition as a result of development of mature follicles in the ovaries. This phenomena is never observed in other species of farm animals except possibly in camels (Cole and Cupps, 1959). The horse breeders exploit this oestrus for breeding purpose and stallions are allowed to serve them. Their aim is obviously to produce the foal as early as possible for various economic reasons. It is a common belief among horse breeders that if this oestrus

is missed the next heat may be delayed considerably and it will take a long time before regular oestrous cycles will follow. There are chances that the mares may become pregnant at this early heat after parturition and hence this heat has been termed as 'foal heat'. This term also might have come into usage as the oestrus occurs soon after foaling.

In the present study occurrence of foal heat in mule producing mares was found to be significantly more than that of horse producing mares and also significantly more than that of donkey mares. Horse producing mares were found to show foal heat 6.952 ± 0.133 days after foaling. According to McKenzie and Andrews (1937) the interval between foaling and foal heat was 7.25 days. Skatkin (1948) found this period to be 5 to 12 days for 80-90 per cent of the mares and Hadi (1966) reported below 14 days in 77.2 per cent of mares. The findings are in agreement with those reported by these authors. 87.67 per cent of the horse producing mares were found to show foal heat within 8 days of foaling. Interval to foal heat specifically for donkey mares and for mule producing mares has not yet been reported in literature. Mule producing mares took on an average 0.848 days less than that of horse producing mares and the difference was statistically significant. However, this phenomenon is not understood as to how the foetus produced as a result of service by donkey stallion effects the

mares to evince foal heat later. The interval was also found to be 1.627 days more in donkey mares than that in horse producing mares but here the difference was not significant. Sex of the foal did not affect the interval to foal heat.

Duration of foal heat has got direct bearing on conception as ovulation occurs about 1-3 days before the end of oestrus. According to Aehnelt and Plas (1946), Skatkin (1948) and Du Plessis (1964) foal heat lasts 2 to 13 days. These findings were similar to those for horse producing mares and mule producing mares in the present study. Donkey mares were found to remain in oestrus for 2-11 days. On an average the duration of oestrus in mule producing mares was 0.415 days more than that in horse producing mares and this difference was highly significant. Sex of foal was not found to have any influence on foal heat duration. Such type of findings have not been reported in literature.

The scientific data concerning the breeding efficiency at foal heat are conflicting. Some authors [Mahaffey (1950), Jordao et al. (1954) and Deskur (1964)] reported a high conception rate from 60 per cent and above while others reported a very low conception rate [Robles (1947), Chieffi et al. (1962) and Hadi (1966)].

In the present study a conception rate of 33.77 per cent

has been obtained in mares which were used for producing horse foals. This rate dropped down to 32.82 per cent in mares which were bred for obtaining mule foals. In donkey mares, however, a conception rate of 42.22 per cent has been obtained. From the literature it seems that where smaller herds are involved better conception rates at foal heat are usually obtainable. Obviously in such small herds better care and management is possible which may help to obtain such higher conception rates. In some herds where large number of animals are involved as in Bulgaria, conception rates as high as 61.5 have been reported. In such countries organised horse breeding has been going on for centuries and the breeding efficiency of the stock might also have been raised possibly through systematic planned breeding. The entire agricultural operations depended on horse and naturally strictest attention might have been paid to the equine husbandry. Findings of the present study were not, however, much different from those obtained by Williams (1926), Bain (1948) and Cannas Simoes and Nunes Duarte (1963). They reported on an average 30 to 36 per cent conception for mares bred during foal heat.

Some authors believe that mares if conceived as a result of breeding at foal heat may have more number of abortions than otherwise. Williams (1926), Jennings (1941) and Hadi (1966) reported 11.1 per cent, 12.8 per cent and

18.5 per cent abortions respectively for mares conceived at foal heat. In the present study only 7.41 per cent abortions for horse producing mares and 8.59 per cent abortions for mule producing mares were found; and in donkey mares no case of abortion was recorded. Hygienic precaution taken at the time of parturition may have significant effect on normal or pathological termination of pregnancy.

If the foal heat is missed, the subsequent heat is usually greatly delayed. Chieffi et al. (1962) recorded that of the mares which did not conceive during post-partum oestrus 74.3 per cent did not come in heat again until after weaning. Constantinescu and Mauch (1936) found that first subsequent heat appears 30-37 days after foaling. In the present study the interval between foal heat and first subsequent heat was 88.544 ± 7.889 days for horse producing mares and for mule producing mares it was 80.827 ± 4.637 days. The range for both the groups was 13 to 294 days. For donkey mares this interval was 51.000 ± 15.236 days and differed significantly from horse producing mares. Constantinescu and Mauch (1936), Bain (1948) and Chieffi et al. (1962) reported very high conception rate of 56.3 to 63.0 per cent by mating at first subsequent heat. But in the present study conception rate for horse producing mares, mule producing mares and for donkey mares was 34.00, 28.62 and 33.33 per cent respectively. Except

for horse producing mares these figures are less than those obtained by foal heat breeding in the present study, though statistically the differences were not significant. References regarding the difference of conception rate at first subsequent heat between horse producing mares and that of mule producing mares are not available. In the present study these differences were also found to be insignificant.

Incidences of pathological termination of pregnancy at first subsequent heat were also found out. Incidences of abortion in mule producing mares and in donkey mares were 4.72 and 16.67 per cent respectively. No abortion was observed in horse producing mares. Williams (1926) and Jennings (1941) found 4.1 per cent and 3.2 per cent abortions respectively by breeding at other than foal heats. The incidence of abortion specifically at first subsequent heat has not yet been reported. Incidence of stillbirth in mule producing mares was found to be 0.79 per cent at first subsequent heat. No case of stillbirth was recorded in horse producing as well as in donkey mares. Jennings (1941) found 1.25 per cent stillbirths by breeding at other than foal heats.

In the present study overall conception rate for horse producing, mule producing and for donkey mares was found to be 36.02 per cent, 25.31 per cent and 28.16 per cent respectively. Some authors have reported very high overall conception rate

for mares. Popov et al. (1968) found 83.8 per cent conception rate. Jaworowska (1967) could observe conception rate as high as 100 per cent. Jordao et al. (1954) found 35.9 per cent conception rate in 259 mares. Conception rate for mule producing mare has not been found to be reported in literature. In the present study it was found to be 10.71 per cent less than that of horse producing mares. This difference was found to be highly significant. This low rate of conception may be due to the extreme outcross mating. Overall conception rate for donkey mares has been reported to be 47.2 per cent by Kohli and Suri (1957). This figure is higher than what has been obtained in the present study.

Fey and Thomann (1948) reported 15.44 per cent abortions and stillbirths while Wussow and Hartwig (1956) found an overall average of 6.91 per cent abortions. In the present study overall percentage of abortion was 9.14 for horse producing mares, 8.63 per cent for mule producing mares and 6.67 per cent for donkey mares. Difference in the overall incidence of abortion between horse producing mares and mule producing mares was not found to be significant statistically. Overall incidence of stillbirth was 0.48 per cent in horse producing mares and 0.40 per cent in mule producing mares. No case of stillbirth was recorded in donkey mares. Jordao et al. (1954) reported 5.4 per cent stillbirths and abortions. Incidence

of stillbirth in mule producing mares did not differ significantly from that of horse producing mares.

Season has got marked influence on the occurrence of foaling as mare is a seasonally polyoestrous animal. Koroljkov (1952) reported that majority of the foalings take place from March to May. Lukomski (1954) found that 90 per cent of the foalings occurred in the period from January to May. In the present study in horse producing mares 32.98 per cent and 30.32 per cent of the foalings took place in summer (dry) and spring, respectively, while in autumn the occurrence was only 1.60 per cent. 76.06 per cent of the foalings took place from March to July. In mule producing mares also the main foaling season was also found to be spring and summer (dry).

Taking into consideration the references available in literature and the findings of the present study it appears that there is considerable scope for improvement of breeding efficiency at foal heat.

Proper hygiene and preventive procedures, careful examination, prompt and effective treatment are the most important consideration to keep in mind at the time of parturition. This has already been confirmed by Bruner (1951) who found that genital tract of almost all the mares becomes infected during the first week after parturition.

Dimock and Edwards (1928), on culturing genital tracts of 1606 barren mares found 36.5 per cent of the mares infected. They isolated following organisms :

1. Streptococcus genitalium.
2. Klebsiella Pneumoniae var genitalium or Encapsulatus genitalium.
3. Escherichia coli.
4. Corynebacterium equi.
5. Pseudomonas aeroginosa.
6. Salmonella abortivo-equina.
7. Shigella equuli.
8. Staphylococci.
9. Micrococci, chromogenic rods, molds and actinomycetes.

In addition to above, Dourine a disease caused by Trypanosoma equiperdum and coital vesciular exanthema (genital horse pox) are almost entirely transmitted by coitus. So far as is known Dourine does not exist in India.

Proper control of the above genital infections in a well managed stud farm with good veterinary services and adequate ration of green roughage with some legumes will definitely help to increase breeding efficiency at foal heat.

Hereditary factors may also have some influence on breeding efficiency at foal heat. Evidences in this respect

have not been reported in literature. Only the stallions with sound hereditary constitution should be selected for breeding purposes.

In cows and some other species like dogs and guinea-pigs incidences of post-oestrous bleeding have been recorded. An incidence as high as 80-90 per cent in heifers and 50 per cent in cows has been found by several workers in Bos taurus (Hansel and Asdell, 1952 and Lagerlof, 1965). This incidence in Indian cattle is very rare. The bleeding occurs because of inter-caruncular haemorrhage as a result of diapedesis of the epithelium of the caruncles. The farmers believe that the animals which show post-oestrous bleeding after breeding are not likely to become pregnant. But this is not always true as Hammond (1927) and others have found some cows getting pregnant even after evincing post-oestrous bleeding. In mares there is no such record in literature and also in the stud farm under study. Mares have defused type of placenta and not cotyledonary as in bovines. This may be possibly one of the reasons why such incidences of haemorrhage following oestrus are not observed in this species.

Bleeding may sometimes be seen after coitus, which may be due to injuries in the vaginal passage during mating and the appearance of blood at the external genitalia may not

be mistaken for post-oestrual bleeding in equine.

An animal is a product of heredity and environment. The horse production has been going on in many countries in Europe for the past several centuries. The horse breeder must have looked to the qualities of this animal while selecting it for breeding purposes all these years. They also tried to provide optimum environment including good feeding and management; obviously a better horse has been evolved. The contradictory reports obtainable from the literature as regards the breeding efficiency particularly at foal heat are possibly due to great variations in environmental conditions at different places.

As compared to the bovines the endocrine constitution in equines is much different as evinced by the manifestation of the pattern of oestrous cycle and other reproductive processes. Particularly during gestation in the blood plasma of equines circulates gonadotrophic like hormone mostly during 45-120 days of pregnancy reaching its peak concentration between 75-80 days. The source of this hormone in the blood plasma has been ascribed to the gel in the endothelial cups of placenta. How the hormone appears in the gel is still a mystery and researches are still underway to find out the exact source of this hormone and its purpose. The circulation of hormone in equines simulates circulation of LH like hormone

in the human female. The appearance of heat soon after parturition and the long period of oestrus indicate the high level of FSH and oestrogens in equines as compared to bovines. It would be certainly interesting to conduct bioassay of various hormones associated with reproduction and establish their relation with various reproductive processes involved particularly in equines. Pincus (1968) in his introductory remark of his book entitled "The Control of Fertility" has stated that "The mystery and wonder of conception becomes describable in terms of gametes and their movements, in terms of fertilization and reactions and the operation of replication mechanism, in terms of oviduct chemistry and hormonal regulation. In each of these is also mystery and wonder, for there is still more to discover than we know now. But in the blessing and flickering light of what we do now, priori judgements and prejudices fade. And our considered and tested knowledge offers a firm basis for what we can do and should do". The researches in reproductive physiology in farm animals as already mentioned before are of recent origin especially in India and though we have gained some knowledge concerning cattle and buffaloes, our knowledge about equine reproduction is very meagre. In the studies incorporated herein, only an effort has been made to initiate the work and much remains yet to be done.

SUMMARY

Records pertaining to 1241 foal heats followed by 1372 foalings of 572 mares, maintained at Equine Breeding Stud, Babugarh for over a period of 16 years were studied. Data were analysed for different aspects of foal heat in horse producing mares, mule producing mares and in donkey mares.

81.91 per cent of the foalings in horse producing mares, 92.38 per cent of the foalings in mule producing mares and 80.36 per cent of the foalings in donkey mares were followed by foal heat. Incidence of occurrence of foal heat in mule producing mares was significantly higher than that in the other two groups.

Average interval to foal heat was 6.952 ± 0.133 days for horse producing mares, 6.104 ± 0.100 days for mule producing mares and 8.579 ± 0.863 days for donkey mares. In donkey mares, the interval was significantly longer than that of mule producing mares, the later being significantly shorter than that of horse producing mares. In mares more than 75 per cent of the foalings were followed by foal heat in 5 to 8 days of foalings. The interval was not influenced by sex of the foal.

Duration of foal heat was 5.269 ± 0.127 days for horse

producing mares, 5.684 ± 0.079 days for mule producing mares and 5.842 ± 0.503 days for donkey mares. In mule producing mares this was significantly longer than that of horse producing mares. In 93.10 per cent of horse producing mares, 88.20 per cent of mule producing mares and 84.21 per cent of the donkey mares the duration of foal heat was 3 to 7 days. It was not influenced by sex of the foal.

Conception rate at foal heat was 33.77 per cent in horse producing mares, 32.82 per cent in mule producing mares and 42.22 per cent in donkey mares. There were no significant differences among the three groups of mares.

Incidence of abortion after breeding at foal was 7.407 per cent in horse producing mares and 8.594 per cent in mule producing mares. No abortion was found to take place in donkey mares. The incidence of stillbirth was 1.172 per cent in mule producing mares. No case of stillbirth was recorded in horse producing mares as well as in donkey mares.

Average interval between foal heat and first subsequent heat was 88.544 ± 7.889 days in horse producing mares 80.827 ± 4.637 days in mule producing mares and 51.000 ± 15.236 days in donkey mares. This was significantly longer in horse producing mares than that in donkey mares.

Conception rate as a result of mating at first subsequent heat was 34.00 per cent in horse producing mares, 28.62 per cent in mule producing mares and 33.33 per cent in donkey mares. This rate was not found to differ significantly from that at foal heat in all the three groups of mares.

Incidences of abortion and stillbirth after breeding at first subsequent heat were also found out. Horse producing mares did not show any abortion or stillbirth. Mule producing mares showed 4.724 per cent abortions and 0.787 per cent stillbirths. Donkey mares showed 16.667 per cent abortions and no case of stillbirth.

Overall conception rate was found to be 36.02 per cent for horse producing mares, 25.31 per cent for mule producing mares and 28.16 per cent for donkey mares. Overall conception rate in mule producing mares as well as in donkey mares was significantly lower than that of horse producing mares.

Overall incidence of abortion was 9.135 per cent in horse producing mares, 8.629 per cent in mule producing mares and 6.667 per cent in donkey mares. Overall incidence of stillbirth was 0.481 per cent for horse producing mares and 0.403 per cent for mule producing mares. No case of stillbirth was recorded in donkey mares.

Seasonal influence on occurrence of foaling was found out in horse producing as well as in mule producing mares. In horse producing mares maximum number of foalings (32.98 per cent) took place in dry summer and minimum (1.60 per cent) in autumn while in case of mule producing mares maximum 31.83 per cent were in spring and minimum, 3.55 per cent in autumn. However, 76.06 per cent of the foalings in horse producing mares and 75.18 per cent in mule producing mares occurred between March and July.

REFERENCES

Aas, S. (1948). Examination of the ovary in mares in connection with heat and service. Norsk Vet.-Tidsskr., 60:106-117.
(c.f. A.B.A., 16, 3, 207, 907).

Aehnelt, E. and Plas, J. (1946). Time of the first ovulation in mares after foaling. Dtsch. tierarztl. Wschr., 53:10-14.
(c.f. A.B.A., 15, 4, 233).

Ahuja, L.D. (1958). Studies on certain aspects of physiology of reproduction in Hariana females. Thesis for M.Sc. Ag., Bombay University, 1958.

Bain, A.M. (1948). Problems associated with infertility in the brood mare. Aust. vet. J., 24:152-155.

Berge, S. (1944-45). Fertility of the Østland horse. Reprinted from Tidsskr. Landbr., 1944 (11/12), 1945 (1/2). (34 p.).
(c.f. A.B.A., 14, 2, 69).

Berliner, V.R., Sheets, E.W., Means, R.H. and Cowart, F.E. (1938). Oestrous cycle of jennets and sperm production of jacks. Proc. Amer. Soc. Anim. Prod., 31st Ann. Meet., 295-298.
(c.f. A.B.A., 8, 107).

Bielanski, W. (1946). Observations on the sexual cycle in the mare. Przegl. hodowl., 14:102-109.
(c.f. A.B.A., 15, 2, 95).

Britton, J.W. and Howell, C.E. (1945). Observations on sterility. Vet. Med., 40:264-268.

Bruner, D.W. (1951). Notes on Genital Infection in the mare. Cor. Vet., 41, 3, 247.

Burri, K. (1948). The oestrous cycle in Freiberg mares. Observations on three mating seasons. Schweiz. Arch. Tierheilk., 90:323-331; 381-401.
(c.f. A.B.A., 17, 1, 16, 35).

Cannas Simoes, J.M. and Nunes Duarte, C.B. (1963). Aspects of reproduction in Equidae. Variations in fertility in relation to interval between parturition and first mating. Reproducao animal. 20 p.
(c.f. A.B.A., 33, 3, 362, 2003).

Chieffi, A., Gouveia, P.F., De Camargo, M.X., Dos Reis, J.M., Leao, J.F.S. and Kalil, E.B. (1962). Contribution to the study of reproduction in Equidae. I. Occurrence of post-partum oestrus and fertility in mares of the Mangalarga breed. Bol. Industr. anim. N.S., 20:149-66.

(c.f. A.B.A., 33, 3, 362, 2006).

Cole, H.H. and Cupps, P.T. (1959). Reproduction in Domestic Animals. U.K. Ed., Academic Press, New York and London.

Constantinescu, G.K. and Mauch, A. (1936). Studies on the sexual life of the mare. Ann. Inst. nat. Zootech. Rouman., 5:9-82.

(c.f. A.B.A., 6, 1, 5).

Deskur, S. (1964). The first oestrus and ovulation after parturition in the mare. Acta agrar. silvest., Ser. Zootech. (Krakow), 4:49-80.

(c.f. A.B.A., 33, 4, 533, 3151).

Detkens, S. (1961). The Silesian horse. Wydaw. wlasne Dzial Dokument. nauk. Inst. zootech. (Krakow), 131:124 (B).

(c.f. A.B.A., 31, 2, 167, 901).

Dimock, W.W. and Edwards, P.R. (1928). The pathology and bacteriology of the reproductive organs of mare in relation to sterility. Ken. Agr. Exp. Stat. Res. Bull. 286.

(c.f. Roberts, S.J. (1956) Veterinary Obstetrics and Genital Diseases, 1st Ed., Ithaca, New York).

Du Plessis, J.L. (1964). Some observations and data in Thoroughbred breeding. J.S. Afr. vet. med. Ass., 35:215-221.

Ensminger, M.E. (1962). Animal Science. Fifth Ed., The Interstate Printers & Publishers, Inc. Danville, Illinois.

Fey, W. and Thomann, H.E. (1948). Results of service of breeding mares and attempts to improve them by vitamin E treatment. Schweiz. Arch. Tierheilk., 90:113-133.

(c.f. A.B.A., 16, 3, 208, 912).

Gotze, R. and Rosenberger, G. (1944). Insemination experiments with cattle and horses. Dtsch. tieraztl. Wschr./ Tierarztl. Rdsch., 52/50:117-121.

(c.f. A.B.A., 12, 4, 176).

Government of India Memorandum (1933). Horse breeding in India. Horse Breed., 9, 1, 2.

Grigorjev, P.M. (1949). The duration of heat in mares. Konevodstvo, 1949(1):25-29.

(c.f. A.B.A., 17, 2, 116, 430).

Hadi, M.A. (1966). Studies on efficiency of reproduction in Indian stabled horses. Indian vet. J., 43:721-726.

Halasz, B. (1954). Contributions to the question of autumn and spring foaling with special regard to large scale horse breeding. Acta agron. (Budapest.), 4:151-174.

(c.f. A.B.A., 22, 4, 290, 1312).

Hammond, J. (1927). Reproduction in the cow. Cambridge.

(c.f. Hammond, J. (1957). Progress in the Physiology of Farm animals. Vol. 3, Butterworths Scientific Publications, London).

Hansel, W. and Asdell, S.A. (1952). The causes of bovine metestrus bleeding. J. Anim. Sci., 11, 346-354.

Heape, W. (1898). Artificial insemination of mares. Veterinarian, Lond., 71, 202.

(c.f. Parkes, A.S. (1952). Marshal's Physiology of Reproduction, Vol. II, Third Ed., Longmans, Green And Co., New York).

Hendrikse, J. (1968). The influence of post-parturient oestrus, mating interval and age of mare on mating results. Tijdschr. Diergeneesk., 93:1300-1306.

(c.f. A.B.A., 37, 1, 18, 60).

Hirt, E. (1943). On the oestrous cycle and infertility of the mare. Schweiz. Arch. Tierheilk., 85:353-365; 391-402 (B).

(c.f. A.B.A., 12, 4, 181).

Horace Hayes, M. (1968). Veterinary Notes for Horse Owners, Sixteenth Revised Ed., Stanley Paul, London.

Hutton, C.A. and Meacham, T.N. (1968). Reproductive efficiency on fourteen horse farms. J. Anim. Sci., 27:434-438.

Jaworowska, M. (1967). Observations on the reproduction of Polish Koniks in the reserve of the experiment station of the Polish Academy of Sciences in Popielno. Biul. Zakl. Hodow. doswiad. Zwierz. polsk. Akad. Nauk, No. 10:145-158.

(c.f. A.B.A., 36, 2, 190, 1108).

Jennings, W.E. (1941). Some common problems in horse breeding. Cor. Vet., 31, 2, 197.

Jennings, W.E. (1950). Twelve years of horse breeding in the army. J. Amer. vet. med. Ass., 116:11-16.

Jordao, L.P., De Camargo, M.X. and Gouveia, P.F. (1952). The reproductive efficiency of the Thoroughbred at the Sao Paulo State Stud. Bol. Industr. anim. N.S., 13:47-62.

(c.f. A.B.A., 22, 2, 102, 431).

Jordao, L.P., De Camargo, M.X. and Gouveia, P.F. (1952). The reproductive efficiency of the Anglo-Arab at the Sao Paulo State Stud. Bol. Industr. anim., N.S., 13:63-77.

(c.f. A.B.A., 22, 2, 102, 432).

Jordao, L.P., De Camargo, M.X. and Gouveia, P.F. (1954). Reproductive efficiency of mares used for mule production at the Sao Paulo Stud. Bol. Industr. anim., N.S., 14:49-62.

(c.f. A.B.A., 23, 4, 362, 1593).

Jordao, L.P., De Camargo, M.X. and Gouveia, P.F. (1954). Reproductive efficiency of mares at the Sao Paulo Stud, with special reference to post-partum oestrus. Bol. Industr. anim. N.S., 14:83-96.

(c.f. A.B.A., 23, 4, 362, 1594).

Jordao, L.P. and Furtado Gouveia, P. (1950). The reproductive efficiency of the English Thoroughbred in Sao Paulo. Bol. Industr. anim., N.S., 11 (1/2):23-71.

(c.f. A.B.A., 19, 3, 303, 1051).

Jordao, L.P. and Gouveia, P.R. (1948). The reproductive efficiency of Thoroughbred race horses in Sao Paulo. Notic. mens. Soc. Paul. Med. vet., 1(8):5. From abstract in Resenha vet., 1949, 3(6):16-17.

(c.f. A.B.A., 19, 2, 162, 511).

Jordao, L.P., Xavier De Camargo, M. and Furtado Gouveia, P. (1951). The reproductive efficiency of Brazilian asses at the Sao Paulo Stud. Bol. Industr. anim., N.S., 12:83-93.

(c.f. A.B.A., 20, 4, 312, 1459).

Kedrov, V.K. and Lihacev, A.N. (1940). Artificial insemination of mares timed according to the occurrence of ovulation. Trud. Lab. iskusst. Osemen. Zivotn. (Mosk.), 1:253-269.

(c.f. A.B.A., 13, 1, 10).

Kern (1950). Reflections on fertility in 'cold-blood' breeding. Zuchtungskunde, 21:176-181.

(c.f. A.B.A., 18, 3, 247, 846).

Kern (1949). The most favourable time for mating mares. Tierzuchter, 1:129-130.

(c.f. A.B.A., 17, 4, 329, 1244).

Kohli, M.L. and Suri, K.R. (1957). Studies on reproductive efficiency in donkey mares. Indian J. vet. Sci., 27:133-138.

Koroljkov, A.G. (1952). Reproduction indices in relation to dates of foaling of mares under taboon conditions. Konevodstvo, 22(6):30-32.

(c.f. A.B.A., 20, 4, 312, 1460).

Lagerlof, N. (1965). Personal communication.

Lipczynski, A. and Deskur, S. (1958). Some observations on a season of artificial insemination of mares. Plodnosc i nieplodnosc .... Akad. Nauk. No. 11:175-78.

(c.f. A.B.A., 26, 4, 367, 1773).

Lipping, V.O. (1933). Science in the service of the Horse Mating compaign. Probl. Zhivotn., No. 2:29-34.

(c.f. A.B.A., 1, 2, 78).

Lukomski, S. (1954). Seasonal variations in foaling of half-bred mares in the Poznan district. Prace Zakladu Szczegolowej Hodowli Zwierzat W.S.R. we Wroclawiu. Med. wet., 10:328.

(c.f. A.B.A., 22, 4, 290, 1313).

Mahafeey, L.W. (1950). Studies of fertility in the Thoroughbred mare. I. Introduction. 2. Early post-partum oestrus ('foal-heat'). Aust. vet. J., 26:267-273; 295-300.

Matassino, D. (1962). A study of the vital statistics of Hafling mares in Southern Italy. I. Services, conceptions, non-pregnancies, abortions, parturitions and average age at different parturitions. Reprinted from Ann. Fac. Sci. agr. Portici, Ser. 3, 28 (1962-63): 249-267.

(c.f. A.B.A., 31, 3, 314, 1788).

Matassino, D. (1962). A study of the vital statistics of hafling mares in Southern Italy. II. Foaling interval and its component periods, their repeatability and heritability. Reprinted from Ann. Fac. Sci. Agr. Portici, Ser. 3, 28 (1962-63):269-285.

(c.f. A.B.A., 31, 3, 314, 1789).

Matross (1936). Early history of horse breeding in India. Horse Breed., 12, 1, 19.

Matthews, R.G., Ropiha, R.T. and Butterfield, R.M. (1967). The phenomenon of foal heat in mares. Aust. vet. J., 43:579-582.

McKenzie, F.F. and Andrews, F.N. (1937). Estrus and ovulation in the mare. A preliminary report. Proc. Amer. Soc. Anim. Prod., 30th Ann. Meet.:64-70.

(c.f. A.B.A., 6, 2, 94).

McManamny, L.F. (1949). Some aspects of horse breeding. Aust. vet. J., 25:274-277.

Merkt, H. (1966). Foal heat and embryonic resorption. Zuchthygiene, 1:102-108.

(c.f. A.B.A., 35, 2, 195, 1035).

Nyborg, R.G. (1953). Irregular ovulation and the unfortunate choice of systems of mating and testing as causes of infertility in mares. Nord. VetMed., 5:473-538.
(c.f. A.B.A., 22, 1, 24, 37).

Parfenov, V.A. (1966). Some biological characteristics of horses of the Anglo Kabarda breed group. Dokl. Timiryazev. sel'.-khoz. Akad., Mosk, No. 127:175-181.
(c.f. A.B.A., 35, 3, 391, 2911).

Pincus, G. (1968). 'The Control of Fertility'. Introductory Part. Academic Press Inc., New York.

Popov, V., Zeljazkov, S., Pesev, F. and Cankov, C. (1968). Determining the optimum time to mate mares with regard to conception. Zhivot. Nauk., 5(4):37-48.
(c.f. A.B.A., 36, 4, 560, 3340).

Pozo Lora, R. (1956). The fertility of the horse. Arch. Zootec. (Cordoba), 5:207-213.
(c.f. A.B.A., 25, 1, 24, 32).

Redon, P. and Fayolle, L. (1957). The sexual behaviour of mares in a tropical environment. Rev. Elev. Med. vet. Pays trop., N.S., 10:257-262.
(c.f. A.B.A., 26, 2, 129, 599).

Robin and Petrov (1945). Two mating seasons at the Tiaret horse breeding centre in Algeria. Rec. Med. vet., 121:161-176.

Robles, M.M. (1947). Observations on horse breeding in the Philippines. Philipp. J. Anim. Industr., 9:5-14.

Satalov, P.I. (1940). The sexual cycle and some changes in the blood of horses in the post-partum period. Ucen. Zap. Kazan. vet. Inst., 52(2):73-81.
(c.f. A.B.A., 12, 1, 9).

Sattar-Zade, R.H. (1958). Some Biological characters of horses in Azerbaijan. Azerb. Kend Teserrufaty Inst. Eserleri (Trud. azerbaidz. sel-hoz. Inst.), 6:129-136.
(c.f. A.B.A., 29, 2, 147, 667).

Skatkin, P.N. (1948). Sexual periodicity in the horse. Konevodstvo, 1948(4):7-13.
(c.f. A.B.A., 16, 4, 298, 1296).

Snedecor, G.W. and Cochran, W.G. (1967). Statistical Methods. Sixth Edition. Iowa State College Press, Ames, Iowa.

Stevenson, W.G. (1945). The comparative fertility of mares bred at foal and non-foal heat. Canad. J. comp. Med., 9:126-130.

Svecin, K. (1939). On the sexual cycle of female asses. Konevodstvo, No. 4:42-45.
(c.f. A.B.A., 9, 302).

Trum, B.F. (1950). The oestrous cycle of the mare. Cornell Vet., 40:17-23.

Tutt, J.B. (1944). Parturition in the Thoroughbred mare. Vet. J., 100:69-80.
(c.f. A.B.A., 12, 2, 66).

Videla, P.H.B. (1944). The fertility of the Thoroughbred in Argentina. Inst. Zootec. Fac. Agron. Vet. B. Aires, 2:189-237 (B).
(c.f. A.B.A., 18, 2, 149, 487).

Williams, W.L. (1926). Genital diseases of horses. Cor. Vet., 17:107.

Williams, W.L. (1943). The Diseases of the Genital Organs of Domestic Animals. 3rd Ed., Ethel Williams Plimpton, 10 Bancroft Tower Road, Worcester, Mass.

Williams, W.L. (1945). Comments on the case of 'Jamie'. Vet. Med., 40:246-248.

Wussow, W. and Hartwig, W. (1953). Pregnancy duration and sex ratio at different seasons of the year in 'cold-blood' horses in Saxony-Anhalt. Tierzucht, 7:196-200.
(c.f. A.B.A., 21, 4, 332, 1598).

Wussow, W. and Hartwig, W. (1956). The effect of age on fertility in mares. Tierzucht, 10:344-345.
(c.f. A.B.A., 25, 2, 131, 570).

Wussow, W. and Hartwig, W. (1956). Effect of age on the number of abortions. Tierzucht, 10:375-377.

(c.f. A.B.A., 25, 3, 245, 1110).

Zwolinski, J. (1960). Foaling rate in different months of the year at the Liszki, Posadowo, Racot and Rzeczna State studs. Med. wet., 16:290-293.

(c.f. A.B.A., 29, 3, 263, 1268).

APPENDIX I

Information pertaining to different aspects of foal heat

Aspects of foal heat	Horse producing mares	Mule producing mares	Donkey mares
Occurrence of foal heat (%)	81.91	92.38	80.36
Interval between foaling and foal heat (days) :			
Average	6.952±0.133	6.104±0.100	8.579±0.863
Range	1-14	1-18	1-16
Duration of foal heat (days) :			
Average	5.269±0.127	5.684±0.079	5.842±0.503
Range	2-13	2-13	2-11
Conception rate at foal heat (%)	33.77	32.82	42.22
Pathological termination of pregnancy after breeding at foal heat (%) :			
Abortion	7.407	8.594	0.000
Stillbirths	0.000	1.172	0.000
Interval between foal heat and first subsequent heat (days) :			
Average	88.544±7.889	80.827±4.637	51.000±15.236
Range	13-293	14-294	16-202
Conception rate at first subsequent heat (%)	34.00	28.62	33.33

APPENDIX I (contd)

Aspects of foal heat	Horse producing mares	Mule producing mares	Donkey mares
Pathological termination of pregnancy after breeding at first subsequent heat (%) :			
Abortion	0.000	4.724	16.667
Stillbirths	0.000	0.787	0.000
Overall conception rate (%)	36.02	25.31	28.16
Overall abortions and stillbirths (%) :			
Abortion	9.135	8.629	6.667
Stillbirths	0.481	0.403	0.000
Conception rate at foal heat as compared with that at first subsequent heat (% higher or lower and its significance)	0.23 NS Lower	4.20 NS Higher	8.89 NS Higher
Occurrence of foalings in percentage in different seasons :			
Summer (dry)	32.98	29.70	
Summer (wet)	22.33	26.33	
Autumn	1.60	3.55	
Winter	12.77	8.59	
Spring	30.32	31.83	

NS = Not significant