ON MATERNAL AND SOME OTHER INFLUENCES ON BIRTH WEIGHT, GROWTH AND HAIR COAT IN TWO DUTCH CATTLE BREEDS

S. A. KASSAB

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(MET EEN SAMENVATTING IN HET NEDERLANDS)

PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD
VAN DOCTOR IN DE LANDBOUWKUNDE
OP GEZAG VAN DE RECTOR MAGNIFICUS IR. W. F. EIJSVOOGEL,
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DE WEG- EN WATERBOUWKUNDE EN DE BOSBOUWARCHITECTUUR
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VAN EEN COMMISSIE UIT DE SENAAT
VAN DE LANDBOUWHOGESCHOOL TE WAGENINGEN
OP VRIJDAG, 6 MAART 1964 TE 16 UUR
DOOR

S. A. KASSAB

H. VEENMAN & ZONEN N.V. - WAGENINGEN - 1964

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THESIS

SUBMITTED IN PARTIAL FULFILMENT OF
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BY

SAAD ABOU EL-NAGA KASSAB

B.Sc. (Animal breeding) and M.Sc. (Animal breeding)
Alexandria University – U.A.R., Egypt

H. VEENMAN & ZONEN N.V. – WAGENINGEN – 1964

THEOREMS

I

Birth weight can be used as an early criterion for selection, particularly for fattening purposes.

II

Breeding with young and not adult animals gives a certain form of late maturing in the herd.

III

Calf's hair characters at birth does not follow the picture of the dam's hair characters just after calving.

IV

In order to improve livestock in Egypt, it is necessary to grade our native stock by using standard breeds such as the Friesian cattle breed and the Texel sheep breed.

Dr. A. R. SIDKY, F.A.O. meeting in Luknow, India in February 1950

V

The problem of meat shortage in some countries such as Egypt can be solved by encouraging the development of animal production co-operative societies.

VI

The utilization of cottonseed products must be increased in farm animal feeding in countries like Egypt.

VII

Since in Africa there is deficiency in animal protein, in human feeding, special attention must be given to sources of vegetable proteins.

F.A.O. Report No. 1958/22, 10–15 November 1958

VIII

If a calf can tolerate, during its first year, atmospheric temperatures above 85°F., then its powers of resistance to tropical and subtropical conditions will undoubtedly be high.

S. A. KASSAB
Wageningen, maart 1964

VOORWOORD

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CHAPTER 1

GENERAL INTRODUCTION

The environmental effects on the birth weight of a calf are the sum of all the influences to which the calf is subjected from the moment of conception until the moment of its being weighed immediately after birth. For most of this period the calf is in intra-uterine environment, where it is provided for by the cow. So it may be said that in a way all prenatal environmental variation is variation in maternal environment. This work studies the relation between sex, season of birth, gestation period, weight of dam and age of dam at calving, on birth weight of Friesian calves, in chapter 2.

In many countries there has been an increased interest in the production of beef from dairy cattle. Attempts have been made to establish a way to select a stock of cattle at an early age, for this purpose. It is obviously of great importance to be able to avoid the cost of rearing calves which subsequently turn out to be unprofitable producers. The purpose of this investigations was to study the influence of birth weight and some other factors which may effect the growth of Friesian calves, from birth till one year old (52 weeks), in chapter 3.

During recent years many workers studied various aspects of the physiology of climatic adaptation among domestic livestock. DOWLING (1955), refered to many investigators that, they emphasize the importance of the skin as on organ of adjustment between the animal and the varying physical conditions of its environment. This study aimed at finding out the effect of some factors on coat characters, on two Dutch cattle breeds, in chapter 4.

CHAPTER 2

BIRTH WEIGHT

2.1. INTRODUCTION

The birth weight of calves is of interest to breeders, because differences in birth weight between calves may indicate differences between them at a later age.

Birth weight can be used as an early criterion for selection, if there is a reasonable correlation with one-year-old body weight. This is important in case where some selection is made before weaning. Consequently it is important to the cattle breeder to know the effects of the various factors causing differences in birth weight. The object of this study is to investigate the relations which maternal and some other environmental factors bear to birth weight.

The mother influences birth weight by:

1. the genes which she transmits,
2. the internal environment which she provides, (age of dam, weight of dam gestation period and feeding),
3. the interaction between genes and environment.

There is no direct method to measure these factors and their proportions. However, the effects of maternal environment can be ascertained by a study of the general individual components.

During pregnancy calves depend entirely on their mothers throughout the gestation period. BURRIS and BLUNN (1952) reported that the foetus has priority over its mother's body, especially during the early months of gestation, and is thus protected against lack of food and other vital requirements, and it asserts this priority by using maternal reserves. So prenatal environmental variation is due to maternal environment.

Differences between mothers which make up the variations in birth weight may result from such factors as differences in age, in weight, in nutrition, in condition during gestation period, in ability to provide the essentials by means of nutrition, or any other permanent differences, particularly including, of course genetic differences.

The present investigation deals with the components of the maternal environment, and other environmental factors affecting birth weight, such as sex and month of birth.

2.2. REVIEW OF LITERATURE

The effect of the several environmental factors on the birth weight of different breeds of cattle has been studied by many investigators. It is understood that such studies are important when fixing a breeding program aiming

TABLE 1. Differences in birth weight of male and female calves

Authors	Country	Year	Breed	♂ kg	♀ kg
Belić, M.	Yugoslavia	1950	Simmental	48.8	45.5
Jordão and Assis	Brazil	1950	Flemish cattle	39.9	36.9
Veiga *et al.*	Brazil	1950	Gir	24.6	23.8
Veiga *et al.*	Brazil	1951	Indo brazilian	30.0	28.9
			Holstein-Friesian	35.5	33.0
Asker and Ragab	Egypt	1952	Buffaloes	38.5	36.4
			Egyptian cows	25.7	23.9
Mahadevan, P.	Ceylon	1953	Black Sinhala	31.0	29.0
Braga, J. W.	Brazil	1954	Gir cattle	25.8	20.8
Ahmed and Tantawy	Egypt	1954	Egyptian cattle	27.0	24.0
			Buffaloes	40.3	37.2
Petrovic, V.	Yugoslavia	1956	Simmental	46.3	42.6
De Vree	France	1961	Charollais	45.8	42.7
Mammerickx, M.	Congo	1962	Kandhi buffaloes	38.5	31.7
				(l.b.)	(l.b.)
Tyler *et al.*	Wisconsin (U.S.A.)	1947	Outbred Holstein-Friesian	95.4	90.3
			Inbred Holstein-Friesian	88.4	83.0
Lazarus and Ranga-swamy	Indian	1950	Zebu calves	52.1	48.5
			Buffaloes	81.4	70.2
Dave, C. N.	Indian	1951	Sindhi cows	41.9	38.8
Burris and Blunn	Nebraska (U.S.A.)	1952	Angus	67.1	61.8
			Hereford	69.9	65.4
			Shorthorn	66.7	61.8
Chaudhuri and Sinha	Sweden	1952	Tharparker cattle	48.7	47.5
Ananta-krishnan and Laz-garus	Indian	1953	Red-Sindhi	47.2	43.9
			Gir	50.9	47.9
			½ Ayrshire × Sindhi	56.6	53.2
Davis *et al.*	Nebraska (U.S.A.)	1954	Holstein	96.7	90.3
Tidbury, G. E.	Zanzibar	1954	Zebu cattle	36.1	34.0
Arnold and Becker	Florida (U.S.A.)	1955	Jersey	55.2	51.9
Koch and Clark (b)	Nebraska (U.S.A.)	1955	Hereford	78.4	72.8
Nelms and Bogart	Corvallis (Britin)	1956	Hereford	73.5	73.2
		1959	Aberdeen-Angus	63.1	57.4
Foote *et al.*	Wisconsin (U.S.A.)	1959	Holstein	83.4	77.5
Koch *et al.*	Nebraska (U.S.A.)	1961	Beef cattle	73.2	68.0
Brinks *et al.*	Montana (U.S.A.)	1961	Hereford	80.2	74.0
Johari, M. P.	Mathura	1962	Murrah buffaloes	74.4	71.9
Haines, C. E.	Honduras		Brahman (Nellor cattle and Gujarati)	60.9	57.2

at genetical improvement of the breed, taking into consideration that breeding cattle are often selected at an early age.

Bull calves are usually heavier at birth than heifer calves. This has been reported by several workers in table 1.

Seasonal or month-of-birth variation in birth weight has been subject to much debate. Those in favour, attribute the variation to the effect of varying amount and quality of food, although *e.g.* ECKLES (1919) and FITCH *et al.* (1924) found that the food given to the dam has little influence on birth weight.

MC CANDLISH (1922), in the course of his investigation including four different breeds of cattle: Ayrshire, Guernsey, Holstein and Jersey calves at Dairy Husbandry Section, Iowa State College, found that there was no marked seasonal variation in birth weight. However, it does appear that the average birth weights of calves born in the months of April to October are lower than the weights of those born at other times (Table 2).

TABLE 2. Average birth weight according to month of birth (MC CANDLISH, 1922)

Month of birth	No.	Average birth weight	Month of birth	No.	Average birth weight
January	30	70	July	25	62
February	43	75	August	27	69
March	51	72	September	31	67
April	26	64	October	39	69
May	25	65	November	27	74
June	23	66	December	22	74

Results obtained by BONSMA (1939) who studied the effect of season on British beef breeds and Afrikaner breeds, in the Union of South Africa, are shown in table 3. He came to the conclusion that calves from cows of the British beef breeds born in May, June and July were 20% lighter than calves from the same animals born in December–January. In contrast, the calves of the well-adapted animals (Afrikaner) born in summer and winter show no difference in weight at birth.

TYLER *et al.* (1947) observed in their data at Wisconsin, on Holstein-Friesian calves in three unrelated herds, that the season of birth had little effect

TABLE 3. Effect of season on birth weight (BONSMA, 1939)

Breed	Season: Summer (Dec.-Jan.) Av. Birth weight (lb.)	Season: Winter (May-June) Av. Birth weight (lb.)	Percentage differences in weight
British beef breeds	65	52	20
Afrikaner	67	67	0

on birth weight. The same results were found by BRAUDE and WALKER (1949) when studying the records of 230 Shorthorn calves at the National Institute for Research in Dairying, Shinfield, near Reading, which showed that there is a slightly irregular variation in birth weight from month to month as in table 4.

TABLE 4. Effect of month of calving on birth weight (BRAUDE and WALKER 1949)

Month of calving	No.	Average birth weight lb	Month of calving	No.	Average birth weight lb
January	22	85	July	10	91
February	27	85	August	20	83
March	30	88	September	31	87
April	26	87	October	30	86
May	18	88	November	31	86
June	15	85	December	25	87

BELIĆ (1950) in Belgrade recorded that the birth weight of Simmental calves born in spring was higher than that of those born in autumn. (62.3% of the cows calved in autumn and winter). Also KOCH and CLARK (1955b) found that calves born later in the calving season were slightly heavier at birth on range Hereford, at Nebraska. Most of the calves in their study were born during the months of April and May. They added that this slight difference might be due to better pasture condition.

On the other hand several investigators found that month of calving had no effect on birth weight. CHIEFFI *et al.* (1951) working on Gir, Nellore, Guzerat and Indo-Brazilian calves at the experimental farm at Uberaba, Brazil, declared that there was no statistically significant difference between the birth weights of those born in the dry season (April–September) and those dropped in the rainy season (Oct.–March). ARUNACHALAM *et al.* (1952) indicated that birth weight of buffaloes freshening in different months at Bangalore, varied between 68.6 to 77.1 lb, as shown in table 5. However, the numbers were too low to afford reliable information. They also reported that these variations were not significant. The same results were found by ANANTAKRISHNAN and LAZARUS (1953), while working on Indian cattle at Bangalore.

TABLE 5. Birth weight according to month of freshening (ARUNACHALAM *et al.* 1952)

Month of freshening	No.	Average birth weight lb.	month of fershening	No.	Average birth weight lb.
January	16	77.1	July	27	72.2
February	5	68.6	August	17	71.7
March	11	74.9	September	22	73.9
April	3	72.2	October	39	72.7
May	13	70.9	November	41	73.6
June	8	74.3	December	23	73.3

They pointed out that even though there were wide variations in birth weight the differences were not statistically significant.

In the work done by ASKER and RAGAB (1952), calving occurred during the months of August to March, the number of calves dropped during the months of April, May, June and July being too small. They stated that month of calving appeared to have no effect on birth weight in either buffaloes or Egyptian cattle. This may be due to the stable system of feeding and management during the whole period of study. The results found by PETROVIC (1956) at Belgrade on Simmental calves confirmed the finding of the previous workers, that the season of calving did not affect birth weight.

Many investigators showed that birth weight of both sexes usually increases with increasing length of gestation period and that male calves were carried longer than female calves (Table 6).

TABLE 6. Differences in gestation period of male and female calves

Investigators	Year	Breed	Differences between ♂ and ♀ in days of gestation	Significance
HERMAN and SPALDING	1947	Jersey	1.0	—
		Holstein	1.2	—
		Guernsey	1.0	—
BRAUDE and WALKER	1949	Shorthorn	1.9	—
DAVE, C. N.	1951	Sindhi	2.0	*
VILLARES and DE ABREU	1951	Indo-Brazilian	3.5	—
		Guzerat	0.3	—
BRAKEL *et al.*	1952	Guernsey	1.5	*
		Holstein-Friesian	1.5	*
		Jersey	0.8	×
		Ayrshire	0.3	×
		Brown Swiss	0.7	×
BURRIS and BLUNN	1952	Angus	2.2	*
		Hereford	1.4	×
		Beef Shorthorn	-0.1	×
JORDÂO and ASSIS	1952	Meuse-Rhine-Issel	2.2	*
LAZARUS and ANANTA-KRISHNAN	1952	Sindhi	1.0	*
		Gir	1.6	*
		½ Ayrshire × Sindhi	1.5	*
SCHMIDT, E.	1953	German Red Cattle	1.8	—
DAVIS *et al.*	1954	Holstein	0.5	×
ARNOLD and BECKER	1955	Jersey	1.4	—
ISHAG, S. M.	1956	Buffaloes	0.4	—
AHMED and TANTAWY	1956	Egyptian cows	1.6	*
PETROVIC, V.	1956	Simmental	1.8	—
ROLLINS *et al.*	1956	Jersey	2.0	—
SLAGSVOLD and AAMDAL	1956	Red Polled Ostland cattle	0.9	*
KOHLI and SURI	1957	Hariana cattle	2.1	*
SIGNORET *et al.*	1957	French Friesian	2.0	—
		Normandy Cattle	1.1	—

Table 6 continued

Investigators	Year	Breed	Differences between ♂ and ♀ in days of gestation	Significance
DE FRIES *et al.*	1959	Ayrshire	1.9	**
		Guernsey	1.4	**
		Brown Swiss	1.3	*
		Jersey	1.2	×
		Holstein Friesian	1.0	×
FOOTE *et al.*	1959	Holstein	1.4	*
BURGKART and SCHMID	1961	D. Fleckvieh	1.5	**
		D. Gelbvieh	1.0	**
		D. Braunvieh	1.7	**
		D. Swartbunte	1.1	**
		D. Rotbunte	1.4	**
		Angler	0.9	**
SINGH and RAY	1961	Red Sindhi	1.0	*
SOMMER and KRIPPEL	1961	D. Rotbunte	1.1	**
		Pinzguaer	1.1	**
		Vorderwalder	1.3	**
		Hinterwalder	1.5	**
HAINES, C. E.	1962	Nellore and Gizarati	1.5	—
KORTSTEE	1963	Friesian and M.R.Y.	1.4	*

* = Significant $P < 0.05$ × = not significant
** = Highly significant $P < 0.01$ — = not estimated

Birth weight was found many workers to be closely correlated with weight of dam, increasing gradually as the dam's weight increased (Table 7).

TABLE 7. Correlation between birth weight of the calf and the weight of its dam

Workers	Year	Breed	Correlations
KUSNER, H. F.	1936	Kozak-Kalmuck	0.30
		Hereford cross cattle	0.42
KRASNOV and PAK	1939	Tazil	0.42/0.56
KNAPP *et al.*	1940	Shorthorn	0.22
RUZEVSKŮ and MALOVA	1940	F_1 Istoben-Friesian	0.27
MŮNOZ and RIGOR	1941	Red Scindi cattle	0.22
DE ABREU	1950	Nellore	0.38
GREGORY *et al.*	1950	Beef cattle	0.21
JORDÂO and ASSIS	1950	Flemish calves	0.28
ARUNACHALAM *et al.*	1952	Murrah buffaloes	0.41
ANANTAKRISHNAN and LAZARUS	1953	Red Sindhi	0.34
		Gir	0.25
		½ Ayrshire × Sindhi	0.40
TSATSKIN and ANGEL	1953	Hereford	0.22
TANTAWY and AHMED	1955	Egyptian cows	0.23
		Buffaloes	0.28
MÄKELÄ and OITTILA	1956	Ayrshire	0.13

Relation of weight of calf to weight of dam were estimated by many authors (Table 8).

TABLE 8. Relation of weight of calf at birth to weight of dam

Authors	Year	Breed	No.	Relation percentage
HENRY and MORRISON	1917	Ayrshire	34	7.8
		Guernsey	57	7.1
		Holstein	104	7.7
		Jersey	119	6.1
ECKLES, C. H.	1919	Ayrshire	53	6.9
		Holstein	154	8.0
		Jersey	196	6.5
FITCH *et al.*	1924	Jersey	92	6.3
		Guernsey	104	6.7
		Ayrshire	115	6.9
		Holstein	75	7.1
		Grade Holstein	69	7.7
		Exp. Holstein	66	8.6
JORDÂO and VEIGA	1940	Mocho Nacional cows	278	6.3
MUNOZE and RIGOR	1941	Red Scindi cattle	85	6.5
KONOPINSKI and KOTLINSKI	1951	Lowland cattle	—	6.6–7.1
JOUBERT and HAMMOND	1954	South Devon Dextor	6	6.9
		Dextor	6	10.3

The results obtained by MCCANDLISH (1922) on Ayrshire, Guernsey, Holstein and Jersey, showed that with an increase in the weight of cows at freshening, there is an increase in birth weight of the calves as shown in table 9.

TABLE 9. Relation of weight of calf to weight of dam (MCCANDLISH, 1922)

Weight of cow in lb	No.	Average birth weight in lb	Relation percentage of weight of calf to weight of dam
700	10	55	7.3
800	18	58	6.8
900	51	61	6.4
1000	58	66	6.3
1100	45	72	6.3
1200	33	76	6.1
1300	17	84	6.2
1400	18	98	6.8
1500	8	100	6.5

The weight of the cows in his work do not indicate exactly the weight after calving, because cows were weighed weekly and the last weight before freshening was considered to be the weight of the cow at freshening. It was estimated by TSATSKIN and ANGEL (1953) that an increase of 100 kg in the weight of the mother corresponded with an average increase of 2.2 kg in weight of the Hereford calves.

FOOTE *et al.* (1959) reached the conclusion that heavier dams may produce heavier calves by virtue of having greater facilities for fetal growth or because of a genetic association between adult weight and birth weight in Holstein cattle.

SMIRNOV (1960) in his work on Simmental, Lebedin, and Red Stapp breeds, reported that a direct relation had been found between birth weight and adult body weight of the animal. Also the finding of ALEXANDER *et al.* (1962) was that the weight of the dam was significantly related to birth weight and was responsible for 6% of the variation in the birth weight of the calf.

BRINKS *et al.* (1962) when studying weight records of Hereford calves reared at the United States Range Livestock Experiment Station, Miles City, Montana, obtained similar results to those found by previous workers. They pointed out that the correlations between cow weight and weight of their calves in the different seasons were:

Previous fall weight	0.23
Spring weight	0.29
Fall weight	0.21

They also reported that, although the correlation between cow weights and calf weights are low, it was found that heavier cows tend to produce heavier calves at birth. In their work the spring weight of the cow is more closely correlated with the birth weight of the calf. This may be due to the fact that spring and fall weights of the cow both contain the weight of the fetal calf, but spring weight contained the weight of a nearly full-term calf.

The relation of age of dam to birth weight has long been known. MC-CANDLISH (1922) stated that there is some slight rise in birth weight of calves from dams up to five years old. From then on there is an irregular decrease in weights of the calves in Ayrshire, Guernsey, Holstein and Jersey breeds. Also KNAPP *et al.* (1942) found that calves from 2-year-old cows were small and those from 4-year-old cows were largest, but the reduction in the size of calves from dams older than 4 years was hardly significant in 770 pure-bred Hereford calves at the Experiment Station, Miles City, Montana.

DAWSON *et al.* (1947) working on 402 Shorthorn beef at Washington, observed an increase in birth weight until the mothers reached the age of 6 years. They also proved that for each month's increase in age of the dam (up to 6 years) female calves weighted 0.20 lb more at birth and male calves 0.23 lb more. The same results were found by DE ABREU (1950) who stated that the heaviest calves were dropped by cows 5 to 6 years old in Nellore breed. BURRIS and BLUNN (1952), studying the birth weight of Angus calves, Hereford and Shorthorn at the Nebraska Experiment Station at Lincoln, concluded that the birth weight increased till dams reached the age of nine to ten years, as in table 10.

In a study by TSATSKIN and ANGEL (1953) on Hereford calves, they reported a tendency of birth weight to increase until the dams reached the age of 5 years, then there was stability until 10–11 years of age, followed by a decrease. They also showed that the calves born of dams of 13 to 14 years old were much lighter in weight than those born of a young mother. EIDRIGEVIĚ and POLJAKOV (1954) found that birth weight was highest in calves produced by 3 to 4-year-old cows in Ala Tau cattle. The birth weights of Hereford calves from three and four-year-old cows averaged four and two pounds less respectively than the birth weights of calves from cows five years and older. This was estimated by ROLLINS and GUILBERT (1954).

TABLE 10. Effect of age of dam on birth weight (BURRIS and BLUNN, 1952)

Age of cow at calving years	Breed			Total lb
	Angus lb	Hereford lb	Shorthorn lb	
2– 3	59.9	63.5	59.3	61.4
3– 4	61.6	67.1	63.4	64.1
4– 5	64.6	68.4	65.3	66.2
5– 6	64.8	69.2	66.8	66.9
6– 7	63.0	69.1	66.0	66.0
7– 8	72.2	58.9	65.9	67.0
8– 9	60.4	75.3	67.5	67.2
9–10	67.6	76.2	66.8	69.6
10–11	74.1	65.5	74.0	64.1
11–12	64.7	77.2	65.0	71.0

In comparing the birth-weights in connection with the ages of the dams for both sexes, KOCH and CLARK (1955b) reported their results as in table 11.

TABLE 11. Relation of age of dam on birth weight (KOCH and CLARK, 1955 b)

Age of cow in years	Males		Females	
	No.	Av. birth weight lb	No.	Av. birth weight lb
3	703	75	693	70
4	619	78	605	73
5	468	80	465	73
6	383	80	367	74
7	304	79	290	75
8	246	79	234	75
9	193	80	167	75
10	107	80	108	73

ANGEL and POLY (1956) declared that at the time of calving the mother seems to have little influence on birth weight. They added that only the calves produced by very young dams are considered to be lighter in weight than those of adult dams. But the results obtained by VSJAKIH and BOROZDINA (1957), while working on 797 calves of Ala Tau breed at Moscow, showed that older cows produced calves of heavier birth weight. In their work the age groups of the dams were:

a. under 5 years and
b. 5–10 years old.

STEGENGA (1961) using Friesian calves in the Netherlands, pointed out that calves born of a 2-years-old mother are on an average lighter in weight at birth, than those delivered by older cows. His results are given in table 12.

TABLE 12. Effect of age of dam on birth weight (STEGENGA 1961)

Sex	Calves from cows kg	Calves from 2 year old heifers kg	Difference in kg
Males	38.5	33.1	-5.4
Females	36.2	31.8	-4.4
♂ + ♀	37.3	32.5	-4.8

Variation in birth weight and age of dam as measured by calving sequence or lactation numbers were studied by many investigators. FITCH *et al.* (1924) concluded that birth weight increases up to the fifth calf in Jersey, Guernsey, Ayrshire and Holstein breeds, while JORDÂO and VEIGA (1940) and DINKHAUSER *et al.* (1944), stated that the average birth weight of Mocho calves and Black Pied calves respectively shows a significant increase from the first to the fourth calving.

TYLER *et al.* (1947) carried out an extensive study on 794 Holstein Friesian calves at the University of Wisconsin. They observed that calves from first-calf heifers were approximately 10 lb lighter than were calves from dams of later calving sequence. Their findings are given in table 13.

TABLE 13. Variation in birth weight according to calving sequence (TYLER *et al.*, 1947)

Calving sequence	Outbreds (lb)	Inbreds (lb)
1	84.3	79.2
2	93.4	89.1
3	96.8	88.7
4	93.5	90.4
5	95.4	91.4

BRAUDE and WALKER (1949) in their study on 230 Dairy Shorthorn calves, reported that calves from older cows were heavier than those from younger ones (Table 14).

TABLE 14. Effect of age of dam on birth weight (BRAUDE and WALKER, 1949)

Lactation	Males (lb)	Females (lb)
1	77.66	74.38
2	82.23	78.94
3	85.65	82.37
4	85.72	82.44
5	86.84	83.55

VENGE, O. (1949) found on 429 Swedish Red and White and Red Danish calves, that calves born at first calving weighed 8–12% less than calves of full-grown mothers.

The results obtained by BELIC (1950) on Simmental cattle, showed that the lowest birth weight was found in calves produced at first calving and the highest in those produced at 5th calving.

ASKER and RAGAB (1952) studying data from the flock of the Faculty of Agriculture, Giza, Egypt, gave their results in table 15.

TABLE 15. Effect of age of dam on birth weight (ASKER and RAGAB, 1952)

Sequence	Egyptian cattle				Egyptian buffaloes			
	Males		Females		Males		Females	
	No.	Average kg	No.	Average kg	No.	Average kg	No.	Average kg
1st.	28	23.75	26	21.73	24	36.13	39	33.67
2nd	41	25.95	30	23.40	25	36.40	24	34.96
3rd	25	26.60	25	24.00	30	39.23	26	36.96
4th	19	26.37	12	25.53	17	41.82	26	37.19
5th and 6th	16	26.81	19	25.37	10	39.20	20	38.15
7th and over	11	25.81	18	25.33	27	39.37	18	40.39
Total	140	25.77	130	23.93	133	38.50	153	36.41

Similar results were found by ARUNACHALAM *et al.* (1952) working on Murrah Buffaloes, at Bangalore. DAVIS *et al.* (1954) found in 755 Holstein calves, at University of Nebraska that the average birth weights for both males and females at the first calving were lower than for succeeding calvings up to the seventh. ARNOLD and BECKER (1955) mentioned that calves averaged over 5 lb. lighter at first calving than at subsequent calvings in pure-bred Jersey.

MÄKELÄ and OITTILA (1956), who used 382 Ayrshire calves, stated that the birth weight of first calves was 2.98 kg less than that of fourth calves, while DREWRY *et al.* (1959) mentioned that there was a correlation of 0.32 between birth weight of calf and lactation number of dam. They came to the conclusion that this correlation shows that older cows gave birth to heavier calves, in 48 Aberdeen-Angus, at Arkansas. The results obtained by DONALD *et al.* (1962) on a herd of Ayrshire, Friesian, Jersey and 2-breed and 3-breed cross cattle derived from them at Edinburgh, showed that the birth weight of the second calves was 6.6 lb heavier than of the first calves.

ALEXANDER *et al.* (1962) found that first-calf heifers gave birth to calves which were 4 lb lighter than those of mature cows in Hereford cattle in sub-tropical environment at "Brian Pastures" in Queensland Department of Agriculture and Stock, Brisbane.

2.3. MATERIAL AND METHODS

The present observations were made on the birth weight of 302 live Friesian calves born during the period of 1959 to 1962, at the Experimental farms of:

1. Laboratorium voor Veeteelt, Wageningen
2. Laboratorium voor Dierfysiologie, Wageningen
3. Proefboerderij De Ossekampen van het Proefstation voor de Akker- en Weidebouw (P.A.W.), Wageningen
4. Instituut voor moderne Veevoeding, De Schothorst, Hoogland (Utr.)
5. U.T.'s proefboerderij voor Veevoeding, Maarssen
6. Instituut voor Veeteeltkundig Onderzoek „Schoonoord", (I.V.O.) Zeist.

The weights of the calves were taken within twenty four hours after birth, when they were nearly dry. The dams were divided into groups according to their ages at calving. The age groups of the dams studied were $2\text{–}2^6$, $2^6\text{–}3$, 3–4, 4–5, 5–6 and over 6 years old.

The correlation between the dam's weight at calving and the birth weight of their calves was studied separately, because the number of calves available with known weight for their dams after calving was small. Cows were not weighed immediately after calving but the weight was taken within 1–3 days after calving. In considering the relation between the weight of dam and the birth weight of the calf, the weights of the dams have been grouped in intervals of 100 kg, for example weights of 400 to 499 kg have been grouped together.

The gestation period was taken as the number of days from the date of insemination to the date of calving. There were 302 gestation periods avail-

TABLE 16. The distribution of the calves born in the different months

Age of dam	$2\text{–}2^6$		2^6 and over		Total
Sexes	♂	♀	♂	♀	
Month of birth	No.	No.	No.	No.	
January	5	5	10	12	32
February	7	5	9	21	42
March	10	9	23	26	68
April	4	4	29	17	54
May	2	1	2	7	12
June	—	—	2	1	3
July	—	—	1	—	1
August	—	—	2	—	2
September	1	—	—	2	3
October	4	9	10	5	28
November	8	5	9	10	32
December	2	6	8	9	25
Total	43	44	105	110	302

able for the period of 1959 to 1962. Lengths of gestation periods have been taken by ten and five-day intervals to show its relation to the birth weight of calves according to the age of dam (2–4 years and 4 years and over).

Calves were born during all the months of the year. Most of the calves were dropped during March, April, February, January, November, October and December, respectively. A few were dropped in other months.

The numbers for each sex for each month are presented in table 16. In some months the numbers were too small. Therefore birth weights of calves were classified according to the season of calving. Winter: January, February and March. Spring: April, May, June. Summer: July, August and September. Autumn: October, November and December.

In this investigation there were 148 males and 154 females. A comparison was made between males and females.

All calves used were considered single born. The number of twins was too small, so that it was left out of consideration.

The simple correlations determined were: weight of calf at birth with weight of the cow shortly after calving: weight of the calf at birth with age of the mother at calving, and weight of the calf at birth with length of gestation period.

Analysis of variance was carried out in the same way as it was done by SNEDECOR (1946).

2.4. RESULTS AND DISCUSSION

Sex:

The average birth weight of all the calves studied was 35.86 kgs. Male calves were heavier than females. The average difference between males and females at birth was 3.04 kg (Table 17). These differences were statiscally

TABLE 17. Means, standard deviation, and coefficients of variability for birth weights of male and female calves (Friesian)

Sex	No.	Mean kg	S.D.	C.V. %
Males	148	37.41	4.45	11.89
Females	154	34.37	4.79	13.93
Total	302	35.86	4.86	13.55

highly significant (Table 19). The results obtained in this work between male and female calves were similar to those recorded by many workers, in that males were heavier than females in different breeds of cattle, *e.g.* by: BELIĆ (1950), ASKER and RAGAB (1952), MAHADEVAN (1953), NELMS and BOGART (1956), JOHARI (1961) and HAINES (1962).

Season of birth:

The results given in table 18 and figure one show that there are irregular

Table 18. Number and average birth weights of calves on different ages of their dams, for all seasons

Age of dam	2–2^6					2^6 – and over				
Sex	Males		Females		Both sexes	Males		Females		Both sexes
Season of birth	No.	Mean kg	No.	Mean kg	Mean kg	No.	Mean kg	No.	Mean kg	Mean kg
Winter	22	34.1	19	30.9	32.5	42	38.6	59	35.1	36.8
Spring	6	34.5	5	29.4	31.9	33	37.7	25	34.9	36.3
Summer	1	31.0	—	—	31.0	3	38.7	2	30.0	34.3
Autumn	14	35.6	20	32.0	34.0	27	39.5	24	37.8	38.6

Table 19. Analysis of variance for birth weights

Source of variation	D.F.	Mean Square
Total	301	23.64
Sex	1	699.94**
Age of dam within sex	2	505.29**
Season of birth within age and sex	11	26.81
Within season	287	17.81

** Highly significant ($P < 0.01$)

variations from season to season. Average birth weights during season of calving ranged from 31.0 to 34.0 kg for the group of mothers of 2–2^6 years of age and from 34.3 to 38.6 kg. in the other group (2^6 years and over). From this table it can be observed that calves born in autumn were heavier at birth than those dropped in the other seasons. These differences, within age of dam and sex, were nearly significant (Table 19). This may be due to the fact that

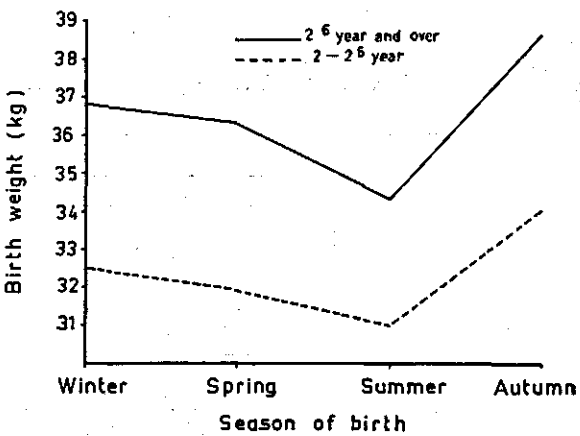

Fig. 1. Relation between seasons of birth and birth weight of Friesian calves on both sexes according to age of dam.

in autumn mothers returned from poor pasture to the stables and received more rest and food. In this respect the experience of STEGENGA (1964) that there is a sharp increase of difficult calving in autumn, is interesting. Also the finding of KORTSTEE (1963) that gestation periods are longer in autumn is of interest.

The results found in this work were in agreement with many workers, *e.g.* MCCANDLISH (1922), TYLER *et al.* (1947), BRAUDE and WALKER (1949), CHIEFFI *et al.* (1951) and ASKER and RAGAB (1952), in that there were variation in birth weight between one season and another, but that these variations were not significant.

Those who found significant variations in birth weights due to season of calving, attributed these variations to management, condition, food, gestation periods and weather, particularly in hot climates. BONSMA (1939) working on British beef breeds at Pretoria, Union of South Africa, reported that calves born in winter (May–June and July) were 20% lighter than calves of the same animals born in summer (December–January), while KNAPP *et al.* (1940) stated that the beef Shorthorn born in autumn were heavier at birth, and that the gestation period had been longer.

Maternal influence:

It is well known that there is a relation between maternal environmental components and birth weight. These components are: gestation period, weight and age of dam.

Gestation period:

The relation of average birth weights with various lengths of gestation is given in table 20. There was a general tendency to the effect that, as the

TABLE 20. Relation between length of gestation period and birth weight of male and female calves

Age of dam	2–4					4 years and over				
Length of gestation period (day)	Males		Females		Both sexes	Males		Females		Both sexes
	No.	Mean kg	No.	Mean kg	Mean kg	No.	Mean kg	No.	Mean kg	Mean kg
250–259	2	32.0	—	—	—	—	—	—	—	—
260–269	5	33.2	10	30.0	31.6	4	31.7	7	34.6	33.1
270–274	22	36.2	17	32.2	34.2	6	38.8	8	35.1	36.9
275–279	28	36.8	40	32.7	34.7	21	38.8	22	35.5	37.1
280–284	15	36.8	17	33.4	35.1	26	39.8	22	38.3	39.0
285–289	7	37.3	2	36.0	36.6	7	36.8	4	36.0	36.4
290–299	1	34.0	2	34.5	34.3	4	40.2	3	40.7	40.4
Total:										
Birth weight in (kg)		35.2		33.1	34.1		37.7		36.7	37.2
Gestation period (day)		276.06		276.00	276.03		279.9		278.2	279.0

gestation period for calves increased, their birth weight also increased slightly. From this table it can be seen that both sexes (from dams 2–4 years) show a slight increase in birth weight after 270 days of gestation, during the normal gestation period (270–289 days). Males and females from dams 2–4 and 4 years and over, reach their maximum birth weight at 285–289 and 290–299 days of gestation, respectively. This was proved by the non significant correlation between birth weight and normal gestation period (270–289 days), being 0.000 1 and 0.043 for bulls and heifers respectively (Table 21).

TABLE 21. Correlation between gestation period and birth weight for both sexes

Characters correlated	Sex	No.	Correlation
Birth weight with:			
Gestation period (270–289 days)	♂	132	0.0001
Gestation period (270–289 days)	♀	132	0.043

The results in table 20 show that male calves were carried longer than female calves. The difference in gestation periods for the sexes was not significant. The non significant variations found in this investigation will be due to the fact that the number of calves was too limited. For in several publications, some of which relate to Dutch breeds, there proved to be a significant difference between male and female according to their findings.

Weight of dam after calving:

The number of cases in which the relation of the weight of cow at freshening to the weight of calf at birth was known, are more limited, because cows were not weighed regularly after birth in all the farms, except in Veeteelt. Table 22 shows that birth weight increased gradually as the dam's weight in-

TABLE 22. Relation between weight of dams at calving and birth weight of their calves

Age of dams (year)	Weight of dams	No. of dams	No. of calves	Av. dams weight (kg)	Av. birth weight (kg)	Relation of weight of calf to weight of dam percent
2–2^{6}	300–399	1	1	399	23.5	5.8
2^{6} and over		1	1	358	22.5	6.3
2–2^{6}	400–499	13	13	456.3	31.0	6.8
2^{6} and over		2	2	484.5	35.5	7.3
2–2^{6}	500–599	6	6	505.1	32.8	6.5
2^{6} and over		23	23	545.8	38.5	7.0
2–2^{6}	600–699	—	—	—	—	—
2^{6} and over		14	14	625.6	40.8	6.5
2 and over	300–699	60	60	533.3	36.2	6.8

creased. This might be due to change in age, since weight and age are highly correlated. The relation of birth weight of the calf to weight of the dam, when expressed as a percentage of the weight of dams at calving, increased from 5.8 per cent in the 300–399 kg. group of cows to 7.3 per cent in the 400–499 kg group and then decreased to 6.5 per cent in last group (Table 22). This corresponds with the findings of: HENRY and MORRISON (1917), MCCANDLISH (1922), FITCH *et al.* (1924), KONOPINSKI and KORTLINSKI (1951), JOUBERT and HAMMOND (1954), FOOTE *et al.* (1959) and SMIRNOV (1960), who all found that birth weight increased as dam's weight increased.

The correlation coefficient between the weight of dams at calving and the weight of calves at birth was a positive correlation (Table 23). The results

TABLE 23. Correlation between weight of dams at calving and weight of their calves at birth

Age of dam	No. of calves	Correlations
Dams 2–3 years old	23	0.399
Dams 3–4 years old	9	0.648 ×
Dams 4 years and over	28	0.438 *
Dams 2 years and over	60	0.698 **

× nearly significant
* significant ($P < 0.05$)
** highly significant ($P < 0.01$)

agree fairly well with those reported by previous workers. KUSNER (1936), KRASNOV and PAK (1939), DAWSON *et al.* (1947), GREGORY *et al.* (1950), TANTAWY and AHMED (1955), MÄKELÄ and OITTILA (1956) and BRINKS *et al.* (1962). The correlation coefficient between the weight of dam and birth weight of the calf are highly positive and statistically highly significant: 0.698 (Table 23).

Thus the finding that the weight of the dam has a significant influence on the birth weight of her offspring is confirmed. This correlation shows that the heavier the weight of the mother, the heavier the weight of the calf at birth. It appears that size of the cow is reflected in this correlation, since weight and size are highly correlated.

Age of dam:

Table 24 shows that the average birth weights of calves increase with the increase of age of dam up to six years old. This is usually attributed to the changes in size, and physiological functions which accompany the aging of dam. An other strong suggestion of an age-of-dam effect is that young dams carry their calves for a shorter period than older cows do.

Results obtained in table 25 show that, within sex, the average birth weights of calves from older dams (2^6 year and over) were heavier than of those from dams between 2 and 2^6 years old. These differences within sex were statistically highly significant (Table 19). These results are in general agreement with the observations made by McCandlish (1922), Dawson *et al.* (1947), Burris and Blunn (1952), Eidrigević and Poljakov (1954), Drewry *et al.* (1959), Stegenga (1961) and Donald *et al.* (1962). From this table it can be observed that the maximum birth weight for males is reached in dams of 2^6 and over. For females not before 4–5 year-old dams. The author did not find any explanation for this finding.

Table 24. Relation between age of dam and birth weight of calves of both sexes

Age of dam (Year)	No.	Mean kg	S.D.	C.V. %
$2–2^6$	87	33.00	4.02	12.18
$2^6–3$	30	36.21	5.33	14.71
3–4	51	35.59	4.11	11.54
4–5	37	37.83	3.74	9.88
5–6	39	38.64	3.90	10.09
6 and over	58	37.07	5.50	14.83
Total	302	35.86	4.86	13.55

Table 25. Means, standard deviations, and coefficients of variability for birth weights of male and female calves on different ages of their dams

Age of dam (year)	Males				Females			
	No.	Mean kg	S.D.	C.V. %	No.	Mean kg	S.D.	C.V. %
$+2–2^6$	43	34.59	3.44	9.94	44	31.44	3.98	12.65
$2^6–3$	17	38.38	4.87	12.68	13	33.38	4.65	13.93
3–4	20	38.15	4.43	11.61	31	33.95	2.92	8.60
4–5	18	38.38	2.89	7.52	19	37.31	4.41	11.81
5–6	25	38.98	3.31	8.49	14	38.03	4.85	12.75
6 and over	25	38.76	5.63	14.52	33	35.80	5.13	14.32
Total	148	37.41	4.45	11.89	154	34.37	4.79	13.93

+ Includes 12 calving at 1^{11}

In comparing the birth weights of the 6 groups of dam ages in table 24, taking each two consecutive groups, the highest difference in birth weight was found between calves of the groups of $2–2^6$ and $2^6–3$ years old. Some of these differences can be attributed to the fact that dams in the age group of $2^6–3$ are higher in growth than in the other group. These results confirm the finding of Stegenga (1961) who came to the conclusion that differences between calves from 2-year-old and adult dams, are much more marked in the first and second years, becoming smaller as the cow grows older. He stated that from researches made on different breeds, it appears that the influence of the age of the mother on birth weight is caused by the fact that a 2-year-old mother is not completely developed, because there is a certain competition between the animal and its foetus concerning the use of the nutrition, resulting production of a smaller calf at birth.

CHAPTER 3

GROWTH

3.1. INTRODUCTION

There is a growing interest among breeders in western European countries to make dual-purpose cattle out of the dairy breeds. As in other countries, the production of beef has shown a rising tendency also here during the last few years. This is due to the price development which depends on the standard of living of the population. The price index for beef cattle has increased to 254%, but for milk only to 210% compared with the pre-war index (LANGLET, 1962).

In the light of modern requirements for beef, Dutch dairy breeds (F.H. and M.R.Y.) are more popular than other European breeds, to suit this new interest. MASON (1962) stated that Friesian breed stands far ahead compared with other breeds in Great Britain. When dealing with domestic animals with such long generation intervals as cattle have, it is important to determine the breeding value of the individual animals at a very early stage. It is obvious that observations made at or soon after birth, give a good indication about the future performance of beef calves. The weight of the new born calf is of great importance to breeders, and a reliable basis of information when predicting its subsequent development.

Efforts have been made to select dual-purpose stock at an early age. It is obviously of great importance to be able to avoid the cost of rearing calves which subsequently turn out to be unprofitable producers. For example, if the animal production is low, considerable losses are to be expected before a decision has been made to cull it. Therefore breeding animals must be selected at an early age. In the production of cattle for meat, the importance of being able to predict future gains from early growth is obvious. HOLTZ *et al.* (1961), reported that appetite in the young animal might be a lifelong trait and that this could be easily measured in terms of growth rate. Growth rate, in its turn, may be correlated with milk production, since each reflects the efficiency of specialized metabolic functions, which are governed by genetic and environmental factors. They also refer to the finding of PRENTICE (1936) that faster growing heifer calves tend to produce more milk as cows.

The growth of the young calves depends on several factors. Genetics undoubtedly play a part, the rate of growth being to some extent an inherited quality. As might be expected, environment has a definite influence upon growth. Nutrition, for example, has a important effect on weight gain. MARTIN *et al.* (1962) reached the conclusion that ration affected weight gains from birth to all ages. They refer to several other investigators, who have found similar results. The object of this study is to evaluate some of the environmental factors affecting growth response.

3.2. Review of literature

Several workers have shown that body weight is heritable, and others have studied the environmental factors affecting growth. The traits used in their work, were pre-weaning growth and post-weaning growth, at different ages.

Krasnov and Pak (1939) found that the correlation between birth weight and weight at four months of age ranged from 0.39 to 0.58 for males and from 0.43 to 0.48 for females. Dawson *et al.* (1947) confirmed these previous results, as they found on beef cattle a correlation coefficient of -0.58 between birth weight and number of days required to reach 500 pounds. Gregory *et al.* (1950), studying data collected at the North Platte and Valentine substations of the Nebraska Agricultural Station during the period of 1936 till 1947, came to the conclusion that in the studied Hereford breed there is a positive correlation value of 0.27 at North Platte Station and 0.60 at Valentine station between birth weight and weaning weight of calves. They also added that calves which were heavier at birth still have a similar advantage at weaning age. They also estimated birth weights, gain and weaning weights in table 26. Weaning weights were corrected to a constant age of 150 days for the Valentine data and to 200 days for the North Platte data by regression of weight on age. The differences between the averages of the two sexes for gain and weaning weight were not significant at either station.

Table 26. Birth weight, weaning weight, gain from birth to weaning (Gregory *et al.* 1950)

Items	Stations					
	North Platte			Valentine		
	No.	Sex	Mean Wt. pounds	No.	Sex	Mean Wt. pounds
At birth	148	♀	69	33	♀	72
	133	♂	74	41	♂	76
	281	♀♂	71	74	♀♂	74
Gain from birth to weaning	146	♀	299	29	♀	252
	124	♂	297	40	♂	263
	270	♀♂	298	69	♀♂	258
At weaning	146	♀	368	29	♀	325
	124	♂	371	40	♂	339
	270	♀♂	369	69	♀♂	333

Jordâo and Assis (1950) stated that at six months bull calves averaged 152.8 kg and heifer calves 157.3 kg in 125 Flemish calves in Brazil. These differences between sexes were not significant. They also indicated that the coefficient of correlation between weight of calf at birth and at 6 months was 0.406 for bulls and 0.271 for heifers. While Vianna and Miranda (1950) observed that, in Charollais breed, bulls were heavier at birth and grew more rapidly than heifers. JOHNSON and DINKEL (1951) came to the conclusion that the weight gain approximated a straight line up to 155 days of age, and after that increased at a decreasing rate, in pure bred Hereford calves in South Dakota. The average weaning weight was 379.7 pounds and the average weaning age was 185 days.

KOCH (1951) analysing the records of U.S. Range Livestock Experiment Station, Miles City, Montana during the period 1938–1948 mentioned that weaning weights (176 days) of Hereford bulls and steers were 44 and 13 pounds heavier, respectively, than of heifers. The regression of weight on age of calf at weaning was 2.27 lb per day. The same results were proved by KOGER and KNOX (1951) who found that weaning weight, standardized to 205 days of age was 437 lb for the steers and 419 lb for range heifers, in the herd of grade Hereford cattle on the semi desert experimental range of the New Mexico College. They also added that offspring from cows selected for heavy weight showed more growth than the others with no consideration given to weight.

VEIGA *et al.* (1951) showed that there was a significant positive correlation between birth weight and live weight at 6 months in Holstein Friesian calves. Also JORDÂO and ASSIS (1952) in their detailed study concerning weight at 12 months denoted that live weight at 12 months averaged 297.49 kg in bulls and 270 kg in heifers, in Meuse-Rhine-Yssel cattle at Brazil. The coefficient of correlation between birth weight and weight at 12 months was not significant for bulls but was significant for heifers (r = 0.36).

At San Juan Basin Experiment Station, Colorado, BURGESS *et al.* (1954) pointed out the relation of age of dam and sex to weaning weight in table 27.

TABLE 27. Effect of age of dam and sex on weaning weight (BURGESS *et al.* 1954)

Variable	Estimate of effect on weaning weight lb
Age of dam	
2 year old	—15.15
3 to 5 year old	4.68
6 to 8 year old	20.71
9 year old and over	—10.24
Sex	
Steer	—6.24
Bull	14.34
Heifer	8.10

Average weaning weight was 402.64 lb.

CARNEIRO and LUSH (1954) confirmed these previous results, as they gave the average weights (in kg) for both sexes of pure-bred Swiss calves at 3 months intervals in table 28.

JOUBERT and HAMMOND (1954) reported that a difference of 20% at birth weight, resulted in a difference that was not less than 28% at the age of 7 months. (Cited by STEGENGA (1961).

TABLE 28. Weight of calves at 3 months' intervals (CARNEIRO and LUSH 1954)

Age month	sex	Pedro Leopold 1931–1947		Pinheiral 1941–1949	
		No.	Av.	No.	Av.
Birth	♂	233	37.6	143	40.4
	♀	199	35.1	158	36.2
3	♂	164	88.9	116	89.7
	♀	161	85.0	139	84.3
6	♂	152	151.7	92	139.7
	♀	149	138.8	106	134.5
9	♂	144	189.3	104	194.5
	♀	138	177.3	125	182.1
12	♂	125	220.9	99	221.4
	♀	129	201.7	124	206.3

ROLLINS and GUILBERT (1954) carried out an extensive study of the factors affecting the growth of pure-bred Hereford calves at University California, and concluded that:

A. The average rate of growth from birth till four months of age was 1.91 pounds per day.
B. Bull calves on an average gained 0.13 pounds per day more than heifer calves did from birth till four months of age.
C. Calves were weaned at about 240 days of age and averaged 534 pounds. For 240-day-weaning weight bull calves were 68 pounds heavier than heifers.
D. Calves produced from young and old cows grow more slowly till four months of age and are lighter in weight of weaning than calves dropped by cows of intermediate ages, as is shown in table 29.

TABLE 29. Effect of age of dam on growth of calves (ROLLINS and GUILBERT 1954)

On an average, calves from cows 7 to 10 years of age, exceed calves from cows	4 months (lb Gain/day)	120 days (lb)	240 days (lb)
3 years of age by	0.17	24	21
4 years of age by	0.10	14	13
12 to 14 years of age by	0.15	—	18

From data collected at the University of Nebraska during the period of 1922 till 1942, DAVIS and HATHAWAY (1955) working on pure-bred Holstein females represented standard weights and gains by one month intervals in table 30.

Data from 4553 calves raised at the U.S. Range Livestock Experiment Station, Miles City, Montana, were analysed by KOCH and CLARK (1955 a). In their detailed study concerning genetic and environmental relationships between economic characters in Hereford, found that the heritability and repeatability estimates were 0.35 and 0.26 for birth weight, 0.24 and 0.34 for weaning weight (182 days), 0.21 and 0.34 for gain from birth to weaning, 0.47 and 0.20 for yearling weight (365 days) and 0.39 and 0.09 for gain from weaning till yearling age, respectively. They also stated that the genetic correlation between birth weight and weaning gain (0.46) indicates that many of the same genes affect pre-natal and post-natal growth till weaning.

TABLE 30. Weights and gains by one-month intervals (DAVIS and HATHAWAY 1955)

Age in months	Actual average		Monthly gain lb average
	No.	Average lb	
Birth	262	88.2	—
1	262	199.1	30.9
2	262	161.8	53.1
3	256	215.5	49.9
4	252	276.3	56.6
5	249	337.7	60.2
6	247	402.3	60.6
7	245	462.5	58.3
8	245	518.6	55.9
9	244	567.7	51.8
10	243	617.1	48.3
11	242	661.6	45.5
12	242	703.9	43.7

KOCH and CLARK (1955 b) recorded the influence of sex on weaning weight (182) for Hereford calves from cows of various ages in table 31.

TABLE 31. Effect of sex and age of dam on weaning weight (KOCH and CLARK, 1955)

Age of cow (years)	Males		Females		Av. difference lb
	No. of calves	Av. weaning weight lb	No. of calves	Av. weaning weight lb	
3	703	363	693	339	24
4	619	388	605	361	27
5	468	399	465	373	26
6	383	408	367	380	28
7	304	406	290	387	19
8	246	414	234	380	34
9	193	406	167	377	29
10	107	407	108	380	27
Total	3023	392.6	2929	366.4	26.2

MACDONALD and BOGART (1955) working in U.S. Western Regional, on 26 Hereford and 16 Aberdeen Angus calves, observed that bull calves gained faster and more efficiently than heifer calves from birth till 500 days. Differences between males and females found by BURNS and ALEXANDER (1956) in Hereford calves were similar to those recorded by other workers, in that males were heavier than females from brith till weaning (9 months). MARTIN (1956) studying factors affecting growth response on 659 dairy calves (Ayrshire, Brown Swiss, Holstein, Guernsey and Jersey) agreed with these previous results, as he found that male calves were heavier than female calves at birth and gained faster than female calves from birth till 8 weeks, birth till 6 weeks, and birth till one year of age. He also explored birth weight effects on growth by correlation of birth weight with gains from birth till various ages. Correlations of birth weight with gain to 4, 6, 8, 12, 16, 26 and 52 weeks of age were positive, and were all less than 0.40.

NELMS and BOGERT (1956) using Hereford and Aberdeen-Angus at Oregon State College pointed out the following:

A. Average for birth weights and suckling gains in table 32.

TABLE 32. Birth weight and daily gain (NELMS and BOGERT, 1956)

Line and sex	No.	Birth weight lb	Daily gain lb
Lionheart:			
Males	8	73.5	1.86
Females	13	73.2	1.63
Prince:			
Males	18	75.1	1.65
Females	10	68.2	1.81
David:			
Males	13	66.0	1.64
Females	8	64.5	1.43
Angus:			
Males	16	63.1	1.94
Females	17	57.4	1.90

a. Average birth weight 67.3 lb
b. They were weaned at approximately 450 lb

B. Daily gain as shown in table 33 according to age of dam.

TABLE 33. Gain per day according to age of dam (NELMS and BOGERT, 1956)

Age of dam	Estimate effect lb per day (1)
2 years	—0.182
3 years	—0.009
4 years	—0.018
5-6-7 years	0.040
8 years and over	0.169

Average daily gain 1.63 lb per day
(1) Deviation from the average.

C. Regression of gains on birth weight (per lb) 0.0115. They pointed out that each change of 10 lb in birth was associated with a difference in rate of gain of 0.115 lb per day. It was reported by VSJAKIH and BOROZDINA (1957) that calves with the greatest weight at all ages (6, 12 and 18 months) were produced by 5 to 10 year-old cows mated with middle-aged to old bulls. Calves with the least weight at all ages, and in which variation in weights was greatest, were produced by 2 young parents, in Ala Tau calves at Moscow.

DREWRY *et al.* (1959) related birth weight variation with changes in growth of Aberdeen-Angus calves, in Arkansas. They reported that the correlation values between birth weight and calf weight, were 0.30, 0.37 and 0.32 for the first, third and sixth months, respectively. They added that the magnitude of these values would suggest that heavier calves at birth were able to maintain their weight advantage through 6 months. HEYNS (1959 a) confirmed these previous results, as he concluded that for every 10 lb increase in birth weight of pure-bred Africander calves, the total gain in weight is likely to be 90 lb more over the first 8 months, and 100 lb. more at weaning. Calves studied in his work were divided into those weighing over 70 lb and those under 70 lb at birth. The former were found to consume an average of 564 lb of milk in the first month and 416 lb for the lighter calves. Average weaning weights of the 2 lots of calves were 460 and 377 lb, respectively.

HEYNS (1959 b) in his research on Africander calves over a 10 year period, gave the average 6-month live weight of calves born in early summer (Oct.-Dec.) as 405 lb with an average gain per day of 1.86 lb, as against 363 lb and 1.58 lb. for those born after December at Glen.

KOCH *et al.* (1959) in the course of their investigation, which included beef cattle on several farms at Nebraska, stated their results in table 34.

TABLE 34. Effect of sex on pre-weaning gain (KOCH *et al.*, 1959)

Items	No.	Birth weight lb	Pre-weaning gain lb/day
Bull	1434	73.2	1.656
Heifers	1512	68.2	1.543
Difference (B-H)		5.2	0.113
Ratio (B/H)		1.076	1.073

Age at weaning (182 to 210 days)

BROWN (1960) carried out an extensive study of the factors affecting growth of 287 pure-bred Hereford, 334 pure-bred Aberdeen-Angus and 271 pure-bred Aberdeen-Angus calves, in 3 different herds, observed that male calves were heavier than female calves. The sex difference at 240 days of age was 57, 33 and 22 lb. in the 3 herds. He also mentioned that there was an increase in the weight of calves associated with an increase in age of dam during the early years of production and a subsequent decline in calf weight after the years of peak production. This was evident at all four ages at which calf weights were studied (60, 120, 180, and 240 days of age). HEYNS (1960) obtained similar results to the above-mentioned worker, as he proved that weaning weights of Africander calves, increased up to a maternal age of approximately 6 to 7 years, and subsequently decreased again. Also DE VREE (1961) confirmed these conclusions, as he found in his publication on the French Charollais, that the age of the dam had an influence on calf growth. Growth was poorest in calves from 1st, 2nd and 3rd calf cows. After the 6th calf the growth rate of the calf declined again. He indicated that birth weight averaged 45.8 kg for bull calves and 42.7 kg, for heifer calves, and that the average weigth at 10 months was 372.2 kg and 275.6 kg, respectively. He also estimated the average daily gain of bull and heifer calves between 1 and 6 months of age as in table 35.

TABLE 35. Daily gain of bull and heifer calves (DE VREE 1961)

Sex	1957		1958		1959	
	No.	Growth per day gr	No.	Growth per day gr	No.	Growth per day gr
Heifers	110	1060	307	1000	366	930
Bulls	118	1220	290	1130	398	1110

The results obtained by BRINKS *et al.* (1961) who studied extensive data from the United States Range Livestock Experiment station, Miles City, Montana, were in general agreement with the findings of many workers, that steers were heavier than heifers at birth and at weaning (180 days), and also gain more than heifers from birth till weaning (321.0 ♂ and 305.5 ♀). PAHNISH *et al.* (1961) working at the Arizona Agricultural Experiment Station, on weaning weights of 329 bull calves and 332 heifer calves found that bull calves were significantly heavier than heifer calves ($P < 0.01$). The sex differences in weaning weights (270 days) ranged from 44 to 99 pounds.

STEGENGA (1961 found that calves born of 2 year old mothers, were on an average lighter in weight at birth than those born of older cows. Differences in development are still noticeable at the age of 3 years and 8 months. He also reported that calves from young mothers (2 years old) were less developed than their half sisters, born of the same mother at 3 years of age and the differences were more pronounced between the calves dropped from 2-year-old cows, and their half sisters from the same mothers at 5 years of age in Friesian calves in the Netherlands.

SWIGER (1961) studying data from the records of pure-bred Hereford cattle owned by Charles E. Haigler and located near Washington Court House in Southern Ohio, found that the effects of age of dam on weaning weight are curvilinear. In his work it is reported in graphical form that weaning weight reached its maximum when the dams age was 8 to 10 years. After this the weaning weight of the calf declined again. He reported also that the average daily gain from birth till weaning was 1.61 lb for bulls and 1.46 lb for heifers, and the average sex difference for post-weaning gains was 0.3 lb per day.

The average age at weaning of the calves used in his study was 230 days. It was reported by BLACKWELL *et al.* (1962) that at 18 months steer calves averaged 720 lb and heifer calves 621 lb in Hereford cattle at New Mexico. They also showed that steers grew more rapidly after weaning (7 months) till 18 months of age, than heifers.

BRINKS *et al.* (1962) in their detailed study concerning the effect of the weight of the dam on the calf's growth, declared that heavier Hereford cows tend to produce heavier, faster-gaining calves. They pointed out that cow weights increased with age up to 8 years and then declined slightly.

FLOCK *et al.* (1962) observed that bull calves were from 4.2 lb (Hereford Shorthorn) to 5.5 lb (Angus) heavier at birth than heifer calves. Pre-weaning gain was approximately the same for steer and heifer calves. They reported that effects due to month of birth, on gain per day, were small. The results obtained by MAMMERICKX (1962) who worked in the Congo on Kundhi buffaloes imported from Pakistan in 1953, showed that birth weights of male and female calves were 38.5 and 31.7 kg respectively. Up to one year old, increase in body weight averaged 907 grams daily in male and 888 gr. in female calves.

MARTIN *et al.* (1962) working on the same data of his work in the year 1956, concluded that season effects were significant in the analysis of 1-year weight gains and added that the reason for these significant season effects are not entirely clear, but the differences may be associated with seasonal variations in feeding and management practices. They declared that feeding was found to affect weight gains from birth to one year of age. They also estimated the correlation between birth weight and six-month and one-year gain as 0.356 and 0.291, respectively. These correlations were significant at the 1% level of probability.

The weight gains of calves during the first 26 weeks of life were 215, 193 and 297 lb for West African Shrothorn, N'Dama and Sokoto (Zebu) cattle in Ghana, respectively, with average birth weights of 46.0, 42.0 and 58.5 lb. The highest recorded weaning weights at 36 weeks for the 3 types were 360, 340 and 550 lb (MONTSMA, 1962).

NEVILLE (1962) from his studies on Hereford calves at Athens concluded the following:

a. Steers were heavier than heifers at 4 and 8 months of age. These differences approached significance at 4 months and were significant at 8 months (14.6 lb).

b. Four and eight-month weights were significantly influenced by differences in birth weight. A calf which was a pound heavier than other calves at birth still had a corresponding advantage at 4 and at 8 months of age.

c. Age of dam was not an important source of variation in calf weights.

d. Differences in milk consumption of the calves were significant sources of variation.

3.3. MATERIAL AND METHOD

Calves used in this study were pure-bred Dutch Friesian, raised in the following experimental farms in the Netherlands.

1. Laboratorium voor Veeteelt, Wageningen
2. Laboratorium voor Dierfysiologie, Wageningen
3. Proefboerderij „De Ossekampen" van Proefstation voor de Akker- en Weidebouw (P.A.W.), Wageningen
4. Instituut voor Moderne Veevoeding De Schothorst, Hoogland (Utr.)
5. Proefboerderij „De Waag", Noord-Oostpolder
6. U.T.'s proefboerderij van Veevoeding, Maarssen.

A calf's first weight estimated within 24 hours after birth. Because the author did weighing on fixed days the once every 4 weeks, the second weight was taken at an age somewhere between birth and one month. Subsequent weights would follow at 4-week intervals till one year-old (52 weeks). This was done in the first 5 above-mentioned farms. At U.T.'s proefboerderij, the first weight was taken at birth and following weights at one-week intervals till the calves were 10 weeks of age. After that they were weighed every two weeks intervals till one year old (52 weeks). Weights were taken by means of a walk on the platform scale. The weight of each calf was corrected to exact four-week intervals from birth till 52 weeks of age, using the weights and average daily gains found for the approximate four-week interval which bracketed the age to which it was desired to standardize.

A calf was weaned (no milk in feeding) on the day closest to its being 5 to 8 months of age, in the first 5 farms. In the last farm weaning took place at 10 weeks of age.

The data analysed were gathered from 152 calves born during the period of 1959–1962. The calves of the first 5 farms were dropped in the period of October 1961 till May 1962, but the calves of the last farm were born from 1959 till 1962.

The data include all live weights available at each age. There were 100 heifers and 52 bulls. The 52 bulls in this work were raised in three farms only (1, 4 and 6). At the other farms (2, 3 and 5) male calves were removed from the herd between a week and 3 weeks of age, thus reducing further the number of bulls available. All calves used were single born. Twinning percentage was very low, so it was left out of consideration.

The majority of the calves were born in February, March, April and November, with a few scattered births in December and January. The data involved no calves dropped in June, July or August and only a very small number in September and October. The seasons of birth were divided into: Winter (Jan., Feb., Mar.), Spring: (Apr., May, June), Summer: (July, Aug., Sep.), Autumn: (Oct., Nov., Dec.). Table 36 shows the distribution of calves born over the different seasons. Since bull calves were only dropped in winter and spring, heifer calves were treated separately in this study to know the effect of season of birth on growth of calves, from birth till 52 weeks of age, using only three seasons (winter, spring and autumn) in which there were weights available of calves in all the ages studied.

TABLE 36. Distribution of calves born over the different seasons

Age in weeks	Winter		Spring		Summer		Autumn	
	♂ No.	♀ No.	♂ No.	♀ No.	♂ No.	♀ No.	♂ No.	♀ No.
Birth	32	53	19	15	—	2	1	30
4	32	53	19	15	—	1	1	30
8	32	53	19	15	—	1	1	33
12	32	53	19	15	—	2	1	36
16	32	52	19	15	—	2	1	42
20	32	52	19	15	—	11	1	42
24	32	51	19	14	—	11	1	42
28	32	51	19	14	—	11	1	42
32	32	51	19	14	—	11	1	42
36	32	50	18	14	—	11	1	42
40	32	50	18	14	—	11	1	42
44	31	50	18	14	—	11	–	39
48	31	50	18	14	—	11	1	37
52	30	50	16	11	—	11	–	29

In the comparison between traits of ages of dam and between sexes, the animals included in this study, 138 calves (46 ♂ and 92 ♀), had all of the following information available: birth weight, every 4 weeks, weight till 52 weeks of age. In the analyses dams were classified into $2–2^6$ years old and older dams (2^6 and over). This was done because the number of dams within each age group ($2–2^6$, $2^6–3$, 3–4, 4–5, 5–6 and 6 and over) was too small. Males were compared with females.

Gain was the difference between each two subsequent corrected weights. Average daily gain at each period studied was the difference in weight between each two subsequent weights divided by 28 days. Yearling daily gain was calculated by subtracting birth weight from weight at 52 weeks of age, and dividing this by the number of days from birth to 52 weeks of age (364 days).

The simple correlation coefficients determined were the weights of calves at birth compared with the weights of the same calves at 12, 24, 36 and 52 weeks of age.

After birth the calves were placed in individual calf pens. Straw bedding was used in all pens and was generally changed daily. Calves received their mother's colostrum for the first three days. After this they were fed on whole milk, except at the last farm at Maarssen, where calves were fed on synthetic milk. At the end of the third or sixth week, according to the management of each farm, the calves were gradually changed over to skim milk or powder milk and butter milk. They were fed hay ad libitum and were given a small amount of grass silage starting at 3 weeks of age. They were also allowed a good supplementary diet of calf meal special to each farm. The diet of concentrates was gradually increased by the time that skim milk and powder milk were discontinued. The grazing period started about the first of June and lasted till the middle of November. In this period the calves stayed out at pasture day and night. After this the calves were allowed to remain at pasture all the day and in the evening they returned to the stable. Up till then they were, of course, turned out every day irrespective of weather conditions. By the middle of December all the calves were indoors. During the grazing period, as the consumption of grass increased, the concentrate diet and hay were reduced. When expressing general recommendation for the feeding systems at these farms, it was found impossible to conclude that the feeding system of any farm was better than the others. This does not mean, however, that all the systems used were identical, but merely that each of them had certain advantages and disadvantages which varied in importance depending upon the individual requirements of the farm.

This study aims at evaluating the relationship of maternal influence (age of dam) and some other factors such as sex and season of birth. It is also desirable to know whether birth weight has a significant positive correlation with weight at 12, 24, 36 and 52 weeks of age, or not. The other environmental factors which might influence gains are probably feed consumption, temperature and management.

3.4. RESULTS AND DISCUSSION

Birth weight:

Several earlier experiments demonstrated that birth weight is a good indicator of later growth. So in this study the special attention was directed towards the relationship between birth weight and growth of Friesian calves till 52 weeks of age. Results given in tables 37, 41 and 43 show that heavier calves at birth were able to maintain their weight advantage throughout the first 52 weeks of their lives in both sexes, but particularly in bull calves. This may be due to the fact that small calves grow more slowly and cannot make effective use of milk and food, as their absorptive capacity is too small. The same results were found for different ages of calves by many workers cited in the literature. JOUBERT and HAMMOND (1954) found on South Devon Dexter crosses, that the difference of 20% at birth weight, resulted in a difference that was not less than 28% at the age of 7 months. NEVILLE (1962) came to the conclusion that the constants for birth weight suggest that a calf which was a pound heavier than other calves at birth still had a corresponding advantage at 4 and 8 months of age.

TABLE 37. Average weights of Friesian heifer calves at 4 weeks intervals according to season of calving

Age in weeks	Winter		Spring		Autumn	
	No.	Mean kg	No.	Mean kg	No.	Mean kg
Birth	53	33.8	15	33.0	30	35.6
4	53	46.1	15	43.7	30	48.7
8	53	62.6	15	59.3	33	70.2
12	53	83.4	15	78.1	36	102.5
16	52	105.6	15	95.8	42	118.8
20	52	127.6	15	117.3	42	140.4
24	51	150.7	14	140.1	42	158.0
28	51	176.0	14	161.5	42	176.1
32	51	201.0	14	179.0	42	196.5
36	50	221.7	14	194.1	42	215.6
40	50	239.8	14	206.9	42	239.3
44	50	253.9	14	224.3	39	261.2
48	50	267.9	14	242.0	37	280.6
52	50	280.0	11	251.6	29	299.5

(Season spans Winter, Spring and Autumn.)

Birth weight effects on growth were estimated by correlation between birth weight and weights at various ages. The correlations of birth weight with various combinations of weights are listed in table 38. Correlations of birth weight with weight at 12, 24, 36 and 52 weeks of age, of males and females, was positive. In the total (males and females) the correlations reached a figure of more than 0.37. These values are all highly significant ($P < 0.01$). The results in table 38 show that there is a positive relation between birth

TABLE 38. Phenotypic correlation

Characters correlated	Males		Females		Total	
	No.	Correlation	No.	Correlation	No.	Correlation
Birth weight with:						
12 weeks of age	52	0.464**	100	0.544**	152	0.514**
24 „ „ „	52	0.526**	97	0.202*	149	0.375**
36 „ „ „	51	0.456**	96	0.275**	147	0.438**
52 „ „ „	46	0.483**	92	0.172	138	0.443**

* Significant ($P < 0.05$)
** Highly significant ($P < 0.01$)

weight and the other weights. It appears that calves with the higher birth weights remained the heavier animals throughout the period studied (52 weeks). These figures are in general agreement with some of the figures reported by previous workers, KRASNOV and PAK (1939), DAWSON *et al.* (1947), GREGORY *et al.* (1950), VEIGA *et al.* (1951), MARTIN (1956), DREWRY *et al.* (1959) and MARTIN *et al.* (1962) for different ages, of various breeds. So the highly significant positive correlation between birth weight and weights at different ages studied may justify selection on the basis of higher birth weight in Friesian calves particularly for fattening purposes.

Season of birth:

Births weights and subsequent weights every four weeks of heifer calves are shown in table 37, and presented graphically in figure 2. From this table a wide variation can be observed in the growth between calves born in autumn and in the remainder of the year. Autumn calves were heavier than winter and spring calves in almost all ages comparisons (Table 37).

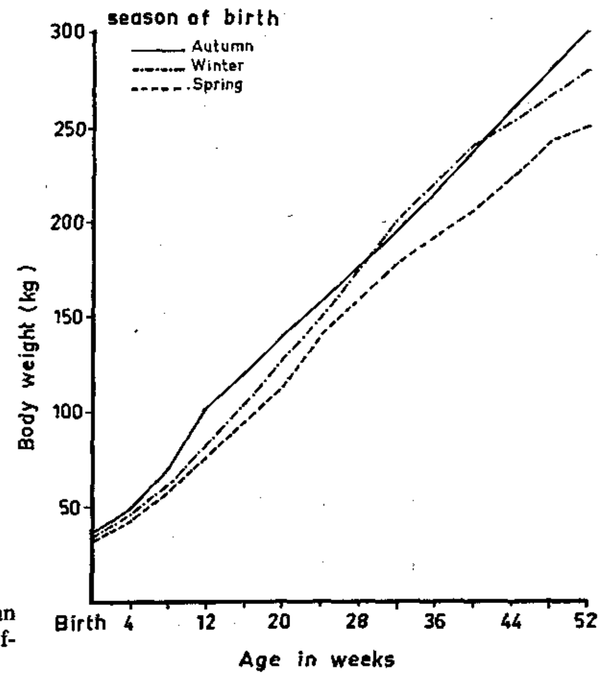

FIG. 2. Growth curves of Friesian female calves born in different seasons.

In the case of gain per day till 52 weeks of age heifer calves born in autumn gained 0.123 and 0.049 kg more than those born in spring and winter respectively (Table 39). Effects of season of birth were highly significant in the analysis of gain per day from birth till 52 weeks of age (Table 40). The reasons for the significant season effects on gain per day may be due to the fact that calves born in autumn had heavier birth weights than those born in spring and winter (Table 37). They probably also resulted from seasonal variations in feeding and management practices during the period of study, because calves studied in this work were not under a stable system of feeding for the whole period of study. The animals received their rations according to the management and also to the forage and pasture available at every farm. The autumn born calves did not get more concentrate included milk than the spring born calves. The same results were found by BROWN (1960), and MARTIN *et al.* (1962) in that the season of birth affects the growth of calves and they ascribe this to the fact that the nutritional level at which calves develop may vary considerably, because of the greater availability of forage and pasture in different seasons. Calves born in certain seasons may

TABLE 39. Daily gain from birth to 52 weeks of age for heifer calves according to season of birth

Season	No.	Total gain per day kg	Mean gain per day kg
Winter	50	33.82	0.676
Spring	11	6.62	0.602
Autumn	29	21.02	0.725
Total	90	61.45	0.683

TABLE 40. Analysis of variance for daily gain from birth till 52 weeks age according to season of birth (Winter-Spring-Autumn) of heifer calves

Source of variation	D.F.	Mean Square
Total	89	0.005
Between seasons	2	0.06 **
Within seasons	87	0.004

** Highly significant ($P < 0.01$)

have access to more nourishing forage than calves born in other seasons. But this finding is not in general agreement with work done by FLOCK *et al.* (1962), who found that the effects on gain per day due to month of birth were small. They came to this conclusion because the calving season was restricted to only 4 months.

Sex:

It has long been noted that bull calves are significantly heavier at birth than heifers. In this study males were heavier at birth and maintained this advantage throughout the experimental work (till 52 weeks of age). The average differences between male and female calves for birth weight and weight at 52 weeks of age were 4.1 and 44.9 kg, respectively, in favour of male calves (Table 41).

As for gain per day, bulls gained 0.112 kg per day more than heifers from birth till 52 weeks of age (Table 42). These differences were highly significant. The sex effect on gain per day was partially dependent on sex difference in birth weight and also due to the fact that bulls were usually kept on a somewhat better feeding system than heifers during this period. The differences in the growth between male and female calves are in agreement with previous investigations, ROLLINS and GILBERT (1954), MARTIN (1956), NELMS and

BOGERT (1956), KOCH *et al.* (1959), BROWN (1960), DE VREE (1961), PAHNISH *et al.* (1961), BLACKWELL *et al.* (1962), FLOCK *et al* (1962) and NEVILLE (1962).

TABLE 41. Average weights of Friesian calves at 4 weeks intervals

Age in weeks	Males		Females		Total		
	No.	Mean kg	No.	Mean kg	Mean kg	Gain in 4 weeks kg	Daily gain kg
Birth	52	36.9	100	32.8	34.8	—	—
4	52	48.0	99	44.9	46.4	11.6	0.41
8	52	65.9	102	62.8	64.3	17.9	0.63
12	52	85.2	105	85.3	85.2	20.9	0.75
16	52	105.4	112	108.2	106.8	21.6	0.77
20	52	129.4	121	129.5	129.4	22.6	0.81
24	52	155.2	119	150.8	153.0	23.6	0.84
28	52	180.9	119	172.6	176.7	23.7	0.85
32	52	207.0	119	194.8	200.9	24.2	0.86
36	51	231.2	117	215.2	223.2	22.3	0.80
40	50	255.0	117	234.8	244.9	21.7	0.78
44	49	278.4	114	252.7	265.5	20.6	0.74
48	49	303.8	112	270.1	286.9	21.4	0.76
52	46	325.9	102	281.0	303.4	16.5	0.59

TABLE 42. Average daily gain of bull and heifer calves from birth till 52 weeks of age

Age of dam (Year)	Sex				Total kg	Differences between age of dam
	Bulls		Heifers			
	No.	Growth per day kg	No.	Growth per day kg		
2–2[6]	11	0.756	23	0.668	0.712	0.044**
2[6] and over	35	0.824	69	0.689	0.756	
Total		0.790		0.678	0.734	

Differences between sexes 0.112**

** Highly significant ($P < 0.01$)

Age of dam:

In general, the age of dam effects observed were the same as have been reported by other workers, in the afore-mentioned literature. There was an increase in the weight of calves associated with an increase in age of dam in both sexes. This was evident in calves of all ages at which weights were recorded (Table 43). It may be noticed in figure 3 that calves from adult mothers gained at a more rapid rate than those from young cows. The average gain per day from birth till 52 weeks of age, for dams 2–2[6] years of age was 0.712 kg and for the dams of 2[6] years and over was 0.756 kg (Table 42). The differences obtained here were statistically highly significant. The suggestion of

TABLE 43. Relation of age of dam on growth of their calves

Sex	Males				Females				Total	
Age of dam (year)	$2–2^6$		2^6 and over		$2–2^6$		2^6 and over		$2–2^6$	2^6 and over
Age of calf (week)	No.	Mean kg	No.	Mean kg	No.	Mean kg	No.	Mean kg	Mean kg	Mean kg
Birth	13	33.5	39	40.3	25	30.8	75	34.9	32.1	37.6
4	13	44.5	39	51.6	25	41.8	74	48.1	49.1	49.8
8	13	61.0	39	70.7	25	59.5	77	66.2	60.2	68.4
12	13	78.0	39	92.5	26	81.9	79	88.8	79.9	90.6
16	13	95.9	39	114.9	26	106.2	86	110.1	96.0	112.4
20	13	118.0	39	140.8	31	126.6	90	132.4	122.3	136.6
24	13	143.2	39	167.1	31	148.2	88	153.5	145.7	160.3
28	13	166.8	39	194.9	31	169.5	88	175.8	168.1	185.3
32	13	193.4	39	220.6	31	191.6	88	197.9	192.5	209.2
36	12	217.7	39	244.6	31	210.5	86	219.9	214.1	232.2
40	12	242.1	38	267.9	31	230.2	86	239.4	236.1	253.6
44	12	267.4	37	289.4	31	248.6	83	256.9	258.0	273.1
48	12	292.2	37	315.4	30	266.1	82	274.2	279.1	294.8
52	11	308.7	35	343.1	28	273.9	74	288.1	291.3	315.6

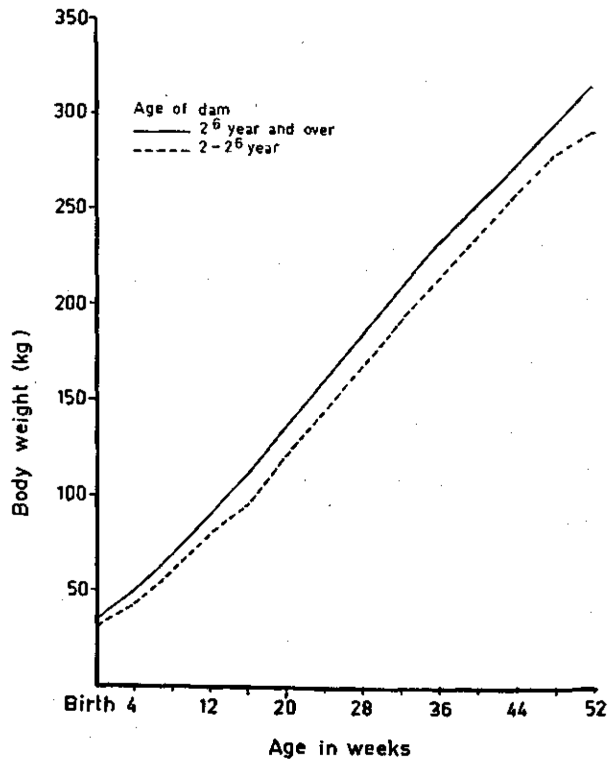

FIG. 3. Growth curves of Friesian calves born from heifers and cows.

an age-of-dam effect on gain per day, is that $2-2^6$-year-old dams gave lighter birth weight to their calves than mature cows do. The present study is not in agreement with the finding of NEVILLE (1962), who reported that age of dam was not an important source of variation in calf weights of Hereford. The cause is that in his work, age-of-dam differences were adjusted for variations in weight of dams and in milk production with the analysis used.

The results of the present investigation revealed that calves from young mothers ($2-2^6$ years old) were on an average less developed than the calves born from mothers 2^6 years old and over. This confirms the finding of STEGENGA (1961) that 2-year-old cows produced smaller calves than adult cows. These smaller calves stay behind in certain body measurements (chest and rump) for 2 years at least. He reached the conclusion that it is probable that calves born from young animals reach the same average growth as calves born from adult mothers but they reach this stage later.

So breeding with young and not with adult animals caused a certain degree of late maturing in the herd. Apart from this, calves with the ability to gain more rapidly or to finish in less time will produce a greater nett return to the breeder, if used for fattening.

CHAPTER 4

COAT CHARACTERS

4.1. INTRODUCTION

The manner in which an animal reacts to meteorological conditions – the rise and fall in temperature, rainfall, the duration of sunlight and day length – is valuable information to cattle breeders as a guide to the selection of cattle. It is necessary to study the effect of specific environmental factors on special organs or parts of the body and it is in the first place necessary for the cattle breeder, particularly in subtropical and tropical regions to determine the effect of radiation, temperature and day light on the hair of cattle.

The production of cattle living in hot countries, is to a certain extent governed by their ability to disperse the excess of heat in their bodies and by their adaptability to the high temperatures prevailing there. The coat of the cattle is one of the important factors affecting the rate of heat dispersal of the body.

The first to work on birth coat fibre was DUERDEN (1927), who recorded differences in size and shape of fibres of lambs. He also reported that epidermal structures, such as hairs, feathers and scales, are known to be highly variable in their growth, readily responding to differences in climate, soil, season, age and all other internal and external stimuli which influence the metabolic activities of the skin. DRY (1941) and co-workers developed this study in an effort to find the developmental pattern of the follicle population. FRASER (1952, 1953) expanded these observations (cited by LOCKART, 1955).

BISSONNETTE and WILSON (1939) were the first to prove experimentally the dependence of the hair growth cycle on the photoperiod. This was later shown by YEATES (1955) to be true also for Shorthorn cattle, and by STEGENGA (1960) for the first time in the Netherlands on the hair growth of the Dutch Red and White breed.

Morphological characteristics of hair fibres in cattle had been studied before. These studies were mainly directed towards the effect of air temperature and season, and did not deal with many other factors of practical interest. There is a complete lack of knowledge about the nature of the birth coat of calves. Taking this into consideration, the morphological characteristics of hair fibres at birth in two Dutch breeds:

1. Black-and-White Friesian (F.H.), and
2. Red-and-White breed (M.R.Y.),

are the object of the present study.

4.2. REVIEW OF LITERATURE

DUERDEN (1927) stated that in some years a sheep may shed its coat and in other years not, and that the shedding may be complete or partial delayed or accelerated. Fibres vary in length, diameter and in the presence or absence of a medulla, in different breeds of sheep. He attributed most of these variations to changes in the metabolic condition of the skin during the year's growth of the fleece, to climatic conditions, and to the metabolic state of the animal generally. He found also that in lambs, the fleece at the natal stage is very unlike that of the adult, but is far more uniform in the different breeds, and that the hair-diameter differs in different individuals in Wild-sheep, Blackhead Persian and Merino, at South Africa. The results obtained by RENDEL (1954) were in agreement with the findings of the former work, in that Welsh Mountain, Romney and strong-wool Merino breeds, are all capable of producing remarkably similar birth coats but very different adult fleeces. His data were collected from the University College of North Wales flock.

DUERDEN and WHITNALL (1930) suggested that the cow they examined had only one period of shedding, the summer coat being composed of short, new fibres which by continued growth became the winter coat. They observed loose fibres in the coat of a Friesian cow at all times of the year.

CARTER (1940) refered to the regular occurrence, in Merino skin, of follicles from which the fibres had been shed and stated that all primary follicles were shed after birth. The results mentioned by BURNS (1949), confirmed this report in that some empty follicles had been observed in the skin samples from Romney lambs 2 and 5 days old, and added that it seemed reasonable to assume that they were follicles from which birth-coat hairs had been shed.

The experimental work done by CSUKÀS (1940) on British, German and Hungarian breeds in Hungaria, showed that hair length was smallest in the dairy breeds (19.98 mm) and greatest in the beef breeds (43.10 mm), with the dual purpose breeds intermediate (30.61 mm). The diameters were 56.82 μ, 56.94 μ and 50.08 μ, in dairy, beef and dual-purpose breeds, respectively. The coats of all the types contained both medullated and non medullated fibres, but the proportion of the former was much greater in the dairy breeds (81.88%). The same results were found by BALDWIN *et al.* (1954) in that medulla was a solid structure, plainly visible in red hairs, and in some hairs the medulla appeared not to be continuous, in Ayrshire and Jersey breeds.

BONSMA and PRETORIUS (1943) found that in both Africander and Shorthorn cattle, the summer coat was much lighter in weight than the winter coat. (Cited by HAYMAN and NAY, 1961).

ARZUMANJAN (1950) indicated that weight and length of hair, were lower in adult cows than in 2-years-old ones, on Tagil, Dutch and Tagil x Dutch crosses. The results found by HAFEZ *et al.* (1955) confirm this finding, in that calves have a lighter-coloured and denser hair coat, in Egyptian cattle and Buffalo, than the adult animals. DOWLING (1955) agreed with the previous results. His investigations showed that age had a great influence on density, and that young animals have a denser hair coat, in Shorthorn. He came to the conclusion that the expansion of the skin as the animal grows, and the manner in which the plane of nutrition can codify growth and consequently the extent of expansion, has a predominating effect on the hair follicle and apocrine gland density.

YEATES (1955) proved that most of the differences in coat characters are due to seasonal variation. The shedding of the long, thick coat is normally a response to increasing day length and most animals start to shed 10 or 12 weeks after the days first begin to lengthen. He also stated that the normal seasonal coat cycles of cattle were shown to be regulated by seasonal fluctuations in daylight duration, on Shorthorn, at Brisbane.

DOWLING (1956) in the course of his investigation, including Shorthorn bulls, estimated the hair characters as follows in table 44. He reported that

TABLE 44. Mean values of coat characters (DOWLING, 1956)

Group	No. of bulls	Weight of hair coat (mg/cm²)	Average diameter (μ)	Average length (cm)	Fibres medullated %
A. Australian Illawara Shorthorn	10	13.7	61.4	0.48	97
B. Pedigree beef Shorthorn	20	5.3	54.3	0.47	70
C. Pedigree beef Shorthorn	10	21.2	41.2	1.57	4

in group A part of the increase in hair weight may be a reflection of the promotion of growth of the body as a whole following a rapid response by the animals to improved nutritional conditions, and that the differences between B and C may be attributed to differences in the degree in which the winter coat had been shed and replaced by a summer coat.

YEATES (1957) using Shorthorn cattle noticed that a profound change of the normal coat cycle followed the transfer of Shorthorn from a temperate-zone light environment to one of equatorial photoperiod. He reached the conclusion that the light environment must therefore be regarded as a risk to the succesful adaptation of European breeds of cattle to hot equatorial regions. His experiments were carried out in Brisbane, Queensland.

DOWLING (1959) studied on Shorthorn, in Northern Australia, his findings are listed in table 45. He reported that the long, insulating type of winter coat

TABLE 45. Seasonal variation in hair coat (DOWLING, 1959 and DOWLING and NAY, 1960)

Season	Weight of hair (mg/cm²)	Hair fibre diameter (μ)	Hair fibre length (cm)	Medullation fibres %
Winter	23.08	56.9	1.36	61.3
Spring	10.83	67.1	0.62	88.1
Summer	10.00	80.3	0.60	100.0
Autumn	14.31	57.3	1.00	72.0

in shed in the period from the end of winter to the early summer, and that the new fibres replacing it are thicker, and more medullated, though shorter, and these thicker, shorter, medullated fibres, which are stiffer, promote air movement on the skin surface. This would provide a greater opportunity for the vaporization of moisture and consequent dispersal of heat from the skin. The late summer and early autumn changes in hair structure, would indicate that shedding of summer hair is more prolonged and less marked than spring shedding. During his investigation he reached the conclusion that a medullated coat was conducive to loss of heat. He refered to the finding of DOWLING (1956, 1958) that the summer coat, must allow of heat loss, which is the side of the balance on which regulation is usually effected under hot conditions. The results obtained by DOWLING and NAY (1960) in table 45, proved that there are two seasons of follicle activity and hair growth, one in spring and the other in autumn, in Shorthorn as presented in table 45. They also stated that hair structure changes with the season. During spring and summer animals wear a coat which is short and thick, whereas in autumn and winter the coat is longer and thinner.

SCHLEGER and TURNER (1960) carried out an extensive study on data obtained from the National Cattle Breeding Station, "Belmont", Rockhampton on Hereford, Shorthorn cows and their progeny. They indicated that there were differences between breed groups in coat characters, which they presented in table 46.

TABLE 46. Coat characters in different cattle breeds (SCHLEGER and TURNER, 1960)

Breed group ×	Weight per unit area	Medullation %
S.H.	16.6	39.5
H.S.	16.4	29.5
S.S.	16.2	30.8
N.B.H.	18.6	27.9
S.B.H.	17.1	26.2
A.H.	18.9	60.7
A.S.	17.9	64.1
B.H.	13.9	100.0
B.S.	13.3	100.0

× Breed of sire first, breed of dam second.

H, Hereford; S, Shorthorn; N.B.H., northern-bred Hereford; S.B.H., southern bred Hereford; A, Africander; B, Brakman

In their work they estimated a correlation between various coat characters as follows in table 47. They came to the conclusion that the source of the variation is a mixture of breed, strain, and seasonal differences, all of which influence both body temperature and coat characters in ways extraneous to the fundamental relationship between them. They observed that they are not primarily concerned with differences between breeds or between seasons, but with hair characters whose variation between animals is correlated with physiological differences.

TABLE 47. Correlations between coat characters in cattle (SCHLEGER and TURNER, 1960)

Characters correlated	Correlation
Between diameter and medullation	0.596
„ length „ „	—0.505
„ „ „ diameter	—0.322
„ Wt./unit area and medullation	—0.249
„ „ „ „ „ diameter	—0.234
„ „ „ „ „ length	0.354

STEGENGA (1960) studied the influence of the intensity of light and light-dark period on 3 pairs of identical twins heifers of the Dutch Red and White breed born on 17 December '57, 31 January '58 and March '58 respectively. He divided the animals in his experimental work as follows: one of each pair of twins was placed in a dark pen with very poor daylight and the 3 control animals in a neighbouring pen with normal window surface. The temperature in the dark pen (experimental group) was 3–4°F. higher than the control group. His results are presented in table 48. He concluded that light intensity did not appear to have any influence on the weight of the coat of hair.

TABLE 48. Weight of hair of a 15 × 15 cm^2 surface (grams) (STEGENGA, 1960)

		9/12 '58	6/1 '59	10/3 '59	3/4 '59	12/5 '59
Experimental group	Paul 1	4.2	4.4	3.2	3.1	1.8
3/12'58 in pen	Waspik 1	5.5	4.4	2.6	0.9	0.7
with decreased	Meddo 1	3.1	2.5	1.8	0.8	1.3
daylight	Total	12.8	11.3	7.6	4.8	3.8
Control group	Paul 2	5.5	5.2	3.6	2.5	1.8
in pen with normal	Waspik 2	5.8	5.0	2.4	1.2	1.1
window surface	Meddo 2	3.1	1.8	2.0	1.2	1.2
	Total	14.4	12.0	8.0	4.9	4.1

TURNER and SCHLEGER (1960) observed that the seasonal changes in hair characters are similar for all breed groups. Highly significant differences between animals of the same breed persist through different seasons. Their results indicate a potential value of coat characters in selecting tropical beef cattle. Also in weaner, the spring shedding is sluggish especially in the longer-coated types. Their data were collected on a herd of about 50 Hereford and Shorthorn cows and their progeny from mating to British and Zebu bulls, at Rockhampton.

BERMAN and VOLCANI (1961) carried out an extensive study of the factors affecting hair characters on Holstein and Syrian x Holstein cattle, in three different climatic regions. They estimated the following hair characters in tables 49 and 50. They mentioned that day length is not the only factor influencing the annual cycle of hair weight, but that, apparently, the air temperatures are of influence too, but hair diameter was influenced only by variations in day length. They refered to many investigators working on the relation between thyroid gland and hair growth. Experimental evidence had shown that L-thyroxine has direct peripheral effects on hair growth and coloration in cattle (BERMAN, 1960). The thyroid secretion rate is affected by ambient temperature, as well as by light. They reached the conclusion that

TABLE 49. Weight of hair in cattle (Mg/100 cm²): (BERGMAN and VOLCANI, 1961)

Herd	Mean annual temperature	Jan.	Febr.	Mar.	Apr.	May	June	Aug.	Oct.	Nov.	Dec.	Average
A	23°C	1088	749	690	652	634	774	700	609	940	976	781
B	23°C	1073	800	716	555	777	846	852	689	980	940	823
C	20.4°C	1619	1100	998	916	811	1119	1107	1038	1259	1326	1129
D	17.5°C	1543	1096	981	853	692	1198	1303	1289	1396	1128	1148
Average		1330	936	846	744	728	984	990	906	1144	1092	970

TABLE 50. Hair diameter in cattle (μ): (BERGMAN and VOLCANI, 1961)

Herd	Jan.	Febr.	Mar.	Apr.	May	June	Aug.	Oct.	Nov.	Dec.	Av.
A	92	102	105	104	106	108	110	105	100	97	103
B	94	94	101	103	110	108	99	97	95	101	100
C	106	101	97	110	107	123	104	110	109	96	106
D	103	82	96	99	103	116	105	103	104	102	102
Av.	99	95	100	103	107	114	105	106	102	99	103

the thyroid may then serve as a common effector of both thermally and photoperiodically induced changes in the coat of cattle, and added that this would explain the apparent contradiction between the results of the Missouri group (WORSTELL and BRODY, 1953), which found a change in coat under constant day length and increasing temperature, and those of other workers whose observations seemed to show dependence on day length only.

HAYMAN and NAY (1961) studied the following data; in 1948 and 1949 observations had been made on the winter and late summer coats of Jersey, Red Poll, Australian Illawarra Shorthorn and Friesian breeds. In 1953 and 1954 data were obtained from Red Poll and crossbred cattle from winter to summer and during the autumn shedding period. These animals were maintained on the F.D. McMaster Field Station, Badgery's Creek, N.S.W., lat. 34°S. Finally, in 1955 and 1956 data covering the whole years, hair growth cycle were obtained from Red Sindhi and Sahiwal breeds, at Werribie, Vic., lat. 38°S. During their study length and diameter measurements were carried out over a 2-year period (July as midwinter and January as midsummer). Data for average weights of hair per unit area of skin for summer and winter coats are given in table 51. The samples from which the data were obtained were taken in July-August and December-January. They estimated the hair length of a very limited number of animals and observed that the hair of their summer coat is much smaller and shorter than of the winter coat. They stated that two shedding periods were observed, one in spring and the other in autumn.

TABLE 51. Weight of hair per unit area of skin (Mg/cm²): (HAYMAN and NAY, 1961)

Breed	No.	January (summer)	No.	July (winter)
Jersey	13	22	14	31
Red Poll (48–49)	16	20	14	35
A.L.S.	20	19	14	29
Friesian	6	15	2	33
Red Poll (53–54)	6	22	6	36
Crossbred	7	10	7	31
Red Sindhi	4	12	4	22
Sahiwal	5	12	5	24

BOSMAN (1962) in his investigation on 42 Hereford oxen, in South Africa, made a monthly record of the hair length during the period beginning 14 September 1959 till 28 November 1960, as shown in table 52. Control-normal day light: Normal daylight sets in 14 minutes before the sun rises and ends 14 minutes after the sun has set. The animals were outside under a shelter. Short daylight: Daylight 12 hours per day during the first period of 12 weeks, beginning December 5th. Thereafter day light decreased gradually ten min/week during period studied. Long day light: Day light 12 hours per day during the first period of 12 weeks, beginning December 5th. After this, light increased gradually, ten min/week during period studied by using artificial light. In his experimental groups day light was shorter and longer than in the control group, in short daylight and long daylight groups, respectively,

TABLE 52. Influence of day length on hair length in Hereford cattle (BOSMAN, 1962)

Month	Normal day light (cm)	Experimental group	
		Short day light (cm)	Long day light (cm)
November 59	2.17	1.95	1.81
December	1.97	1.70	1.72
January 60	2.01	2.21	1.88
February	2.35	2.80	1.93
March	2.66	2.74	1.93
May	3.31	2.15	1.92
June	4.02	2.46	2.50
July	3.64	2.87	3.15
August	3.33	3.26	3.63
September	2.72	3.13	3.46
October	2.27	2.75	3.02
November	2.24	2.26	2.15
End Nov.	2.27	2.11	2.12
Mean	2.69	2.49	2.41

after the first 12 weeks. He also found that there is a positive correlation ($r = +0.71$) between hair length and thiroid hormone, and a negative correlation ($r = -0.81$) between hair length and Gonadotropic hormone.

TURNER (1962) in his research on Hereford, Shorthorn, Africander x Hereford and Africander x Shorthorn, found that during late summer and autumn the clipped coat shows more rapid regrowth than in late winter and spring. He stated that this phenomenon, combined with the seasonal variation in coat type of the unclipped animals, results in a greater difference in coat cover between groups in winter and spring than in summer and autumn.

These reviews demonstrated that there are many publications on the hair coat of cattle. Several of them proved the influence of environment and genes on the hair coat. Moreover there are several publications on the wool of sheep relating to environmental and genetic influences. They deal partly with the condition in young lambs. However, no publications were found treating of the hair coat in the new-born calf.

4.3. MATERIAL AND METHOD

The coat characteristics studied include:

1. 90 Friesian (F.H.) calves at birth, and 33 of their dams just after calving.
2. 56 Red and White Dutch breed (M.R.Y.) calves at birth, and 28 of their dams just after calving.

The cattle used in this investigation were drawn from the herd (F.H. and M.R.Y.) of the "Laboratorium voor Veeteelt" and "Laboratorium voor Dierfysiologie", Wageningen in the Netherlands.

Morphological research was directed towards the following:

1. Weight of hair per unit area. The area chosen here was (14 x 14 cm).
2. Hair measurements, including:
   a. Hair diameter.
   b. Hair length.
   c. Presence or absence of medulla.

The above measurements were found from samples taken within 1–3 days after birth, during the period of 1960–1962. The first sample was taken in January 1960. The relationship of sex, year age of dam and season of birth, on coat characters at birth were observed.

In the case of mothers, the relation of age of cows and season of calving and the variations between the two breeds were also noted. Dams were divided into two groups according to their ages after calving ($2–2^6$ and over 2^6 years old).

The four seasons used in this investigation were:

Winter : January – February – March.
Spring : April – May – June.
Summer : July – August – September.
Autumn : October – November – December.

Hair characters of calves were classified according to the different bulls to which the cows were mated.

In the present experiment also the hair growth was studied on the following cows and their calves:

1. 12 Friesian (F.H.) calves (♀ 6 + ♂ 6) with their dams.
2. 8 Red and White (M.R.Y.) calves (♀ 5 + ♂ 3) with their dams.

These cows and their calves were reserved at the "Laboratorium voor Veeteelt". Samples were taken at intervals of one month, beginning in June 1962 till December. Samples were clipped in the middle of each month, as indicated in table 53. The hair was cut from the places shown in the plate 1, and from the same areas for both the cows and their calves. During the experiment one F.H.-cow was sold in November, while in December 3 F.H.-cows, 2 M.R.Y.-cows and 3 M.R.Y.-calves (bulls), were also sold.

TABLE 53. Number of animals tested monthly in each herd

F.H.		M.R.Y.		Date of cutting the hair	Place on plate 1
Dams No.	Calves No.	Dams No.	Calves No.		
12	12	8	8	15 June	1
12	12	8	8	18 July	2
12	12	8	8	15 August	3
12	12	8	8	12 September	4
12	12	8	8	15 October	5
11	12	8	8	15 November	6
8	12	6	5	15 December	7

Procedure:

a. Method of sampling:

Samples were taken from a unit area of skin. A 14 x 14 cm piece of leather was placed on the skin and its borders were marked with a hair clipper. There after the marked area was clipped with an electric or vacuum clipper.

The samples of hair of the calves at birth, and of the mothers at calving, were taken from a standard point on the side, approximately half way between the mid-dorsum and the mid-venter in the line of the umbilicus. They were cut close to the skin ± 3 mm, from the two sides for calves, and one side for the mothers at calving. This area is believed to be the most suitable, as the density of hair in this region is near the average value for all body regions (FINDLAY and YANG, 1950), as reported by DOWLING (1955), CARTER and DOWLING (1954), SCHINCKEL (1958), PILKINGTON and PURSER (1958) and SCHLEGER and TURNER (1960), working on different cattle and sheep breeds, proved that the midside position occupies a fairly consistent intermediate

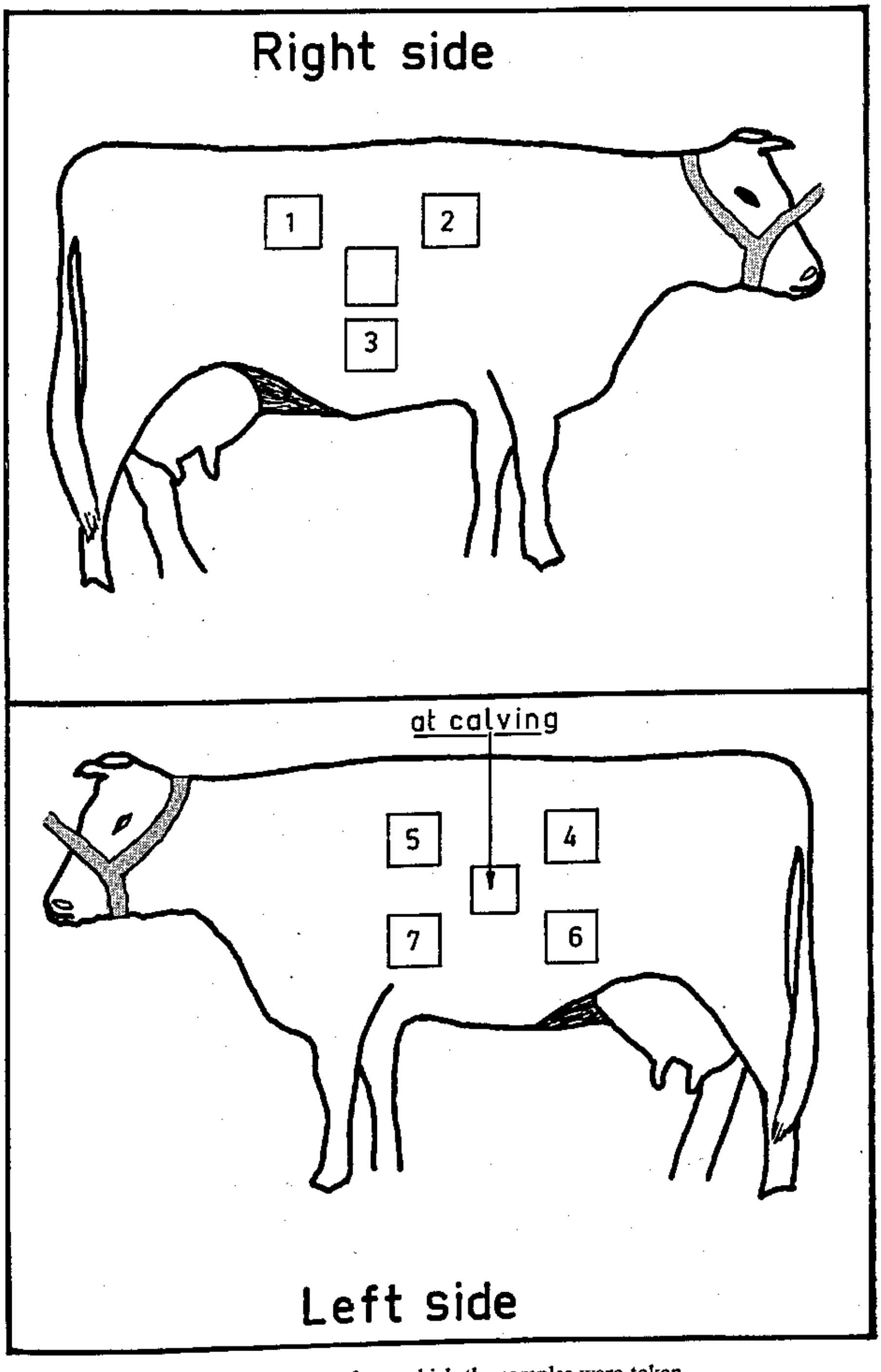

PLATE 1. Areas from which the samples were taken.

place in the range of follicle population values usually found over the skin surface as a whole.

It is of interest to mention here that the samples were taken from live and healthy animals, when they were at ease and standing normally. Samples in this experiment were clipped by four different persons, and collected in envelopes.

b. Weight of hair per unit area:

The average weight of hair of both sides of the calf was considered. As regards the cows and calves for studying hair growth, only one side was clipped, as has already been mentioned.

c. Hair length:

For measuring the hair length long hair were chosen to be measured for their lengths in different hair samples, for the following convenient reasons:

1. Long hairs are easily sorted out.
2. There is a symmetry between the long hairs in the sample.
3. The difficulty of measuring twisted hairs.

There were several workers who used the longest hair to measure hair length in their work. SCHLEGER and TURNER (1960), *e.g.*, used the longest hair in their investigation. BOSMAN (1962), working on Hereford oxen measured only the longest hair, because he found a relation of 83% between them and the rest of the hairs in the same sample.

A wooden box provided with a longitudinal opening in its cover was used. The opening was covered with a piece of glass to which a transparent piece of ordinary graphical millimeter paper was fixed. Two fluorescent lamps under a blue glass covering, were fitted in bottom of the box. When putting on the light, the divisions of the millimeter paper were sharp and clearly visible when measuring the length of a hair, one extremity was placed on one of the lines of a main division of the millimeter paper and the length was then directly read from the line of the division corresponding with the other extremity. Fifty hairs were examined from each sample.

d. Hair diameter and medullation:

Before the beginning of the examination of the hairs, only the black ones were subjected to the following treatment, as shown by ROMEIS (1943). Hairs of other colours (red and white) were in fact plainly visible without the use of Hydrogen peroxide. Microscopic examination of hairs carried out by BALDWIN *et al.* (1954) showed that the structural outlines of the cuticle, cortex and medulla are plainly visible in red hairs. Microscopically, the black pigmented granules of blackish hairs, in their experiment, very closely clumped, making it impossibe to distinguish the medulla from the cortex.

Treatment:

1. Cleaning by water and soap.
2. Removal of fat by ether.

3. Hydrogen peroxide 10 per cent for bleaching the black hairs, to facilitate the observation of the medulla. LILLIE (1954) and EVERSON (1960), reported that 24 hours' treatment is necessary to decolorize melanin and ganglion cell pigment.

In this study observations were made on hairs of various colours in each sample, (Black, White or Black and White in F.H. and Red, White, and red and white in M.R.Y.) taking from 40 cows (17 M.R.Y. and 23 F.H.) in the year 1963.

Hair diameter:

After mixing the hair, 50 hairs were taken at random from each sample. They were put on a glass plate under a microscope provided with a movable micrometric eye-piece (unit 8 μ). Diameters of hairs were measured at the cut end of the hair.

Presence or absence of medulla:

The percentage of partially and completely medullated hairs to non-medullated ones, was calculated from 50 hairs in each sample. Hair diameter and medullation measurements were carried out in glyserol.

The phenotypic correlation between birth coat characters were studied, with weight at birth, gestation period and coat characters of the mothers at calving. The correlation between birth coat characters was noted, and also the correlation between coat characters of mothers at calving was estimated.

4.4. RESULTS AND DISCUSSION

The total number of hairs examined in this investigation, for diameter, length and presence or absence of medulla was 25850, taken from 517 samples.

BIRTH COAT

Sex:

Tables 54 and 55 show that for heifers the average weight of hair at birth was heavier than for bulls (0.23 and 0.78 gram), in the F.H. and M.R.Y. breeds, respectively. The results reported in these tables show that there are small differences between hair length of the sexes (males 0.92 mm longer than females in F.H. and one mm in M.R.Y. in favour of females). It can also be observed that the fibre diameter is 0.36 and 1.25 μ larger for heifers than for bulls in F.H. and M.R.Y. breeds, respectively. Variations in these characters were however not found to be significant (Tables 56 and 57). These results do not accord with the finding of SCHINCKEL (1958), on Merino sheep in South Australia, that the diameter of secondary fibres showed a highly significant difference between sexes for birth coat (rams had the greater diameter). In his work the differences did perhaps not exist at birth, because the samples were taken 3–4 months after birth and not with standing were considered as birth coat. The sex differences observed in his work will include an environmental effect since it is known that the rams always had some preferential treatment by being fed at a higher plane of nutrition.

TABLE 54. Sex difference in coat characters (F.H. calves at birth)

Year	Males				Females			
	No.	Weight 14 × 14 cm g	Diameter (μ)	Length (mm)	No.	Weight 14 × 14 cm g	Diameter (μ)	Length (mm)
1960	15	5.95	53.03	24.86	23	7.56	54.25	25.12
1961	12	7.04	50.15	29.04	15	6.84	50.90	27.17
1962	16	6.36	50.74	24.63	9	5.64	49.83	23.47
Total	43	6.45	51.30	26.17	47	6.68	51.66	25.25

TABLE 55. Sex differences in coat characters (M.R.Y. calves at birth)

Year	Males				Females			
	No.	Weight 14 × 14 cm g	Diameter (μ)	Length (mm)	No.	Weight 14 × 14 cm g	Diameter (μ)	Length (mm)
1960	9	6.07	52.82	25.69	9	7.83	55.36	27.34
1961	15	6.95	49.79	29.13	9	6.29	50.02	27.48
1962	5	5.02	49.74	24.22	9	6.27	50.73	27.22
Total	29	6.01	50.78	26.34	27	6.79	52.03	27.34

TABLE 56. Analysis of variance for hair weights, diameters and lengths (F.H. calves at birth)

Source of variation	Weight		Diameter		Length	
	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.
Total	89	2.30	89	8.32	89	15.73
Sex	1	7.03	1	20.87	1	5.28
Year within sex	4	8.04*	4	59.26**	4	60.62*
Age of dam within year and sex	27	2.96	27	1.86	27	10.33
Season within age, year and sex	26	0.77	26	7.01	26	14.05
Within season	31	2.11	31	8.06	31	16.38

* Significant ($P < 0.05$)
** Highly significant ($P < 0.01$)

TABLE 57. Analysis of variance for hair weights, diameters and lengths (M.R.Y. calves at birth)

Source of variation	Weight		Diameter		Length	
	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.
Total	55	1.82	55	11.56	55	13.13
Sex	1	2.83	1	23.47	1	0.18
Year within sex	4	7.36**	4	52.90**	4	30.20
Age of dam within year and sex	24	1.66	24	10.08	24	15.46
Season within age, year and sex	15	1.07	15	6.13	15	5.76
Within season	11	1.09	11	6.07	11	13.07

** Highly significant ($P < 0.01$)

Year of birth:

Tables 54 and 55 and figure 4 show yearly fluctuations in the average weights of calves hair at birth. From these tables, it can be noticed that year of birth is a factor affecting hair diameter at birth. Mean diameters ranged between 49.83 μ and 54.25 μ for F.H. and between 49.74 μ and 55.36 μ for M.R.Y. Variations in hair length were rather large from year to year, within

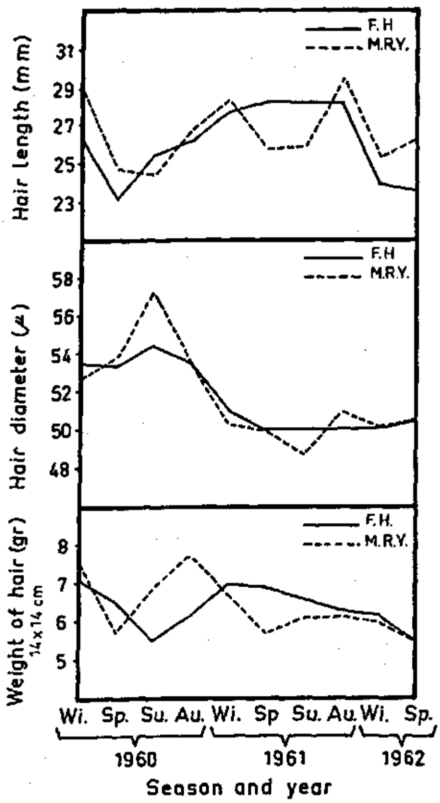

FIG. 4. Yearly and seasonal changes in hair characters of calves at birth.

sex in the F.H. breed (Table 54 and Figure 4). While in table 55 it can be seen that hair length in the M.R.Y. breed ranges between 24.22 mm and 29.13 mm. The differences observed here were however not statistically significant (Table 57). Variations in the other characters, between the different years studied, within sex, were significant and highly significant in the Friesian and the Red and White Dutch breed (Tables 56 and 57). These differences might be due to the fact that, between the years there are differences in temperature and rainfall. These fluctuations markedly affect the forage available and the comfort of the animals. In 1959 there was an exceptionally dry and hot summer and good hay were given to the animal, which probably influenced the hair characters of calves born in the year 1960. The difference in hair characters between years may also have been influenced by the different persons taking the samples during the period of this experimental work. This can influence the weight and the length because samples were cut close to the skin nearly ± 3 mm, but it seems very questionable if the diameter definitely can be influenced by the man taking the sample.

Age of dam:

Mean values for weight, diameter and length of hair at birth, are given in table 58 and figure 5, where the calves are classified according to age of their dams. It is clear that a small variation in these characters can be observed in the different groups of age of the dams. These small differences within year

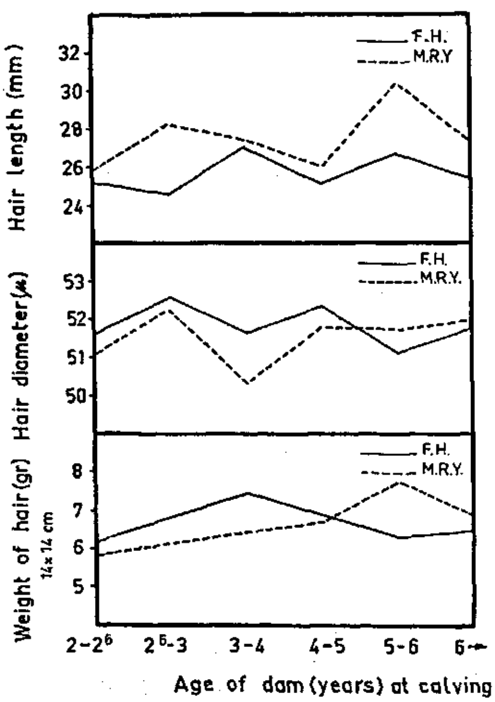

FIG. 5. Coat characters of calves at birth according to age of dam.

and sex were not found to be significant (Tables 56 and 57). Possibly the similarity in management and nutritional condition contributes to this result.

TABLE 58. Relation between calves coat characters at birth and age of dam

Age of dam	F.H.				M.R.Y.			
	No.	Wt. (g)	Dia. (μ)	Len. (mm)	No.	Wt. (g)	Dia. (μ)	Len. (mm)
2–2⁶	26	6.28	51.69	25.25	17	5.91	51.15	25.90
2⁶–3	7	6.90	52.69	24.58	6	6.19	52.36	28.27
3–4	13	7.55	51.75	27.17	13	6.57	50.38	27.53
4–5	14	6.98	52.40	25.27	7	6.80	51.89	26.00
5–6	7	6.39	51.21	26.88	7	7.88	51.76	30.52
6→	23	6.54	51.79	25.58	6	6.92	52.00	27.37

Season of birth:

The results obtained in tables 59 and 60 and figure 6, illustrated that winter born calves for the F.H. breed clipped little heavier hair than those of other seasons. While the smallest weight of hair was observed to be in summer. In the M.R.Y. breed, autumn born calves produced the heaviest weights and spring born ones the smallest amount of hair. The results given in these tables also show that summer born calves have a slightly thicker hair diameter at

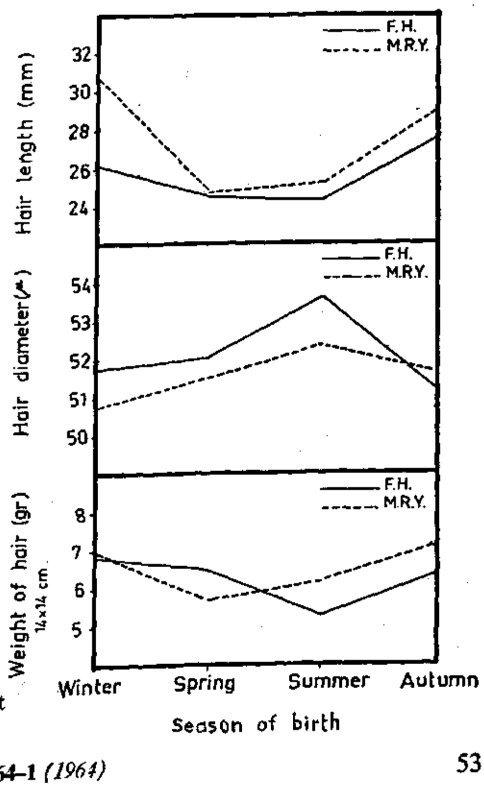

FIG. 6. Birth coat of calves born in different seasons.

birth than the calves dropped in the other seasons. The thinner diameters were in autumn for F.H. and in winter for M.R.Y. In the case of the effect of season on hair length at birth, it can be observed from tables 59 and 60, that the autumn born F.H. calves had the longest hair and the summer born ones the shortest hair. In M.R.Y., winter born calves had the longest, and spring born

TABLE 59. Seasonal variation in coat characters (F.H. calves at birth)

Season	No.	Wt. (g)	Dia. (μ)	Len. (mm)	Presence of medulla %
Winter	51	6.93	51.78	26.06	99
Spring	29	6.53	52.01	24.70	99
Summer	3	5.28	53.68	24.57	100
Autumn	7	6.32	51.20	27.55	99

TABLE 60. Seasonal variation in coat characters (M.R.Y. calves at birth)

Season	No.	Wt. (g)	Dia. (μ)	Len. (mm)	Presence of medulla %
Winter	27	6.95	50.84	30.84	100
Spring	13	5.72	51.56	24.75	100
Summer	10	6.27	52.33	25.17	100
Autumn	6	7.12	51.65	29.07	100

calves the shortest. These variations, within age of dam, year of birth and sex were found not to be significant (Tables 56 and 57). These small variations between season of birth may be due to that, the calves being protected by the uterine wall during prenatal life and are not or only to a small extent affected by weather fluctuations or management in different seasons. Apparently the daylight differences which influence the dams hair coat, do not pass the uterine wall, or only to a small extent. Also 82% of the data was restricted to only two seasons (winter and spring).

The presence of medulla in the birth coat seems not to be affected by any of the factors studied. During the examination of hairs the structural outlines of the medulla were plainly visible and the medulla appeared as a solid black structure. In the two breeds some little hairs were observed with discontinuous medulla. There were, however, a very few exceptions in some F.H. hairs without medulla. Tables 59 and 60 summarize the presence of medulla at birth. All M.R.Y. calves' hair was medullated, while in F.H. breed the percentage of fibres medullated was nearly 99%.

Relation of sire to birth coat:

Table 61 shows the distributions of calves examined in different years for each sire. Results given in tables 62 and 63 and figures 7 and 8, verify the relation between sires and hair characters of their calves at birth, regardless of year, because for every sire no calves were available for all years studied,

TABLE 61. Number of calves tested in different years for each sire

F.H.					M.R.Y.			
	Sires	1960 No.	1961 No.	1962 No.	Sires	1960 No.	1961 No.	1962 No.
1	Beanster Bonne	12	2	–	Benno	5	5	–
2	Jenne 311	–	9	5	Roza's Boris	5	4	–
3	Berber's Adema	10	–	–	Robert	2	7	–
4	Hask. Ad. Bloed	–	8	–	Katrinus	–	2	5
5	Rikus	–	–	7	Boudewijn	–	1	6
6	Fr. Gerared 12	–	1	6	Gustaaf Heino	2	2	3
7	Z.A. Wouter	–	4	2	....	–	–	–

TABLE 62. Relation of sires to the hair characters of their calves at birth (F.H.)

Sires	No. of calves	Weight (g) 14 × 14 cm	Diameter (μ)	Length (mm)
1	14	6.91	53.2	29.5
2	14	6.72	51.4	24.7
3	10	7.73	52.5	25.3
4	8	7.71	49.6	30.6
5	7	5.54	50.0	24.0
6	7	5.65	49.5	25.3
7	6	6.41	49.0	26.4

TABLE 63. Relation of sires to the hair characters of their calves at birth (M.R.Y.)

Sires	No. of calves	Weight (g) 14 × 14 cm	Diameter (μ)	Length (mm)
1	10	7.74	51.3	29.3
2	9	6.77	52.0	28.0
3	9	6.37	49.0	26.9
4	7	5.72	51.2	27.3
5	7	5.76	49.6	25.3
6	7	7.17	52.6	27.6

TABLE 64. Analysis of variance for hair weights, diameters and lengths, of calves at birth from different sires (F.H.)

Source of variation	Hair weight		Hair diameter		Hair length	
	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.
Total	65		65		65	
Between sires	6	6.12**	6	25.32**	6	63.03
Within sires	59	1.86	59	5.72	59	31.32

** Highly significant ($P < 0.01$)

TABLE 65. Analysis of variance for hair weights, diameters and lengths, of calves at birth from different sired (M.R.Y.)

Source of variation	Hair weight		Hair diameter		Hair length	
	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.
Total	48		48		48	
Between sires	5	5.23**	5	13.71	5	14.57
Within sires	43	1.48	43	11.03	43	12.77

** Highly significant (P < 0.01)

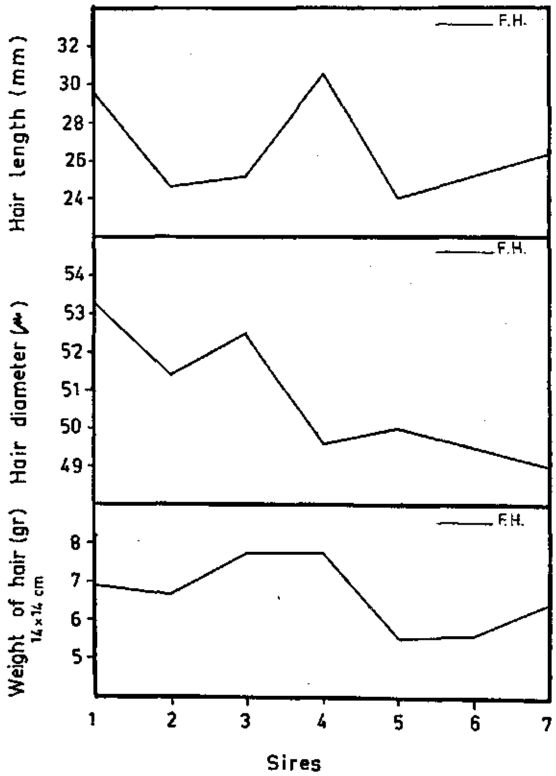

FIG. 7. Relation between sires and hair characters of their calves at birth (F.H.).

but some have calves in one year only and others in two years as it shown in table 61. Among F.H. calves, the average weights of hair per unit area ranged from 5.54 gram to 7.73 gram, and 49.02 μ to 53.17 μ for hair diameter. In the case of the M.R.Y. breed a great variation was found in weight of hair (Table 63). These differences in weight and diameter between sires were highly significant (Tables 64 and 65), while there was no significant effect of sires on F.H. calves' hair length and on M.R.Y. diameter and hair length (Tables 64 and 65). These variations between sires may be attributed to the genetic structure of the sire. The results obtained here confirm the finding of BERMAN and VOLCANI, (unpublished data), that a large variation in coat characteristics was found between groups of daughters of different sires.

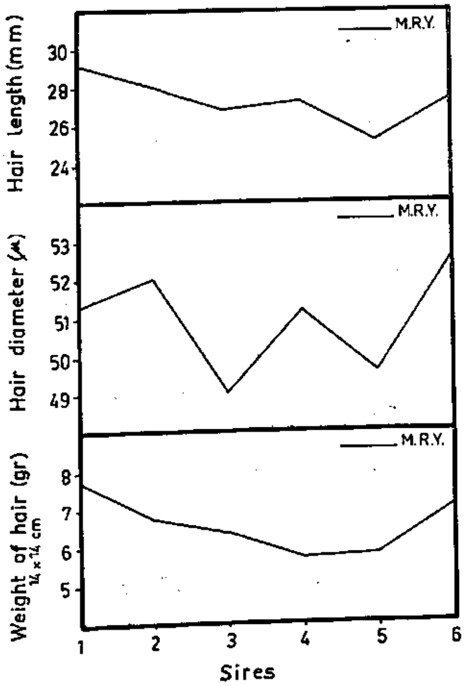

FIG. 8. Relation between sires and hair characters of their calves at birth (M.R.Y.).

Correlation coefficients:

A statistical analysis of the correlation between the different calf hair characters, was made and the findings were given in table 66. A significant correlation was found between weight of hair per unit area and hair length in the two breeds, while there was no significant correlation between diameter and hair length.

Correlations between calf hair characters at birth, and hair characters of the mother at calving, were estimated. In table 67 no data are given for the

TABLE 66. Correlation between hair characters of the calves at birth (weight per unit area 14 × 14 cm)

Characters correlated	F.H.		M.R.Y.	
	No.	Correlation	No.	Correlation
Weight and diameter of hair	90	0.460**	56	0.175
Weight and length of hair	90	0.519**	56	0.563**
Diameter and length of hair	90	—0.137	56	—0.154

** Highly significant ($P < 0.01$)

summer season because the number of animals available for this season was too small (2 calves). Within season low positive and negative correlations were observed. The correlation in all characters studied for the two breeds was not statistically significant (Tables 67 and 68). This is in resemblance with the finding of DUERDEN (1927) and RENDEL (1954), that birth coat is unlike that of the adult fleeces, on different breeds of sheep.

TABLE 67. Correlation between hair characters of the mother at calving and their calves at birth within season (F.H.)

Characters correlated	Season					
	Winter		Spring		Autumn	
	No.	Correlation	No.	correlation	No.	correlation
Weight of hair	18	0.120	6	0.432	7	—0.715
Hair diameter	18	0.065	6	0.250	7	—0.016
Hair length	18	0.271	6	0.506	7	—0.493
Presence of medulla	18	0.008	6	0.096	7	0.298

TABLE 68. Correlation between hair characters of the mother at calving and their calves at birth within season (M.R.Y.)

Characters correlated	Season							
	Winter		Spring		Summer		Autumn	
	No.	correlation	No.	correlation	No.	correlation	No.	correlation
Weight of hair	8	0.282	8	0.033	7	0.362	5	—0.220
Hair diameter	8	0.182	8	—0.086	7	0.320	5	—0.187
Hair length	8	0.386	8	0.228	7	—0.347	5	0.767
Presence of medulla	8	0.000	8	0.000	7	0.000	5	0.000

TABLE 69. Correlation between birth weight and hair character of the calves per unit area (14 × 14 cm)

Characters correlated	F.H.		M.R.Y.	
	No.	correlation	No.	correlation
Birth weight and weight of the hair	71	+0.133	48	+0.276
Birth weight and hair diameter	71	—0.017	48	—0.074
Birth weight and hair length	71	+0.277*	48	+0.183

* Significant ($P < 0.05$)

Table 69 summarizes the correlation between birth weight and hair character of the calves at birth. As can be seen a significant positive correlation could only be found between birth weight and hair length in the F.H. breed, but the very low positive and negative correlations between birth weight and other characters studied were found to be statistically nonsignificant.

The gestation period bore a low positive correlation with hair length and a low negative correlation with diameter in both breeds. While it was very small and positive with weight of hair in M.R.Y. and small negative in F.H. breed. All these correlations were however found not to be statistically significant (Table 70). From these correlations between birth-weight, gestation period and hair characters of the calf at birth, it can be concluded that there is no important relation between these traits and calves hair characters.

TABLE 70. Correlation between gestation period and hair character of the calves per unit area (14 × 14 cm)

Characters correlated	F.H.		M.R.Y.	
	No.	Correlation	No.	Correlation
Gestation period and weight of the hair	90	–0.107	56	+0.083
Gestation period and hair diameter	90	–0.089	56	–0.112
Gestation period and hair length	90	+0.147	56	+0.109

Breed differences:

Mean values of coat characters of the two breeds are presented in table 71. In the herds studied, birth coat characters of F.H. and M.R.Y. calves were nearly similar. From table 71 it can be noticed that the differences between the two breeds were 0.14 gr. (14 x 14 cm) and 0.50 μ, in weight of hair and hair diameter, respectively, in favour of the F.H. breed. While hair length and medullation were 1.6 mm and one per cent, respectively in favour of M.R.Y. breed. These differences between the two breeds were not significant. This is in agreement with the observation of DUERDEN (1927) on wild-sheep, Blackhead Persian and Merino sheep, at South Africa, who stated that in lambs the fleece at the natal stage is far more uniform in the different breeds. This also agrees with the results obtained by RENDEL (1954) on Welsh Mountain. Romney and strongwool Merino breeds, that all these breeds produce a remarkably similar birth coat.

TABLE 71. Differences in hair characters of the calves at birth, between the two breeds (F.H. and M.R.Y.)

Breed	No.	Weight of hair (g)	Diameter (μ)	Length (mm)	Presence of medulla %
F.H.	90	6.70	51.9	25.7	99
M.R.Y.	56	6.56	51.4	27.3	100
Differences		0.14	0.5	1.6	1

TABLE 72. Relation between age and hair characters of the mothers at calving

Age of the cow	F.H.					M.R.Y.				
	No.	Weight 14 × 14 cm (g)	Diameter (μ)	Length (mm)	Presence of medulla %	No.	Weight 14 × 14 cm (g)	Diameter (μ)	Length (mm)	Presence of medulla %
2–2^6	11	2.92	58.7	24.9	65.1	9	3.21	64.5	29.0	83.6
2^6 and over	22	2.28	60.9	19.5	74.5	19	3.02	66.6	27.0	85.0
Difference	33	0.64	2.2	5.4	9.4	28	0.19	2.1	2.0	1.4

TABLE 73. Seasonal variation in mothers coat characters at calving

Breed	F.H.					M.R.Y.				
Season	No.	Weight (g)	Diameter (μ)	Length (mm)	Presence of medulla %	No.	Weight (g)	Diameter (μ)	Length (mm)	Presence of medulla %
Winter	18	2.46	56.4	23.7	64.1	8	3.84	56.6	34.1	65.8
Spring	6	0.66	64.5	12.1	83.3	8	1.82	67.2	23.4	86.0
Summer	2	2.70	77.8	20.7	100.0	7	3.34	78.1	22.9	100.0
Autumn	7	4.09	61.0	23.0	71.7	5	3.54	61.8	30.4	77.5

Age of the cow:

Hair characters of the mothers just after calving were studied (Table 72), in different age groups. A slight difference between heifers and older cows was observed. These variations were found not to be significant, (Tables 76 and 77), except for hair length in the F.H. breed, in which case the differences were statistically significant in favour of the group 2–2⁶ years-old. This might be due to the fact that for 7 out of the 11 cows in group 2–2⁶, sampling was performed in winter. Practical experience indicates that younger animals have heavier weight of hairs than older ones. The results of table 72 also show a uniformity in differences between heifers and cows for the two breeds.

TABLE 74. Average weight, diameter, length of hairs cutting from a square area (14 × 14 cm), each sample 50 hairs, (F.H. mothers at calving)

Month of calving	Weight		Diameter	Length
	No.	Mean (g)	Mean (μ)	Mean (mm)
January	5	3.53	57.6	27.5
February	4	2.44	55.9	29.6
March	9	1.88	56.0	19.0
April	4	0.85	64.2	13.4
May	1	0.08	64.1	7.2
June	1	0.50	66.3	12.1
July	–	—	—	—
August	–	—	—	—
September	2	2.70	77.8	20.8
October	5	3.77	63.6	20.9
November	1	3.32	59.3	24.6
December	1	6.51	49.9	32.3

TABLE 75. Average weight, diameter, length of hairs cutting from a square area (14 × 14 cm) each sample 50 hairs (M.R.Y. mothers at calving)

Month of calving	Weight		Diameter	Length
	No.	Mean (g)	Mean (μ)	Mean (mm)
January	5	4.70	56.4	35.1
February	–	—	—	—
March	3	2.41	56.9	33.0
April	4	2.10	67.4	26.9
May	4	1.54	67.0	19.8
June	–	—	—	—
July	–	—	—	—
August	3	2.32	78.6	19.3
September	4	4.11	77.7	25.7
October	3	1.89	65.6	30.2
November	2	4.00	56.0	30.8
December	–	—	—	—

Season of calving:

It is a well known fact that at the latitude of the Netherlands, hair coat of cattle becomes heavier in autumn. In winter or spring shedding takes place; the period of shedding seems to depend besides season on feeding, calving date and probably on hereditary factors. Different characters of the hair coat were studied (Table 73), and although in some seasons particularly the summer, the number of cows calving was very small, a certain seasonal fluctuation of some characters is very definite, and also statistically significant (Tables 76 and 77). In autumn and winter the coat is heavy and long; while the hair diameter is thinner than in the other seasons and the percentage of medullation is lowest. In summer samples, all fibres were found to be medullated. Figure 9 demonstrates very clearly that the picture in both breeds is similar.

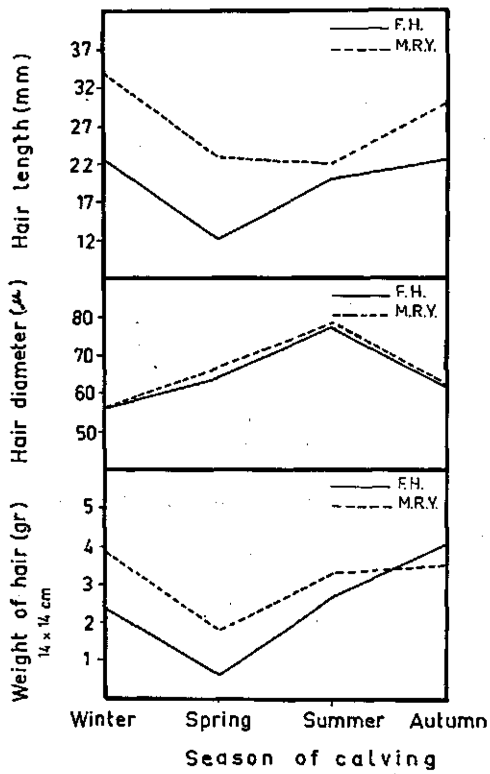

FIG. 9. Seasonal changes in hair characters of mothers at calving.

Monthly records (Tables 74, 75 and figure 10) show that in December and January the coat is at its maximum for weight and length of hair. In this period the hair diameter is smallest. These findings are in agreement with the results found by DOWLING (1959 and 1960), BERMAN and VOLCANI (1961) and HAYMAN and NAY (1961).

TABLE 76. Analysis of variance for hair weights, diameters, lengths and presence of medulla (F.H. mothers at calving)

Source of variation	Weight		Diameter		Length		Presence of medulla	
	d.f.	M.S.	d.f.	M.S.	d.f.	M.S.	d.f.	M.S.
Total	32		32		32		32	
Age of the cow	1	2.96	1	36.50	1	218.54*	1	655.51
Season within age	6	7.94**	6	192.37**	6	117.44*	6	614.20
Within season	25	1.64	25	10.23	25	40.03	25	272.60

* Significant (P < 0.05)
** Highly significant (P < 0.01)

TABLE 77. Analysis of variance for hair weights, diameters, lengths and presence of medulla (M.R.Y. mothers at calving)

Source of variation	Weight		Diameter		Length		Presence of medulla	
	d.f.	M.S.	d.f.	M.S.	d.f.	M.S.	d.f.	M.S.
Total	27		27		27		27	
Age of the cow	1	0.22	1	25.38	1	23.90	1	13.68
Season within age	6	3.88	6	313.82**	6	126.48*	6	640.21**
Within season	20	2.11	20	14.88	20	35.88	20	37.99

* Significant (P < 0.05)
** Highly significant (P < 0.01)

Correlation coefficients:

Correlation coefficients between various coat characters are given in table 78. In this table large positive correlations between weight of hair per unit area and hair length and also between hair diameter and presence of medulla can be observed, while the other correlations studied were negative. The cor-

TABLE 78. Correlation between hair characters of the mothers at calving per unit area (14 × 14 cm)

Characters correlated	F.H.		M.R.Y.	
	No.	Correlation	No.	Correlation
Weight and diameter of hair	33	−0.168	28	−0.234
Weight and length of hair	33	0.719**	28	0.703**
Weight and presence of medulla	33	−0.201	28	−0.284
Diameter and length of hair	33	−0.356*	28	−0.594**
Diameter and presence of medulla	33	0.552**	28	0.859**
Length and presence of medulla	33	−0.458**	28	−0.575**

* Significant (P < 0.05)
** Highly significant (P < 0.01)

relations given were statistically significant and highly significant, except in the case of the correlation between weight of hair and diameter and presence of medulla, these were negative and not significant. These results confirm those obtained by DOWLING (1959 and 1960) and are in general agreement with the correlations reported by SCHLEGER and TURNER (1960).

Breed differences:

Breed differences in four coat characters of cows, at calving, are given in table 79. F.H. animals have lighter coats with thinner, shorter hair fibres and less medullation than M.R.Y. animals. The variations between the two breeds were found to be highly significant, except for hair weight. These differences might be due to genetic differences between breeds and to differences in metabolic conditions of the skin. However, the devision of both breeds at calving over the year was not the same, and this might have some influence. This experiment was in agreement with the finding of DUERDEN (1927), CSUKÁS (1940), DOWLING (1956), SCHLEGER and TURNER (1960) and HAYMAN and NAY (1961) working on different breeds of sheep and cattle.

TABLE 79. Differences in hair characters of the mothers at calving, between the two breeds (F.H. and M.R.Y.)

Breed	No.	Weight of hair (gr).	Diameter (μ)	Length (mm)	Presence of medulla %
F.H.	33	2.49	60.2	21.3	71.4
M.R.Y.	28	3.08	65.9	27.6	84.6
Differences		0.59	5.7 **	6.3 **	13.2 **

** Highly significant ($P<0.01$)

This investigation indicate that cattle hair characteristics pass through an annual cycle process. From tables 74 and 75 and figure 10, it can be seen that, in January hair weight reaches a peak and thereafter it decreases gradually until it reaches a minimum in May. After June an increase in hair weight takes place in the two breeds till December, although a decrease in hair weight for the M.R.Y. breed was observed in October. Hair length starts to decrease in March and reaches its lowest value in May for the F.H. and in August for M.R.Y. It then increases till December and January. Hair diameter is smallest between December and March and begins to increase in April (very clear shedding of long fibres). It reaches a peak in August and September, after which it gradually decreases until December. Our results show that in February there seemed to be a beginning of shedding. The winter coat begins to change into a summer coat very clear at about 12 weeks following the shortest day, with the samples cut close to the skin at ± 3 mm. YEATES (1955) indicated that, the shedding of winter coat began, about 12 weeks following the shortest day. But the results obtained by BERMAN and VOLCANI (1961), show that this change starts much earlier, not later than 5–6 weeks after the shortest day. YEATES (1955) and BERMAN and VOLCANI (1961) carried out their work at latitudes of 27° 28's., and 31° 47'N, respectively, while the Netherlands is located on lat 5° 52'N. Absolute day length of the shortest day in the Netherlands is 8.1 hour, while at the previously mentioned latitudes it is 10.1 hour and 10.3 hour, respectively. Therefore the difference is probably not caused by differences in day-length or in absolute day-length only, but might also be

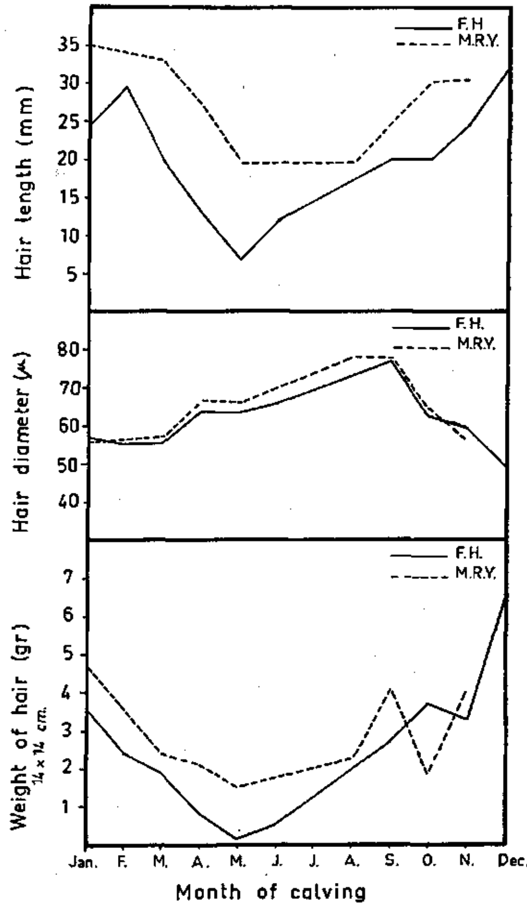

FIG. 10. Monthly variations in hair characters of mothers at calving.

due to environmental temperature and to the condition and food of the animal.

Inspection of table 73 shows that hair growth takes place in two seasons of the year, namely in spring and autumn. It appears probable that most of the winter hairs to be shed from their growing follicles are substituted by a short, thick and hard coat during spring. The change from a long to a short coat in spring is very obvious. In autumn the thick short hairs start to shed in order to give way to the new growth of longer and thinner hairs. There is consequently less shedding. These results confirm the finding of HAYMAN and NAY

(1961) who came to the conclusion that shedding is a response to both increasing and decreasing length of hair. The differences in coat characteristics observed in this work, in winter and spring and in summer and autumn are mainly due to a seasonal replacement of fibres. The summer coat is characterised by club hairs, which cannot grow continuously until the time of shedding, while the winter coat has long hairs with smaller diameters in comparison with the shorter and thicker hairs of summer. So winter coat must be a new coat and not an elongation of the summer coat. It is worthy to mention here that the summer fibres are much more medullated than the longer and thinner winter fibres.

It must be put in consideration that hair characters are an important factor in selecting animals to live in tropical and subtropical regions. HAYMAN and NAY (1961) refered to this point. They stated that animals shedding their winter coat rapidly and completely, and replacing it with a very short, course and light in weight. Summer coat, are more efficient in coping with a hot environment. This suggests that selection for short coated animals would be effective in hot environments, and of value in producing an animal adapted to them.

In general, it was found during our work that birth-coat of the calf is very much unlike that of the mother just after calving. While on the other hand there appears to be a far greater uniformity between the birth coats of various calves, even of different breeds, than might be expected considering their variability at a later stage. The conditions associated with hair in the period of prenatal life appear, however, to give some light upon the problem. Before birth the foetus is enclosed inside the imbryonic membranes, where it is surrounded by the amniotic fluid. So the form of each individual hair fibre is determined by its actual structure as it leaves the follicle, uninfluenced by any mechanical outside agency or action of the fibres one upon another. So, during the gestation period, the foetus is isolated from the seasonal fluctuations in temperature, feeding, humidity and day-light. The food nutrients pass from the dam to the foetus through the placenta. Therefore foetuses usually in the same condition because their mothers are in the same level of management and feeding. Also the nervous system of the mother and the calves before birth are separated. We may, therefore conclude that before birth the form of the hair is mainly dependent the genetic structure and the condition of the mother, unaffected by such influences as *e.g.* day light. It seems that hair growth during pregnancy continues to take place until birth, *i.e.* the birth-coat of the calf does not pass through a growth cycle or shedding in prenatal life. The dam's coat has been affected by the previous influences (seasonal fluctuation) all the time, and passes through a cycle of growth. Therefore calf birth coat does not follow the picture of its dam's coat. In the first few months after birth the hair fibres gradually move up (shed), and shedding takes place. After this shedding, the hair of the calf follows the picture of the dam's coat, since for now on they are both continuously exposed to the influences of day-length and seasonal fluctuation.

Calves:

Weight of hair:

The distribution of number of calves and their mothers which were tested monthly in each herd, is given in table 80. The results given in table 81 and figure 11 summarize a description of the weight of hair at birth and at different months of the year for the two breeds (F.H. and M.R.Y.). It can be noticed that a birth the hair weight is maximal and thereafter it decreases till August and then gradually increases till December.

TABLE 80. Number of calves and their mothers tested monthly in each breed

Month	F.H.		M.R.Y.		Total No.
	Calves No.	Mothers No.	Calves No.	Mothers No.	
June	12	12	8	8	40
July	12	12	8	8	40
August	12	12	8	8	40
September	12	12	8	8	40
October	12	12	8	8	40
November	12	11	8	8	39
December	12	8	5	6	31
Total	84	79	53	54	270

TABLE 81. Average weights of hair on 14 × 14 cm within months and breed

Month	Mothers		Total g	Calves		Total
	F.H. g	M.R.Y. g		F.H. gr.	M.R.Y. g	
Birth*	—	—	—	6.07	5.33	5.70
June	0.84	0.88	0.86	4.01	3.70	3.85
July	1.24	1.39	1.31	2.04	2.26	2.15
August	1.41	2.24	1.82	1.51	1.96	1.73
September	1.62	3.03	2.32	1.97	2.13	2.05
October	3.62	4.45	4.03	2.47	3.04	2.75
November	3.32	4.48	3.90	2.83	3.71	3.27
December	3.69	4.52	4.10	3.42	4.57	3.99
Total	2.25	2.99	2.62	2.60	3.52	3.06

* March-April-May.

Hair diameter:

From table 82 and figure 11 it can be observed that the diameter increased slightly after birth till June and then remained nearly constant till August, after which it gradually decreased. The minimum hair diameter was in December. Variation in hair diameter differed from those in weight of hair.

TABLE 82. Hair diameter (μ): Average of months and breed

Month	Mothers		Total	Calves		Total
	F.H.	M.R.Y.		F.H.	M.R.Y.	
Birth*	—	—	—	49.62	49.96	49.79
June	76.42	77.23	76.82	51.51	51.91	51.71
July	76.44	77.31	76.87	50.42	51.16	50.79
August	75.18	76.60	75.89	51.75	51.73	51.74
September	71.86	72.73	72.29	48.50	48.24	48.37
October	65.12	66.67	65.89	45.16	45.70	45.43
November	62.33	63.56	62.94	41.57	42.01	41.79
December	59.27	60.64	59.95	38.28	39.93	39.10
Total	68.23	70.67	69.45	46.74	47.24	46.99

* March-April-May.

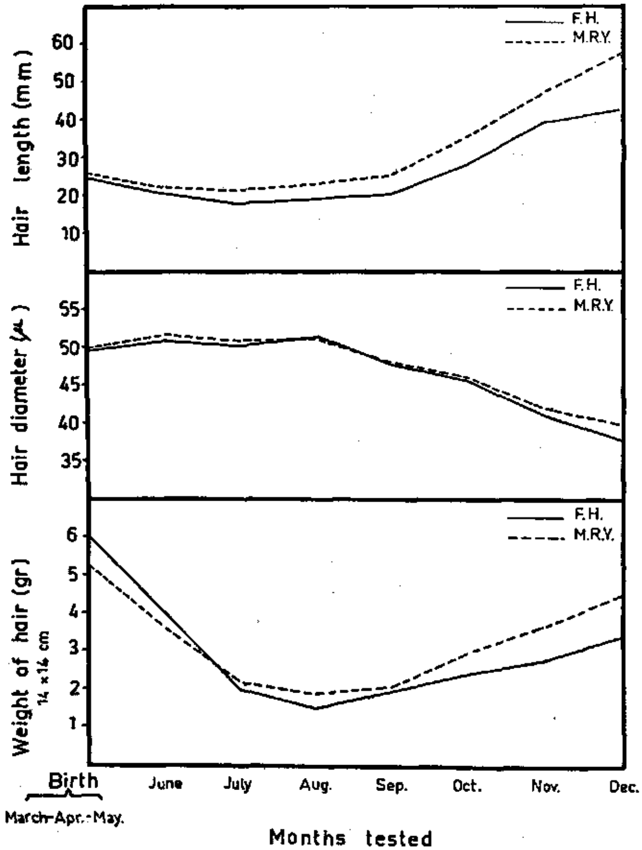

FIG. 11. Monthly changes in calves hair characters.

Hair length:

The results found in table 83 show the average hair length for each breed at birth and at several months of the year. Hair length at birth is higher than after birth. Variations in hair length as presented in figure 11 show that hair length gradually decreases after birth till July. After July it increases until a maximum in December.

TABLE 83. Hair length (cm): Average of months and breed

Month	Mothers		Total	Calves		Total
	F.H.	M.R.Y.		F.H.	M.R.Y.	
Birth*	—	—	—	24.75	25.93	25.34
June	11.67	16.11	13.89	20.44	22.71	21.57
July	14.10	19.91	17.00	18.52	22.35	20.43
August	15.26	25.81	20.53	19.09	23.29	21.19
September	17.96	28.90	23.43	19.95	25.97	22.96
October	26.64	36.80	31.72	28.08	35.95	32.01
November	33.39	46.35	39.87	39.43	47.62	43.52
December	35.02	46.45	40.73	40.24	57.78	49.01
Total	22.00	31.47	26.73	26.53	33.66	30.09

* March-April-May.

Medullation:

Variations in presence of medulla have been estimated and are given in table 84. The percentage of medullated fibres is in this group of spring born calves maximal at birth and during the first months of postnatal life.

TABLE 84. Presence of medulla (%): Average of months and breed

Month	Mothers		Total	Calves		Total
	F.H.M	M.R.Y.		F.H.	M.R.Y.	
Birth*	—	—	—	99	100	99.5
June	100	100	100	100	100	100
July	100	100	100	100	100	100
August	100	100	100	88.3	100	94.2
September	100	100	100	83.8	97.5	90.7
October	84.5	83.7	84.1	68.2	91.0	79.6
November	72.7	79.0	75.8	57.5	77.2	67.3
December	68.0	74.0	71.0	56.2	64.0	60.1
Total	89.3	90.9	90.1	79.1	89.9	84.5

* March-April-May.

From the results obtained in this work, it can be observed that the old hair clubs are being shed after birth and replaced by new ones of a different type. From figure 11 it seems that this process goes on gradually throughout the months tested. After birth it is clearly found that hair fibres begin to fall out gradually. The coat of the calves then passes through the annual cycle *i.e.* the shedding of birth coat is done after birth, nearly in the first autumn. This shedding can be ascribed to the difference between foetal and post-foetal metabolism, and more probably due to the absence of shedding during prenatal life. An adequate proof to such a suggestion is provided by our findings, that weight of hair attains its maximum in the birth coat and also that hair length is longer at birth than after birth. That hair length and hair diameter at birth are not maximal, may be attributed to a form of prenatal check. The calf in prenatal life may be influenced by the pressure of the amniotic fluid which interfers with liberal growth of hair, as well as with the adjacent internal organs. So this prenatal check is reflected in the reduction of hair diameter and the unattainability of maximum hair length at birth.

It seems that further extension in this respect is needed to examine section of the skin on different periods during prenatal life of the calf.

Mothers:

Weight of hair:

Table 81 shows the average weight of hair per 14 x 14 cm for each breed and for calves and their mothers. Weight of hair for mothers shows monthly variations. In June the minimum is reached, and thereafter it increases gradually until October. In October there is an increase in hair weight, followed by a very slight decrease in November (0.3 gram in F.H. breed only). In December the peak is reached (Figure 12).

Hair diameter:

Variations in hair diameter differ from those in weight of hair. The average hair diameter of each breed is given in table 82. Differences in hair diameter are rather large from month to month (Figure 12). In June and July hair diameter reaches a peak and then gradually decreases until December, where it is at its minimum.

Hair length:

Variations in hair length follow similar trend as those of hair weight. The results in table 83, gave a picture to the difference in hair length during months tested. It is largest in December and smallest in June. After June it increases again (Figure 12).

Medullation:

Monthly fluctuations in presence of medulla are presented in table 84. From this table it can be observed that variations in presence of medulla are similar to those in hair diameter. Medullation reaches a maximum in June and remains constant till July and August in F.H. and M.R.Y. breeds, respectively. Then gradually decreases till December. These results are in general agreement with those obtained by many investigators. DOWLING (1959), SCHLEGER and TURNER (1960), BERMAN and VOLCANI (1961) and HAYMAN and NAY (1961).

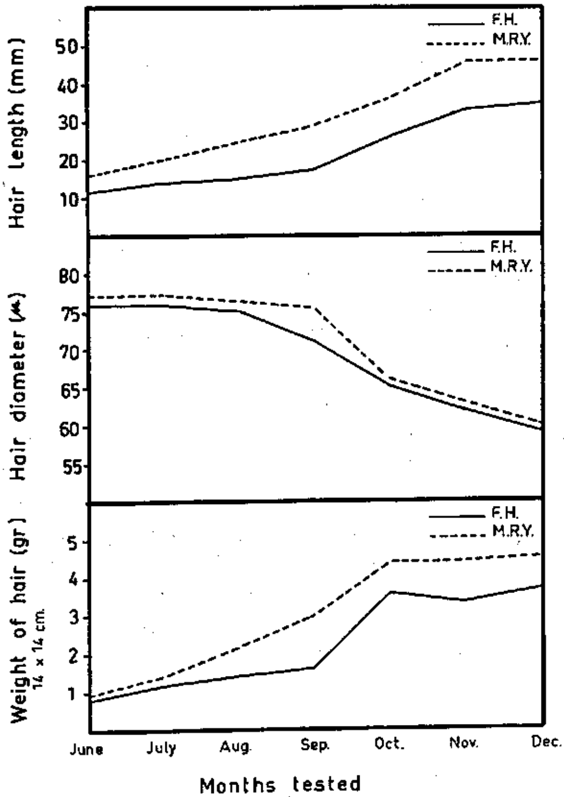

FIG. 12. Monthly changes in mothers hair characters.

Coloured hair:

We noticed that hair fibres from the white area of the coat are longer, thicker and more medullated, than those from red and black areas within animal and breed. Also red hairs in M.R.Y. breed are characterised by a longer, thicker and higher percentage of medullation than black hairs in F.H. breed, irrespective of season (Tables 85 and 86). This result confirm the

TABLE 85. Seasonal variation in mothers coat characters according to colours (F.H.)

Season	Black hair				White hair			
	No.	Dia. (μ)	Len. (mm)	Medull. %	No.	Dia. (μ)	Len. (mm)	Medull. %
Winter	275	53.00	24.11	59.33	25	64.16	24.48	84.00
Spring	525	61.92	10.79	78.90	325	64.50	14.58	87.14
Total	800	57.46	17.45	69.11	350	64.33	19.53	85.57

TABLE 86. Seasonal variation in mothers coat characters according to colours (M.R.Y.)

Season	Red hair				White hair			
	No.	Dia. (μ)	Len. (mm)	Medull. %	No.	Dia. (μ)	Len. (mm)	Medull. %
Winter	280	53.61	25.22	60.08	120	62.06	25.58	81.25
Spring	270	65.54	19.14	81.19	280	67.19	21.01	94.50
Total	550	59.57	22.18	70.63	400	64.62	23.29	87.87

finding of CSUKÁS (1939) who reported that, unpigmented fibres were found to be longer, thicker and have a more developed medulla than the pigmented fibres from the same individual or other animals of the same breed, on British, German and Hungarian breeds at Hungaria.

This investigation revealed the existence of an annual cycle, as mentioned before, in weight of hair, hair fibre diameter, hair length and medullation. It was found that the rate by which hair weight, hair diameter, hair length and medullation change, does not exactly correspond with the changes in day-length, whereas the hair diameter closely follows the variations in day-length. The obvious conclusion is that there must be additional factors affecting hair length, weight of hair and medullation. These factors may well be the direct influence of higher skin temperature, air temperature, feeding and secretion of special glands such as thyroid, on hair growth.

CHAPTER 5

CONCLUSIONS

Birth weight of Friesian calves is highly affected by sex, age and weight of dam. The average birth weight of all the calves studied was 35.86 kg. (Table 17). There was a general tendency that, as the gestation period for calves increased, their birth weight also increased slightly. The average percentage of birth weight of the calf to weight of the dam after calving was 6.8 per cent (Table 22). Birth weight increases with the increase of age of dam up to six years old (Table 24).

Calves that were heavier at birth were able to maintain their weight advantage through 52 weeks of age in both sexes, particularly bull calves. It must be put into consideration that bulls were usually kept on a somewhat better feeding system than heifers. There are wide variations in the growth of calves born in autumn and the other seasons. Average weight of autumn heifer calves at birth and at 52 weeks of age, was heavier than that of other seasons (Table 37 and Figure 2). Gain per day from birth till 52 weeks of age is highly affected by birth weight.

There were yearly fluctuations in the average weight, diameter, and length of calf's hair at birth (Tables 54 and 55 and Figure 4). In this work the results verify the relation between sires and some hair characters of their calves at birth (Tables 64 and 65 and Figures 7 and 8). In the case of presence of medulla in birth coat, it seems that it was not affected by any factor studied. Birth coat characters of F.H. and M.R.Y. calves, were nearly similar, and the differences were not significant (Table 71). It does not pass through a growth cycle or shedding in prenatal life. Therefore calf birth coat does not follow the picture of mother's coat.

A slight difference in mother's hair characters were observed between heifers and older cows (Table 72). Seasonal fluctuation of some characters is very definite (Figure 9). In the course of the year the coat of cattle passes through a cycle of growth. Hair growth takes place in two seasons of the year, namely in spring and autumn. During this cycle, heavy, thinner and long-haired winter coat is replaced by a light, thicker and short-haired summer coat. In February there seemed to be a beginning of shedding. Winter coat began to change into summer coat very clear at about 12 weeks following the shortest day. Friesian cows have the lighter coats with thinner, shorter hair fibres and less medullation than M.R.Y. cows. Birth coat of the calf is unlike that of the mother just after calving. There proved to be more uniformity between the birth coats of various calves, even of different breeds, than between the dams.

The old hair clubs of the calves being shed continuously after birth and replaced by new ones of a different type. After this the coat of the calves passes through the annual cycle.

Mothers weight of hair, hair diameter, hair length and medullation showed monthly variations (month tested from June to December).

This investigation revealed the existence of an annual cycle in weight of hair, hair diameter, hair length and medullation. Hair diameter closely follows the variation in day-length, while the other characters do not exactly correspond with the changes in day-length.

Hair fibres from the white area of the coat are longer, thicker and more medullated, than those from red and black areas within animal and breed. Also red hairs in M.R.Y. breed are characterised by a longer, thicker and higher percentage of medullation than black hair in F.H. breed.

SUMMARY

An investigation was carried out to study the influence of some environmental factors on birth weight, growth from birth till 52 weeks of age and hair characters.

The effect of sex of the calf, season of birth, gestation period, weight of dam and age of dam at calving on birth weight was studied. This study included 302 Friesian calves. Male calves were 3.04 kg. heavier than the female calves. These differences were statistically highly significant (Table 19). Season of birth had no significant influence on the birth weight. However, it does appear that the average birth weights of calves born in autumn were heavier than those dropped in the other seasons (Table 18 and Figure 1). Birth weight and gestation period for the calves dropped from dams 2–4 years old, were 34.1 kg and 276.03 days, respectively, while for those from dams 4 years and over, were 37.2 kg and 279.0 days respectively (Table 20). There was no significant correlation between birth weight and gestation period in the normal range (270–289 days) for bulls and heifers (Table 21). The correlation coefficients between weight of dam in different ages (2–3 years, 3–4 years and 4 year-old and over) and birth weight of the calf were 0.40, 0.65 and 0.44, respectively (Table 23).

Growth data on 100 heifer and 52 Friesian bull calves were used to determine the effects of birth weight, season of birth, sex and age of dam on weight gains to 52 weeks of age. Correlation of birth weight with weight at 12, 24, 36 and 52 weeks of age (bulls and heifers together) were 0.51, 0.38, 0.44 and 0.44, respectively (Table 38). To 52 weeks of age, heifer calves born in autumn gained 0.123 and 0.049 kg. per day more than those born in spring and winter, respectively (Tables 37 and 39 and Figure 2). Male calves were 4.1 and 44.9 kg. heavier than female calves at birth and at 52 weeks of age, respectively (Table 41). Bulls gained 0.112 kg. per day more than heifers, from birth to 52 weeks of age (Table 42). Average gain per day from birth to 52 weeks of age, for calves born from dams $2–2^6$ years of age was 0.712 kg., and for those from dams 2^6 years and over was 0.756 kg. (Table 42).

The object of this study was to evaluate some of the factors affecting calf's hair characters at birth, mother's hair characters at calving and hair growth. The total numbers of hairs examined in this investigation, for diameter, length and presence or absence of medulla were 25850 hairs, taken from 517 samples.

Variations in all characters between sexes on birth coat, were found not to be significant. Differences between the different years studied within sex were significant in all characters in F.H.- and M.R.Y.-breeds, except hair length in M.R.Y. breed (Tables 56 and 57). Neither the age of dam nor the season of birth had any significant influence on hair characters at birth, in the two breeds (Tables 58, 59 and 60, Figures 5 and 6). There was a relation between

sires and some hair characters of their calves (Tables 62 and 63 and Figures 7 and 8). At birth nearly all fibres proved to be medullated. The correlations found between the following calf's hair characters at birth: Weight and hair diameter, weight and hair length, and hair diameter with hair length, were +0.46, +0.52 and —0.14 for F.H. calves and +0.18, +0.56 and —0.15 for M.R.Y. breed (Table 66). Correlation among calves hair characters at birth and hair characters of mothers at calving, were not significant (Tables 67 and 68). There was a significant correlation between birth weight and only hair length in F.H. breed (Table 69). The correlation between gestation period and hair characters studied were not significant (Table 70).

The differences in hair characters between heifers and older cows, were found not to be significant on all characters studied except for hair length in F.H. breed (Table 72). In autumn and winter the coat is heavy and long; while the hair diameter is thinner than in the other seasons and the percentage of medullation is lowest (Table 73 and Figure 9). In summer samples, all fibres were found to be medullated. The percentage of medulla were 64.1, 83.3, 100.0 and 71.7 in winter, spring, summer and autumn, respectively for F.H., and 65.8, 86.0, 100.0 and 77.5 in winter, spring, summer and autumn, respectively for M.R.Y. (Table 73). Correlation between various coat characters as: Weight of hair with: hair diameter, hair length and presence of medulla, were —0.17, +0.72 and —0.20 for F.H., and —0.23, +0.70 and —0.28, for M.R.Y., respectively (Table 78). Hair diameter with: hair length and presence of medulla, were —0.36 and +0.55 for F.H. and —0.59 and +0.86 for M.R.Y., respectively. Correlation between hair length and presence of medulla was —0.46 and +0.58 for F.H. and M.R.Y., respectively (Table 78). The variations between the two breeds were found to be highly significant in all characters, except for weight of hair (Table 79).

Hair growth of calves born between March and May were studied in the months from June to December. At birth, weight of hair per unit area reached the peak (Table 81 and Figure 11). Hair diameter increased slightly after birth (Table 82 and Figure 11). Hair length was higher at birth than after birth (Table 83 and Figure 11). The percentage of medullated fibres reached the maximum at birth and during the first months tested (Table 84).

Weight of hair for cows showed monthly variations (from June to December). In June the minimum was reached and the maximum was observed in December (Table 81 and Figure 12). In June and July the peak of hair diameter was reached; then it decreased gradually till December (Table 82 and Figure 12). Hair length was the largest in December and lowest in June (Table 83 and Figure 12). Presence of medulla reached the maximum in June, then it decreased gradually till December (Table 84).

Hair fibres from the white area of the coat are longer, thicker and more medullated, than those from red and black areas within animal and breed. Also red hairs in M.R.Y. breed are characterised by a longer, thicker and higher percentage of medullation than black hairs in F.H. breed (Tables 85 and 86).

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SAMENVATTING EN CONCLUSIES

I. Inleiding

Er is een onderzoek ingesteld naar enkele milieu-invloeden op het geboortegewicht van kalveren en hun groei vanaf de geboorte tot een leeftijd van 52 weken. Daarnaast is ook een onderzoek ingesteld naar enkele eigenschappen van het haarkleed bij rundvee, speciaal bij kalveren vanaf de geboorte.

II. Het geboortegewicht van kalveren

De invloed van het geslacht, het geboorteseizoen en de lengte van de draagtijd op het geboortegewicht van kalveren is bestudeerd. Eveneens is de invloed nagegaan van het gewicht en de leeftijd van de moeder bij het kalven op dit geboortegewicht. De gegevens hebben betrekking op 302 zwartbonte kalveren. Het gemiddelde geboortegewicht van alle kalveren was 35.86 kg (tabel 17). Er werd een duidelijk significant verschil tussen het geboortegewicht van de twee geslachten geconstateerd. De mannelijke kalveren waren 3.04 kg zwaarder dan de vrouwelijke kalveren (tabel 19). Er werd geen significante seizoensinvloed op het geboortegewicht aangetoond. De tendens bestaat echter, dat het gemiddelde geboortegewicht van in de herfst geboren kalveren hoger is dan dat van de in de overige seizoenen geboren kalveren (tabel 18, figuur 1). In het algemeen steeg het geboortegewicht iets, als de draagtijd langer werd; kalveren geboren uit 2 tot 4-jarige moeders wogen 34.1 kg en de draagtijd was gemiddeld 276.03 dagen; het geboortegewicht en de draagtijd van kalveren van oudere moeders was respectievelijk 37.2 kg en 279.00 dagen. Bij de vaars- en stierkalveren werd geen significant verband gevonden tussen het geboortegewicht en de draagtijd, als de draagtijd normaal (270-289 dagen) was (tabel 21). De draagtijd van mannelijke kalveren was langer dan die van vrouwelijke (niet significant). Het geboortegewicht nam geleidelijk toe als het gewicht van de moeder toenam. De correlatie coëfficienten tussen het gewicht van de moeder op verschillende leeftijden (nl. op 2–3 jaar, 3–4 jaar en 4 jaar en ouder) en het geboortegewicht van het kalf waren respectievelijk 0.39, 0.65 en 0.44 (tabel 23). Het gemiddelde geboortegewicht van het kalf in procenten van het gewicht van de moeder na het kalven was 6.8% (tabel 22). Het gemiddelde geboortegewicht van de kalveren steeg met het toenemen van de leeftijd van de moeder tot een leeftijd van 6 jaar (tabel 24).

III. De groei vanaf de geboorte tot een leeftijd van 52 weken

De gewichtstoename tot een leeftijd van 52 weken is bepaald bij 100 vaars- en 52 stierkalveren. De invloed van het geboortegewicht, het geboorteseizoen, het geslacht van het kalf en de leeftijd van de moeder op deze groei is nagegaan. De kalveren die bij de geboorte zwaarder waren hielden hun voorsprong gedurende deze 52 weken; dit gold voor beide geslachten, maar vooral voor de stierkalveren. Er dient rekening gehouden te worden met het feit dat de stieren in het algemeen beter gevoerd werden dan de vaarzen. De correlatie tussen het geboortegewicht en het gewicht op 12, 24, 36 en 52 weken (voor stieren en vaarzen tezamen) was respectievelijk 0.51, 0.37, 0.44 en 0.44 (tabel 38). Deze correlaties waren duidelijk significant. Er werd een significante seizoensinvloed op de groei geconstateerd (tabel 40). De vaarskalveren, die in de herfst geboren waren, groeiden respectievelijk 0.123 en 0.049 kg per dag beter dan de vaarskalveren, die in het voorjaar en in de winter geboren waren (tabel 37 en 39 en figuur 2).

De stierkalveren wogen bij de geboorte 4.1 kg en op een leeftijd van 52 weken 44.9 kg meer dan de vaarskalveren (tabel 41). Vanaf de geboorte tot een leeftijd van 52 weken groeiden de stieren 0.112 kg per dag beter dan de vaarzen (tabel 42). Deze verschillen waren duidelijk significant. Ook hier dient weer gewezen te worden op de gemiddeld iets rijker voeding bij de stierkalveren.

De leeftijd van de moeder had een significante invloed op de groei van het kalf. De kalveren van moeders van 2 tot 2^6 jaar groeiden over de gehele periode gemiddeld 0.712 kg en van oudere moeders was de groei per dag 0.756 kg. De laatsten waren bij de geboorte gemiddeld ook zwaarder, zoals eerder reeds werd gemeld.

IV. HAAREIGENSCHAPPEN

Enkele eigenschappen van het haar van kalveren bij de geboorte, van koeien bij het afkalven en de groei van het haar zijn bestudeerd. In het totaal zijn er van 25.850 haren uit 517 monsters de diameter en de lengte gemeten, bovendien is er nagegaan of er wel of niet een medulla aanwezig was. De monsters waren van verschillende dieren, nl. van:

1) 90 F.H. kalveren bij de geboorte en van 33 van hun moeders bij het kalven.
2) 56 M.R.Y. kalveren bij de geboorte en van 28 van hun moeders bij het kalven.
3) 12 F.H. kalveren en hun moeders (maandelijks bemonsterd).
4) 8 M.R.Y. kalveren en hun moeders (maandelijks bemonsterd).

Daarnaast is de diameter, de lengte en de aanwezigheid van een medulla van verschillend gekleurde haren (zwart, rood en wit) van 40 koeien (23 F.H. en 17 M.R.Y.) bepaald. Al deze dieren waren van het Laboratorium voor Veeteelt en het Laboratorium voor Dierfysiologie van de Landbouwhogeschool te Wageningen.

Het haarkleed bij de geboorte

De verschillen tussen het haarkleed van vaars- en stierkalveren bij de geboorte waren niet significant. Het gemiddelde gewicht en de diameter van het haar van kalveren bij de geboorte verschilde van jaar tot jaar (tabel 54 en figuur 4) en de verschillen in haarlengte waren tamelijk groot. De jaarverschillen, berekend binnen geslachten, waren voor alle gemeten haareigenschappen voor beide veeslagen (F.H. en M.R.Y.) significant, behalve voor de haarlengte bij het M.R.Y. veeslag (tabel 56 en 57). Bij geen der veeslagen kon een significante invloed van de leeftijd van de moeder of het geboorteseizoen op de haareigenschappen van het kalf bij de geboorte worden aangetoond (tabellen 58, 59 en 60, en figuren 5 en 6).

Uit resultaten van dit onderzoek blijkt dat er een duidelijk verband is tussen de stier en de haareigenschappen van zijn kalveren bij de geboorte (tabellen 62 en 63 en figuren 7 en 8). De verschillen tussen het gewicht en de diameter van het haar van kalveren van verschillende vaders waren duidelijk significant, terwijl er voor de haarlengte en de haardiameter van de M.R.Y. kalveren geen significante stierinvloed aangetoond kon worden (tabel 64 en 65).

De bestudeerde eigenschappen van het haarkleed bij de geboorte schijnen niet beïnvloed te worden door de aanwezigheid van een medulla. Bij de geboorte zijn bijna alle haren merghoudend.

De verschillende haareigenschappen bij de geboorte zijn gecorreleerd. De correlaties tussen het gewicht en de diameter van het haar, tussen het gewicht en de lengte van het haar en tussen de diameter en de lengte van het haar waren bij de F.H. kalveren respectievelijk +0.46, +0.52 en —0.14 en voor de M.R.Y. kalveren +0.18, +0.56 en —0.15 (tabel 66).

Er is geen significant verband geconstateerd tussen het haarkleed van het kalf en dat van de moeder bij de geboorte van het kalf (tabel 67 en 68).

Bij de F.H. kalveren was er een significante correlatie tussen het geboortegewicht en de haarlengte, terwijl tussen het geboortegewicht en de andere haareigenschappen geen correlatie kon worden aangetoond (tabel 69). Evenmin was er een duidelijk verband tussen de draagtijd en het haarkleed (tabel 70). Het haarkleed bij de geboorte was voor de F.H. en M.R.Y. kalveren ongeveer gelijk (tabel 71).

Het haarkleed van de moeder bij het kalven

Er werden kleine verschillen gevonden tussen de haareigenschappen van vaarzen en oudere koeien (tabel 72); deze verschillen waren bij beide veeslagen niet significant, uitgezonderd de haarlengte bij de F.H. dieren, de 2–2^{6}-jarige dieren hadden een gunstiger haarkleed; dit verschil was wel significant.

Er is een duidelijke seizoensinvloed op enkele haareigenschappen. In de herfst en winter is het haarkleed dik en lang; terwijl de haardiameter kleiner is dan in de andere seizoenen en het percentage merghoudende haren het laagst (tabel 73, figuur 9). Alle haren uit de monsters die in de zomer genomen waren hadden een medulla. In de winter had 64.1% van de onderzochte haren van de F.H. dieren een medulla, in het voorjaar 83.3%, in de zomer 100.0% en in de herfst 71.7%; voor de M.R.Y. dieren zijn deze percentages respectievelijk 65.8, 86.0, 100.0 en 77.5. In december en januari was het haarkleed het zwaarst en de haren het langst, terwijl de haardiameter het geringste was (tabel 74 en 75, figuur 10).

In februari kon het begin van de haarwisseling in onze monsters worden geconstateerd.

De correlaties tussen het gewicht van het haar en de haardiameter, en de haarlengte, en de aanwezigheid van een medulla is bij de F.H. dieren resp. —0.17, +0.72 en —0.20; bij de M.R.Y. dieren resp. —0.23, +0.70 en —0.28. De haardiameter gecorreleerd met de haarlengte en de aanwezigheid van een medulla gaf bij de F.H. dieren als antwoord resp. —0.36 en +0.55 en bij de M.R.Y. dieren —0.59 en +0.86. De correlatie tussen de haarlengte en de aanwezigheid van een medulla was bij de F.H. dieren —0.46 en bij de M.R.Y. dieren —0.57 (tabel 78). Al deze correlaties waren significant, uitgezonderd die tussen het haargewicht en de haardiameter en tussen het haargewicht en de aanwezigheid van een medulla. Zwartbonte koeien hebben een lichter haarkleed met dunnere en kortere haren dan de roodbonte koeien, terwijl het percentage merghoudende haren bij de zwartbonte dieren geringer is. Uitgezonderd het haargewicht waren de verschillen in haareigenschappen tussen beide veeslagen zeer duidelijk significant (tabel 79).

Het haarkleed van het kalf bij de geboorte leek niet op dat van de moeder direkt na het kalven. Het leek dat de uniformiteit tussen het geboortehaarkleed van de verschillende kalveren, zelfs tussen de veeslagen groter was dan tussen het haarkleed van de moeders.

De groei van het haar

Alle kalveren werden geboren tussen maart en mei. Bij de geboorte was het haargewicht per oppervlakte eenheid het hoogst (tabel 81, figuur 11) en het haar het langst (tabel 83, fig. 11). De haardiameter nam na de geboorte geleidelijk toe (tabel 82, figuur 11). Het percentage haren met een medulla was maximaal bij de geboorte en tijdens de eerste maanden, waarover dit onderzoek zich uitstrekt (tabel 84). Het oude haar begon na de geboorte geleidelijk uit te vallen en werd vervangen door een ander type haar. Daarna volgde het haarkleed van de kalveren de jaarlijkse cyclus.

Het gewicht van de vacht was bij de moeders minimaal in juni en het maximum werd in december geconstateerd (tabel 81 en fig. 12). In juni en juli was de haar diameter het grootst en deze nam geleidelijk af tot december (tabel 82 en figuur 12). Het haar was het langst in december en het kortst in juni (tabel 83 en figuur 12). De aanwezigheid van een medulla was maximaal in juni en daalde tot december (tabel 84). Er werd een jaarlijkse cyclus geconstateerd voor het haargewicht, de haardiameter, de haarlengte en de aanwezigheid van een medulla. De haardiameter verandert met de verandering van de daglengte, terwijl dit voor de andere eigenschappen niet precies correspondeert.

Haren van het witte gedeelte van de huid zijn langer, dikker en hebben een hoger percentage met een medulla, dan de aangrenzende rode of zwarte gedeelten van hetzelfde dier. De rode haren van de M.R.Y. dieren zijn langer en dikker dan de zwarte haren van de F.H. dieren terwijl het percentage merghoudende haren bij het M.R.Y. vee hoger ligt (tabel 85 en 86).

REFERENCES

AHMED, I. A., and TANTAWY, A. O. (1954). Alexandria J. Agric. Res., **2** (1): 1–11.

AHMED, I. A., and TANTAWY, A. O. (1956). Empire Journal Exp. Agric. **24**, 213.

ALEXANDER, G. I., SUTHERLAND, D. N., DAVEY, G. P., and BURNS, M. S. (1962). Qd J. Agric. Sci., **17**: 123–134 (Abs. in Anim. Breed. Abstr., Vol., **30** No. 1: 23).

ANANTAKRISHNAN, C. P., and LAZARUS, A. J. (1953). Indian. J. Dairy Sci., **5**: 23–36

ANGEL, H., et POLY, J. (1956). Annales de Zootechnie **1**: 81.

ARNOLD, P. T. D., and BECKER, R. B. (1955). Bull. Flo. Agric. Exp. Sta., 529: 23 (Abs. in Anim. Breed. Abstr., Vol. **23**, No. 2: 144).

ARUNACHALAM, T. V., LAZARUS, A. J., and ANANTAKRISHNAN, C. P. (1952). Indian J. Dairy Sci., **4**: 117–123.

ARZUMANJAN, E. A. (1950). Dokl. Akad. Seljskohoz. Nauk Lenin., 1950 (**5**): 17–21 (Abs. in Anim. Breed. Abstr., Vol. **18** No. 3: 249).

ASKER, A. A., and RAGAB, M. T. (1962). Indian J. Vet. Sci., **22**: 265–272.

BALDWIN, C. S., GILMORE, L. O., and FECHHEIMER, N. S. (1954). J. Dairy Sci. Vol. **37**, No. 11: 1368.

BELIĆ, M. (1950). Vet. Glasn., 3 (11/12): 15–43. (Abs. in Anim. Breed. Abstr., Vol. **18** No. 4:396)

BERMAN, A. (1960). J. Endocrin **20**: 288 (Cited by BERMAN and VOLCANI 1961).

BERMAN, A., and VOLCANI, R. (1961). Austr. J. Agric. Res. Vol. **12** No. 3: 528.

BISSONNETTE, T. H., and WILSON, E. (1939). Science **89**, 418 (Cited by BERMAN and VOLCANI, 1961).

BLACKWELL, R. L., KNOX, J. H., SHELBY, and CLARK, R. T. (1962). J. Anim. Sci. Vol. **21** No. 1: 101.

BONSMA, J. C. (1939). J. Agric. Sci. Vol. **39** No. 2: 204.

BONSMA, J. C., and PRETORIUS, A. I. (1943). Fmg. in S. Afr. (Feb. 1943). (Cited by HAYMAN and NAY 1961).

BOSMAN, D. J. (1962). M. Sc. (Agric.) in die Fakulteit Landbou, Univ. Pretoria.

BRAGA, J. W. (1954). Veterinaria (Rio de J.), 6 (3): 75–92. (Abs. in Anim. Breed. Abstr. Vol. **22** No. 1: 27).

BRAKEL, W. J., RIFE, D. C., and SALISBURY, S. M. (1952). J. Dairy Sci. Vol. **35** No. 3: 179–194.

BRAUDE, R., and WALKER, D. M. (1949). J. Agric. Sci. Vol. **39** No. 2: 156.

BRINKS, J. S., CLARK, R. T., KIEFFER, N. M., and QUESENBERRY, J. R. (1962). J. Anim. Sci. Vol. **21** No. 3: 501.

BRINKS, J. S., CLARK, R. T., RICA, F. J., and KIEFFER, N. M. (1961). J. Anim. Sci. Vol. **20** No. 2: 363.

BROWN, C. J. (1960). J. Anim. Sci. Vol. **19** No. 4: 1062.

BURGESS, J. B., LANDBLOM, N. L., and STONAKER, H. H. (1954). J. Anim. Sci. Vol. **13** No. 4: 843.

BURGKART, M., and SCHMID, D. O. (1961). Züchtungskunde **33**: 484.

BURNS, M. (1949). J. Agric. Sci. Vol. **39** No. 1: 64.

BURNS, M. A., and ALEXANDER, G. I. (1956). Qd agric. J. Vol. **82**: 505–508.

BURRIS, M. J. and BLUNN, C. T. (1952). J. Anim. Sci. Vol. **11** No. 1: 34–41.

CARNEIRO, G. G., and LUSH, J. L. (1954). J. Dairy Sci. Vol. **39** No. 10: 1145.

CARTER, H. B. (1940). Austr. J. Sci. Vol. **2** No. 5: 143 (Cited by BURNS, M., 1949).

CARTER, H. B., and DOWLING, D. F. (1954). Austr. J. Agric. Res. Vol. **5** No. 4: 745.

CHAUDHURI, A. C., and SINHA, C. (1952). Indian J. vet. Sci., **21**: 69–79 (Abs. in Anim. Breed. Abstr. Vol. **20** No. 4: 335).

CHIEFFI, A., ANDREASI, F., and VEIGA, J. S. (1951). Rev. Fac. Med. vet. S. Paulo, 4: 315–338 (Abs. in Anim. Breed. Abstr. Vol. **19** No. 4: 451).

CSUKÁS, Z. (1940). Mezogazdas. Kutatás., 12: 173–189. (Abs. in Anim. Breed. Abstr. Vol. **8** No. 1: 18).

DAVE, C. N. (1951). Poona Agric. Coll. Mag., 40 (4): 12–17 (Abs. in Anim. Breed. Abstr. Vol. **19** No. 2: 194).
DAVIS, H. P., and HATHAWAY, I. L. (1955). Res. Bull. Neb. Agric. Exp. Sta., No. 177.
DAVIS, H. P., PLUM, M., and BROST, B. (1954). J. Dairy Sci. Vol. **37** No. 2: 162.
DAWSON, W. M., PHILLIPS, R. W., and BLACK, W. H. (1947). J. Anim. Sci., **6**: 247–257.
DE ABREU, J. C. (1950). Rev. Agric. (Piracicaba. S. Paulo), 24: 231–251 (Abs. in Anim. Breed. Abstr. Vol. **18** No. 2: 166).
DE FRIES, J. C., TOUCHBERRY, R. W., and HAYS, R. L. (1959). J. Dairy Sci. Vol. **42** No. 4:598.
DE VREE, J. (1961). Veeteelt en Zuivelberichten, **4**: 410–413.
DINKHAUSER, F., TRAMPEN, K., and BERGMANN, H. (1944). Züchtungskunde, **19**: 23–28 (Abs. in Anim. Breed. Abstr. Vol. **12** No. 4: 194).
DONALD, H. P., RUSSELL, W. S., and TAYLOR, ST. C.S. (1962). J. Agric. Sci., **58**: 405–412.
DOWLING, D. F. (1955). Austr. J. Agric. Res. Vol. **6** No. 4: 645.
DOWLING, D. F. (1956). Austr. J. Agric. Res. Vol. **7** No. 5: 469.
DOWLING, D. F. (1958). Austr. J. Agric. Res. Vol. **9** No. 4: 579.
DOWLING, D. F. (1959). Austr. J. Agric. Res. Vol. **10** No. 5: 736.
DOWLING, D. F. (1960). Austr. J. Agric. Res. Vol. **11** No. 5: 870.
DOWLING, D. F., and NAY, T. (1960). Austr. J. Agric. Res. Vol. **11** No. 6: 1064.
DREWRY, K. J., BROWN, C. J., and HONEA, R. S. (1959). J. Anim. Sci. Vol. **18** No. 3: 938.
DRY, F. W. (1941). Proc. 1st. Ann. Conf. N.Z. Soc. Anim. Prod., P. 13 (cited by LOCKART, 1955).
DUERDEN, J. E. (1927). South African Journal of Sci. Vol. **24**, 388–415.
DUERDEN, J. E., and WHITNALL, A. B. (1930). South African Journal Sci. Vol. **27**: 521–545.
ECKLES, C. H. (1919). Missouri Agricultural Experiment Station Research Bul. 35: 11.
EIDRIGEVIČ, E. V., and POLJAKOV, E. V. (1954). Ž. absc. Biol., 14: 435–440 (Abs. in Anim. Breed. Abstr. Vol. **22** No. 4: 292).
EVERSON PEARSE, A. G. (1960). „Histochemistry Theoretical and applied" second editions, P 634.
FINDLAY, J. D., and YANG, S. H. (1950). J. Agric. Sci. **40**: 126–133.
FITCH, J. B., MCGILLIARD, P. C., and DRUMM, G. M. (1924). J. Dairy Sci. Vol. **7** No. 3: 222.
FLOCK, D. K., CARTER, R. C. and PRIODE, B. M. (1962). J. Anim. Sci. Vol. **21** No. 3: 651.
FOOTE, W. D., TYLER, W. J. and CASIDA, L. E. (1959). J. Dairy Sci. Vol. **42** No. 2: 305.
FRASER, A. S. (1952). Austr. J. Agric. Res. 3: 435–44 (Cited by LOCKART 1955).
FRASER, A. S. (1953). J. Genet. 51: 222–36 (Cited by LOCKART, 1955).
GREGORY, K. E., BLUNN, C. T., and BAKER, M. L. (1950). J. Anim. Sci. vol. **9** No. 3: 338.
HAFEZ, E. S. E., BADRELDIN, A. L. and SHAFFI, M. M. (1955). Emp. J. Exp. Agric., **23**: 34–38.
HAINES, C. E. (1962). Ceiba, 9 (2): 81–83. (Abs. in Anim. Breed. Abstr. Vol. **30** No. 3: 348).
HAYMAN, R. H. and NAY, T. (1961). Austr. J. Agric. Res. Vol. **12** No. 3: 513–527.
HENRY, W. A., and MORRISON, F. B. (1917). Feeds and Feeding 17th edition.
HERMAN, H. A., and SPALDING, R. W. (1947). J. Dairy Sci. Vol. **30**: 545.
HEYNS, H. (1959a). Fmg S. Afr., 35 (8): 19–20.
HEYNS, H. (1959b). Fmg S. Afr., 35 (9): 28–29.
HEYNS, H. (1960). S. Afr. J. Agric. Sci., **3**: 349–366; 517–530.
HOLTZ, E. W., ERB, R. E., and HODGSON, A. S. (1961). J. Dairy Sci. Vol. **44** No. 4: 672.
ISHAG, S. M. (1956). Agric. Pakist., 5: 225–228 (Abs. in Anim. Breed. Abstr. Vol. **24** No. 4: 352).
JOHARI, M. P. (1961). Indian vet. J., 37,' 354—364 Abstr. in Anim. Breed. Abstr. Vol. *29* No. 2:167).
JOHNSON, L. E., and DINKEL, C. A. (1951). J. Anim. Sci. Vol. **10** No. 2: 371.
JORDÂO, L. P., and ASSIS, F. DE P. (1950). Bol. Industr. Anim., N.S., 9 (½): 38–47 (Abstr. in Anim. Breed. Abstr., Vol. **18** No. 3: 278).
JORDÂO, L. P., and ASSIS, F. DE P. (1952). Bol. Industr. Anim. N.S. 12: 45–61 (Abstr. in Anim. Breed. Abstr., Vol. **20** No. 4: 337).
JORDÂO, L. P., and VEIGA, J. S. (1940). Rev. Industr. Anim., N.S. 2(2): 27–38 (Abs. in Anim. Breed. Abstr. Vol. **8** No. 2: 128).

JOUBERT, D. M., and HAMMOND, J. (1954). Nature (Lond.), 174: 647–648.
KNAPP, B. (JR.), BAKER, A. L. QUESENBERRY, J. R., and CLARK, R. T. (1942). Bull. Mont. Agric. Exp. Sta. 400: 13.
KNAPP, B. (JR.), LAMBERT, W. V., and BLACK, W. H. (1940). J. Agric. Res., **61**: 277–285.
KOCH, R. M. (1951). J. Anim. Sci. Vol. **10** No. 3 P.768.
KOCH, R. M., and CLARK, R. T. (1955a). J. Anim. Sci. Vol. **14** No. 3: 775.
KOCH, R. M., and CLARK, R. T. (1955b). J. Anim. Sci. Vol. **14** No. 2: 386.
KOCH, R. M., GREGORY, K. E., INGALLS, J. E., and ARTHAUD, R. L. (1959). J. Anim. Sci. Vol. **18** No. 2: 738.
KOGER, M., and KNOK, J. H. (1951). J. Anim. Sci. Vol. **10** No. 3: 760.
KOHLI, M. L., and SURI, K. R. (1957). Indian J. Vet. Sci. Vol. **27**: 33–38.
KONOPIŃSKI, T., and KOTLIŃSKI, J. (1951). Roczn. Nauk rol., 53: 28–50 (Abs. in Anim. Breed. Abstr. Vol. **19** No. 2: 187).
KORTSTEE, G. J. J. (1963). Overdruk uit „Veeteelt en Zuivelberichten" (Uitgave Ministerie van Landbouw en Visserij). 6e jaargang no. 3, maart 1963, pag. 88 t/m 97.
KRASNOV, K. E. and PAK, D. N. (1939). Abs. in Anim. Breed. Abstr. Vol. **7**: 108.
KUSNER, H. F. (1936). Abs. in Anim. Breed. Abstr. Vol. **4**: 412.
LANGLET, J. F. (1962). (NATO). Third summer course on organization and evaluation of animal producten in larger areas. (August 27–September 8, 1962).
LAZARUS, A. J., and ANANTAKRISHNAN, C. P. (1952). Indian J. Dairy Sci., **5**: 9–24.
LAZARUS, A. J., and RANGASWAMY, M. C. (1950). Indian J. Dairy Sci., **3**: 46–51.
LILLIE, R. D. (1954). „Histopathologic Technic and Practical Histochemistry".
LOCKART, L. W. (1955). Austr. J. Agric. Res. Vol. **7** No. 2: 152.
MACDONALD, M. A. and BOGART, R. (1955). N.Z.J. Sci. Tech., Agric., **36**: 460–469.
MAHADEVAN, P. (1953). Emp. J. Exp. Agric., **21**: 55–60.
MÄKELÄ, A. and OITTILA, R. (1956). Maataloust. Aikakausk., 27: 77–84. (Abs. in Anim. Breed. Abstr. Vol. **24** No. 1: 30).
MAMMERICKX, M. (1962). Publ. Inst. Nat. Agron. Congo, Sér. tech., No. 64: 97 PP. (Abs. in Anim. Breed. Abstr. Vol. **30** No. 3: 324).
MARTIN, T. G. (1956). Lowa St. Coll. J. Sci., **30**: 412–413.
MARTIN, T. G., JACOBSON, N. L., MC. GILLIARD, L. D., and HOMEYER, P. G. (1952). J. Dairy Sci. Vol. **45**: 886–892.
MASON, I. L. (1962). (NATO) Third summer course organisation and evaluation of animal production in larger areas. (August 27–September 8, 1962).
MC CANDLISH, A. C. (1922). J. Dairy Sci. Vol. **5** No. 3: 301.
MONTSMA, G. (1962). Trop. Agriculture (Trin.) **39**: 123–129 (Abstr. in Anim. Breed. Abstr. Vol. **30**: 328).
MÜNOZ, M., and RIGOR, T. V. (1941). Philipp. J. Anim. Industr., **7**: 263–267. (Abs. in Anim. Breed. Abstr. Vol. **9** No. 1: 9).
NELMS, G. E., and BOGART, R. (1956). J. Anim. Sci. Vol. **15** No. 3: 662–666.
NEVILLE, W. E. (JR.) (1962). J. Anim. Sci. Vol. **21** no. 2: 315–320.
PAHNISH, O. F., STANLEY, E. B., BOGART, R. and ROUBICEK, C. B. (1961). J. Anim. Sci. Vol. **20** No. 3: 454.
PETROVIC, V. (1956). God. poljopr- Fak. Zemun (Beograd), No. 4: 363–374. (Abs. in Anim. Breed. Abstr., Vol. **24** No. 4: 353).
PILKINGTON, J. M., and PURSER, A. F. (1958). J. Agric. Sci. Vol. **51** No. 3: 257.
PRENTICE, E. (1936). Hoard's Dairyman, 81: 120 (Cited by HOLTZ *et al.* 1961).
RENDEL, J. M. (1954). Austr. J. Agric. Res. Vol. **5** No. 2: 297.
ROLLINS, W. C. and GUILBERT, H. R. (1954). J. Anim. Sci. Vol. **13** No. 2: 517.
ROLLINS, W. C., LABEN, R. C., and MEAD, S. W. (1956). J. Dairy Sci. Vol. **39**: 1578–1593.
ROMEIS, B. (1943). „Taschenbuch Der Mikroskopischen Technik". 14th Edition.
RUZEVSKÜ, A. B., and MALOVA, E. A. (1940). Probl. Zivotn., no. 4: 48–58 (Abs. in Anim. Breed. Abstr., Vol. **8** No. 1: 22).
SCHINCKEL, P. G. (1958). Austr. J. Agric. Res. Vol. **9** No. 4: 567.

SCHLEGER, A. V., and TURNER, H. G. (1960). Austr. J. Agric. Res. Vol. **11** No. 5: 875.
SCHMIDT, E. (1953). Bodenkult Vet. Med., Giessen 30 PP (Abs. in Anim. Breed. Abstr., Vol. **21** No. 2: 147).
SIGNORET, J. P., POLY, J., and VISSAC, B. (1957). Ann. Zootech. (Paris), 5: 273–294 (Abs. in Anim. Bteed. Abstr., Vol. **25** No. 3: 269).
SINGH, R. S., and RAY, S. N. (1961). Indian J. Dairy Sci. **14**: 1–7.
SLAGSVOLD, P., and AAMDAL, J. (1956). Tidsskr. Norske Landbr., 63: 10–20 (Abs. in Anim. Breed. Abstr., Vol. **24**: 354).
SMIRNOV, A. (1960). Mol. mjasn. zvotn., 4 (10): 45–48. (Abs. in Anim. Breed. Abstr., Vol. **28**: 31).
SOMMER, O. A. and KRIPPEL, J. (1961). Bayerisches Landwirtschaftliches Jahrbuch, 4, 417 (Cited by KORTSTEE, 1963).
SNEDKOOR, G. W. (1946). „Statistical Methods" The Iowa State College Press, Ames, Iowa, U.S.A.
STEGENGA, TH. (1960). Seventh Study meeting of the European Association for Animal production Stockholm, June 7–11.
STEGENGA, TH. (1961). Overdruk uit „Veeteelt- en Zuivelberichten", 4e jaargang no. 9, September 1961, Pag. 319 t/m 323.
STEGENGA, TH. (1964). Tijdschr. voor Diergeneeskunde, januari 1964.
SWIGER, L. A. (1961). J. Anim. Sci. Vol. **20** No. 1: 183.
TANTAWY, A. O., and AHMED, I. A. (1955). Alexandria J. Agric. Res., 3 (2): (13 PP).
TIDBURY, G. E. (1954). E. Afr. agric. J., 19: 219–224.
TSATSKIN, H., ANGEL, H. (1953). Thesis, Kansas State College Library, Manhattan, Kansas (Cited by ANGEL and POLY, 1956).
TURNER, H. G. (1962). Austr. J. Agric. Res. Vol. **13** No. 1: 180.
TURNER, H. G., and SCHLEGER, A. V. (1960). Austr. J. Agric. Res. Vol. **11** No. 4: 645.
TYLER, W. J., CHAPMAN, A. B., and DICKERSON, G. E. (1947). J. Dairy Sci. Vol. **30**: 483.
VEIGA, J. S., ANDREASI, F., and CHIEFFI, A. (1951). Bol. Industr. Anim. N.S. 11 (314): 31–40 (Abs. in Anim. Breed. Abstr., Vol. **19** No. 4: 452).
VEIGA, J. S., CHIEFFI, A., and ABREU, J. (1950). Publ. Inst. Zootec. (Rio de J.), No. 1: 48 PP. (Abs. in Anim. Breed. Abstr., Vol. **18** No. 3: 262).
VENGE, O. (1949). Nord. Jordbr. Forskn., (718): 208–224 (Abs. in Anim. Breed. Abstr., Vol. **17** No. 3: 232).
VIANNA, A. T., and DE MIRANDA, R. M. (1950). Publ. Inst. Zootec. (Rio de J.). No. 2: 31 PP. (Abs. in Anim. Breed. Abstr., Vol. **18** No. 3: 262).
VILLARES, J. B., and DE ABREU, J. (1951). Bol. Industr. Anim. N.S., **10**: 30–40 (Abs. in Anim. Breed. Abstr., Vol. **19** No. 1: 64).
VSJAKIH, A., and BOROZDINA, A. (1957). Mol. mjason, Zivotn., 1956 (9): 40–45 (Abs. in Anim. Breed. Abstr., Vol. **25** No. 2: 138).
WORSTELL, D. M., and BRODY, S. (1953). Res. Bull. Mo. Agric. Exp. Sta. No. 515.
YEATES, N. T. M. (1955). Austr. J. Agric. Res. Vol. **6** No. 6: 891.
YEATES, N. T. M. (1957). Austr. J. Agric. Res. Vol. **8** No. 6: 733.