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A Study of Lamb Mortality in the Michigan State College Flock

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Ganapathy Venkatachalum

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R. H. Nelson
Major professor

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A STUDY OF LAMB MORTALITY IN THE MICHIGAN STATE COLLEGE FLOCK.

By

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A THESIS

Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

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1. Dr. R. H. Nelson, Ph.D., Associate Professor, Animal Husbandry Section, Michigan State College.
2. Dr. F. J. Thorp, Ph.D., Research Professor, Animal Pathology Section, M. S. C.

INTRODUCTION.

It is in order to explore the possible hereditary causes of the high rate of lamb mortality in the Michigan State College Flock that the author has made earnest attempts while compiling this material. From the results of 700 autopsies performed by Dr. L. B. Scholl, during 15 years (up to 1939), it has been noted that parasitism and feeding problems constituted the chief factors of loss in sheep raising in Michigan, as a whole. But, to-day, under strict sanitation and a well-balanced system of feeding and careful management, the shepherd is confronted not with feeding problems but with actual breeding problems.

A study of the previous autopsies done by Dr. L. B. Scholl reveals that pneumonia has taken a heavy toll of sheep losses; and at least one case of patent foramen ovale has been recorded. The present analysis deals only with lamb mortality, excluding sheep. From a more detailed post-mortem examination and recordings done during 3 years (1945 to 1947) by Dr. F. J. Thorp, and his assistant, Mr. M. L. Gray, of the Animal Pathology Section, it has been possible to show a definite cause of congenital abnormalities as a main factor for heavy lamb loss. The abnormalities include patent foramen ovale of the heart, freaks and still-births. Some deaths are also attributed to undetermined causes. So, this analysis leads to the conclusion that, besides the various causes already known, heredity also plays an important role in lamb mortality.

REVIEW OF LITERATURE

Foetal circulation.

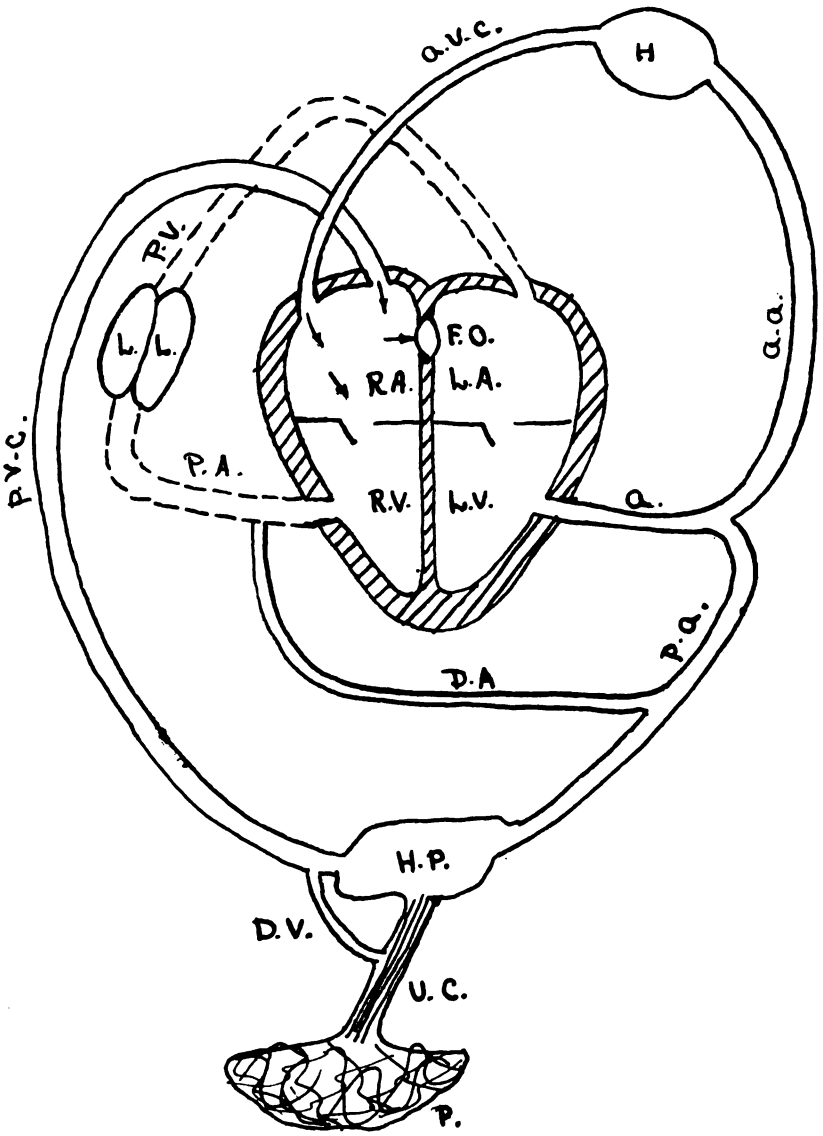


Figure 1.

EXPLANATION for Figure 1.

R. A. = Right Atrium (Right Auricle).

R. V. = Right Ventricle.

L. A. = Left Atrium (Left Auricle).

L. V. = Left Ventricle.

F. O. = Foramen Ovale (Via Sinistra).

P. A. = Pulmonary Artery.

L. = Lungs (Right and Left).

P. V. = Pulmonary Vein.

D. A. = Ductus Arteriosus.

a. = aorta.

a.a. = anterior aorta.

p.a. = posterior aorta.

H. = Head of the Foetus.

a.v.c. = anterior vena cava.

H. P. = Hind Parts of the Foetus.

p.v.c. = posterior vena cava.

D. V. = Ductus Venosus.

U. C. = Umbilical Cord (Navel cord).

P. = Placenta.

Placenta formed by the maternal and foetal membranes is the foetal organ of nutrition, respiration and excretion.

Umbilical cord (Navel cord) consists of 2 umbilical arteries, 2 umbilical veins, the allantoic duct (urachus) and many small blood vessels - all covered up by the Whartonian jelly-like connective tissue.

It is important to note that the Eustachian valve is absent in the foetal heart of lamb. Although the anterior and posterior vena cavae carry blood respectively from head and hind parts of the foetus, they pour into right atrium where a mixing of blood is said to take place. Later on, a portion of the mixed blood is directed into left atrium via the Foramen ovale, and the other portion into right ventricle through the right auriculo-ventricular opening.

In the adult circulation, the foramen ovale closes, the ductus arteriosus and ductus venosus obliterate; and hence, these are all rendered functionless after the severance of umbilical cord and placenta at birth. This is what happens in the case of normal circulation.

Persistency of Ductus Arteriosus.

A knowledge of the closure of ductus arteriosus throws light on the normal and abnormal conditions of the latter. The closure of ductus arteriosus is said to occur in two different stages (Barclay, Franklin and Prichard, 1945).

1. Physiological occlusion takes place very soon after birth. This is called the Functional closure.
2. Anatomical occlusion requires a very considerable time for its completion. This is called the Anatomical closure.

Ductus Arteriosus closes at least functionally after birth - 4 minutes after ligation of the umbilical cord. Failure to ligature the cord delays the closure of the ductus. However, the functional closing is immediate within 3 hours. The anatomical obliteration takes place more leisurely in three months of life (Smith, C. A., 1945). The closure is not effected by any nerve pathway or neuromuscular reflex but it is due to the sphincter action of the intima layer. Immediate closure is due to increased oxygenation of foetal blood. So, a period of postnatal anoxia is suspected cause of patent ductus arteriosus. Since the ductus is more muscular with a potential sphincter the closure may be due to muscular effect rather than neuromuscular one.

A ductus closed for only a short time (as shown by X-ray) may be found to be open post-mortem. If the foetus deteriorates a closed ductus may reopen. However, in a healthy foetus, the closure is rapid, complete and lasting.

Patency of Foramen Ovale.

It has already been mentioned that there is no Eustachian valve in the foramen ovale of the foetal heart of a lamb; and even a projection that some writers have taken for the rudiment of this valve proves, on probing from the outside, to be nothing but a slight infolding of the wall. "Guy ropes" (free borders of cords) are a characteristic feature of foramen ovale in lamb's heart. This structure favours a mechanical rather than the neuromuscular process for the closure of foramen ovale. Closure is due to increased pulmonary venous return induced by the onset of respiration. It has been observed that foramen ovale can close before the cord is tied and while the ductus arteriosus is still patent. Closure of the ductus follows

the closure of foramen ovale, cessation of the placental circulation being a necessary preliminary (Barclay, Franklin and Prichard, 1945).

The closed foramen ovale may reopen after some time if the foetus deteriorates but in a healthy foetus, the process is rapid and the effect permanent. The heart attains its postnatal functional independence usually after the closure of foramen ovale and ductus arteriosus. If the umbilical vessels do not close down at, or soon after birth the lamb will die. Patency of foramen ovale or of the ductus arteriosus may have a very serious consequence such as predisposition to pneumonia and bacterial endocarditis.

NOTE: In man, the continued patency of ductus arteriosus for years after birth is a common occurrence but the condition predisposes toward bacterial endocarditis and is in itself a danger because of the additional load placed upon the left ventricle which may lead to cardiac decomposition (Windle, W. F., 1940).

Lamb Loss in Other Flocks.

A study was made of the 25 years of records on the flocks kept by the Ohio Agricultural Experiment Station (Bell, 1947). These records were quite complete in that they included a lamb mortality record in addition to the usual ones kept in a modern barn. During the past 25 years much attention had been given to the feeding and nutrition of the pregnant and nursing ewes; and deliberately the nutritional influences had been eliminated as a cause of mortality.

Then, during the ten year period from 1935 to 1944 inclusive, an analysis was made to study the loss of foetuses which failed to survive. The barn consisted of both purebred and grade sheep which were

classified into fine wool breed and mutton breed. A total of 1,309 pregnancies occurred resulting in the development of 1,702 foetuses. By the time the lambs averaged two months of age, 1,374 lambs were surviving. Altogether, 328 foetuses failed to survive. Roughly, one out of every five foetuses carried was either aborted, born dead, or died within the first two months after birth. The mortality rate was 19.27 per cent. It is interesting to note here that the mortality rate of lambs 2 months old in the M. S. C. Flock is 28.57 per cent. Over-all mortality appeared to be the collective effect of numerous causes.

Under their analysis it was clear that a relatively small percentage of the ewes contributed a high percentage of the total mortality. Certain individual ewes were found which consistently yeaned and reared a single or a pair of twins each year, and made no contribution whatever to the mortality table. Some ewes consistently lost each successive lamb born to them. Some were very irregular in ability to yean and rear offspring each year. Likewise, certain individual rams might be getting progeny which showed high mortality or high livability. Many of the factors for livability or its converse, high infant mortality - are inheritable. Unfortunately, the identity of the genes responsible for inherited (?) mortality among the lambs and the mode and manner of their inheritance are not made clear by their analysis.

Each death which occurred among the little lambs was classified under two headings. One was called "Death-causing factors totally unrelated to possible inheritance," and the other, "Death-causing factors which appear to be closely allied with inherited weakness." Under this grouping it was found that in Flock A, 75 per cent of the mortality

traced to factors which had the aspect of being inherent weakness, while 25 per cent of the mortality arose from factors totally unrelated to any inheritance. In Flock B, the figure was 72 per cent related to inherent weakness, with 28 per cent totally unrelated to inheritance. Assuming that the foregoing is a correct analysis the greatest hope for a reduction in the number of infant deaths among little lambs lies mainly and plainly in BREEDING.

SURVEY OF THE SHEEP FLOCK.

Analysis of Lamb Crop.

The M. S. C. sheep flock consisted of six breeds, namely: Shropshire, Hampshire, Oxford, Rambouillet, Southdown and Cotswold, in the years 1945 and 1946, and five breeds in 1947, without any Cotswold. The number of ewes in each breed varied considerably between 4 and 40 in any one year, and between 20 and 110 in all the three years put together. These unequal numbers in the various breeds made some of the statistical calculations very discouraging and the interpretation of the results very cautious especially for significance test between breeds, as far as lamb mortality was concerned. However, it was found that a high mortality rate occurred in Cotswold, Oxford and Hampshire breeds than in Shropshire, Southdown and Rambouillet.

During the three year period (1945-1947), the flock had 312 ewes, which dropped 483 lambs out of which only 337 survived. This gives a lamb crop of 108.01 per cent raised. In spite of the good care and management as well as good feeding, the lamb mortality is as high as 30.22 per cent, which draws the attention of every animal husbandman to check it as soon as possible.

The age of lambs at the time of death varied up to 8 months. See Table II. The highest mortality occurred within a fortnight after birth. As the age advanced, the death rate decreased. In other words, the lamb mortality is highest at, or soon after birth. However, about 95 per cent of the lambs died within 2 months of age. Only 8 out of 146 lambs died between 2 and 8 months of age. Excluding these 8 lambs which were over 2 months old, the over-all mortality rate comes down from 30.22 per cent to 28.57 per cent which is still high.

Tables I, II and III give the detailed figures of the number of ewes and lambs born and dead for the three years. The gist of the tables runs as follows:

Total number of ewes	= 312
Total number of lambs born	= 483
Total number of lambs died	= 146
Total number of lambs raised	= 337

Therefore,

Lambs dropped	= 154.87%
Lambs raised	= 108.01%
Lamb mortality	= 30.22%
Lamb mortality 2 months old	= 28.57%

Table I

ANALYSIS OF LAMB CROP.

Breeds	Total number for 3 years (1945-1947)			Over-all Mortality
	Ewes	Lambs born	Lambs died	
Shropshire	110	160	31	19.37%
Hampshire	76	120	48	40.00%
Oxford	46	75	31	41.33%
Rambouillet	38	61	14	22.95%
Southdown	20	34	7	20.58%
Cotswold	22	33	15	45.45%
Total	312	483	146	30.22%

Table II

AGE OF LAMBS AND MORTALITY RATE.

Breeds	Number of Lambs for 3 years (1945-1947)			
	Premature to 15 days	Over 15 days to 1 month	Over 1 month to 2 months	Over 2 mo. to 8 mo.
Hampshire	34	8	4	2
Shropshire	25	4	2	0
Oxford	24	1	4	2
Rambouillet	7	4	0	3
Southdown	6	1	0	0
Cotswold	8	2	4	1
Total	104	20	14	8
Mortality %	71.23	13.70	9.59	5.48

Lamb Mortality up to 1 month of age = 84.93%

Lamb Mortality up to 2 months of age = 94.52%

Table III

ANALYSIS OF LAMB CROP BY YEARS.

Breeds	Number of Ewes			Number of Lambs born			Number of Lambs died		
	1945	1946	1947	1945	1946	1947	1945	1946	1947
Shropshire	32	38	40	53	57	50	17	8	6
Hampshire	25	27	24	40	44	36	19	13	16
Oxford	16	15	15	25	21	29	10	8	13
Rambouillet	14	16	8	26	22	13	5	6	3
Southdown	4	7	9	6	12	16	2	4	1
Cotswold	10	12	0	14	19	0	8	7	0

Year Variation.

An earnest attempt was made to find out if there was any environmental change from year to year, which might contribute to the causes of lamb mortality. The Cotswold breed which was extinct in the flock in 1947 was excluded for this calculation. The over-all mortality rate of all the other breeds for three years separately has been worked out in detail as shown in Table IV. The significance test was run and the "t" value for three pairs of years calculated. Between 1945 and 1946, the "t" value is 1.97, which is statistically slightly significant.[1] Between 1946 and 1947, the "t" value is 0.41, which is non-significant. Between 1945 and 1947, the "t" value is 1.54, which is not significant.

From the practical point of view the above "t" values are of no significance, at all. Obviously, the environmental factor has impartially played the same role in lamb mortality in each of the three years.

1. R. A. Fisher.

Table IV

YEAR VARIATION.

Breeds	Number of Lambs born			Number of Lambs died			Mortality %		
	1945	1946	1947	1945	1946	1947	1945	1946	1947
Hampshire	40	44	36	19	13	16	47.50	29.54	44.44
Shropshire	53	57	50	17	8	6	32.07	13.93	12.00
Oxford	25	21	29	10	8	13	40.00	38.09	44.82
Rambouillet	26	22	13	5	6	3	19.23	27.27	23.07
Southdown	6	12	16	2	4	1	33.33	33.33	6.25
Cotswold	14	19	0	8	7	0	57.14	36.84	0.00
Total	164	175	144	61	46	39	37.19	26.28	27.08
Total excluding Cotswold	150	156	144	53	39	39	35.33	25.00	27.08

Individual Sire Effect.

Some flockmen are of the opinion that certain rams carry simple recessive lethal factors which contribute to the high rate of mortality, and that if these rams are culled from the flock, then the percentage of lamb loss can be reduced considerably (Bell, 1947). This sounds logical and practically useful, too. But, the present analysis which is clearly illustrated in Table V is rather discouraging and misleading to draw any conclusion on account of the very varying period for which the sires are kept in the flock. For example, a ram sires only two lambs, both of which survive, and then, the ram is not in the flock for some reason or other. The individual effect of such a sire cannot be measured unless and until its further progeny is examined. So, the attempt made to measure the effect of the individual sire has not given any satisfactory result.

Table V

INDIVIDUAL SIRE EFFECT.

Sire		Lambs born	Lambs died	Mortality %
Hampshire.	146801	65	~~74~~ 28	43.07
	193741	13	9	69.23
	179467	5	2	40.00
	209446	17	1	05.88
	217886	6	4	66.66
	Brown Ram	14	4	28.57
	Total	120	48	40.00
Shropshire.	915756	64	16	25.00
	866190	39	8	20.51
	M52072	7	1	14.28
	M2104	50	6	12.00
	Total	160	31	19.37
Oxford.	176611	39	15	38.46
	181700	7	3	42.83
	187077	29	13	44.82
	Total	75	31	41.33
Rambouillet.	436046	59	14	23.72
	463185	2	0	00.00
	Total	61	14	22.95
Southdown.	143967	18	6	33.33
	167089	9	1	11.11
	Goods	7	0	00.00
	Total	34	7	20.58
Cotswold.	122300	14	8	57.14
	125111	17	6	35.29
	125096	2	1	50.00
	Total	33	15	45.45
Grand Total		483	146	30.22

Sex Difference.

Although both the ram lamb and the ewe lamb suffered a tremendous loss in the flock it was pertinent to know which sex suffered more and if there was any significant difference between the two sexes. Accordingly, a list was prepared showing the necessary figures in Table VI and a significance test was run. Sex of four lambs could not be determined because of freaks and mummified foetuses and hence, they have been excluded for the calculations. 92 males died out of a total of 268 ram lambs resulting in 34.32 per cent mortality whereas only 50 females died out of 211 ewe lambs, making a mortality of 23.69 per cent.

The "t" value between male and female was calculated to be 2.58, which is highly significant.[1] So, there is apparently a real difference between male and female mortality - males suffering more than females.

If, for any reason, one sex is weaker than the other during the early stages of development that sex will suffer a higher mortality, and the sex ratio will be altered. Sex-linked lethals are a cause of some upsets in the expected sex ratio. Here, the males suffer a higher mortality at birth, and the sex ratio is altered. However, the sex ratio tends to be 50:50 as the age advances.

	Males	Females
Sex Ratio at birth	126.3	100
Sex Ratio at 8 months of age	109.2	100

1. R. A. Fisher.

Table VI

SEX DIFFERENCE.

Breeds	Number of Lambs born		Number of Lambs dead	
	Male	Female	Male	Female
Hampshire	73	46	34	13
Oxford	38	36	16	14
Rambouillet	35	26	8	6
Shropshire	87	72	21	9
Southdown	15	19	3	4
Cotswold	20	12	10	4
Total	268	211	92	50

NOTE: Sex of 4 lambs could not be determined because of freaks and mummified foetuses, and hence, they have been excluded.

Male mortality = 34.32%

Female mortality = 23.69%

"t" value = 2.58**

Single and Multiple Birth Difference.

It was believed that ewes had more lamb loss and trouble when they had twins or triplets rather than single births. This belief was confirmed by the actual calculation of mortality rate in both single and multiple births. The multiple births include mostly twins, and a few triplets. The following Table VII gives a detailed analysis. The single birth mortality is only 20.12 per cent when compared with the multiple birth mortality which is as high as 34.95 per cent. The "t" value between these two is 3.56, which is very highly significent. Evidently, the loss is more in multiple births than in single.

Table VII

SINGLE AND MULTIPLE BIRTH DIFFERENCE.

Breeds	Number of Lambs born		Number of Lambs dead	
	Single Birth	Multiple Birth	Single Birth	Multiple Birth
Hampshire	34	86	10	38
Oxford	22	53	7	24
Rambouillet	18	43	2	12
Shropshire	63	97	8	23
Southdown	6	28	1	6
Cotswold	11	22	3	12
Total	154	329	31	115

Single birth mortality = 20.12%

Multiple birth mortality = 34.95%

"t" value = 3.56**

POST-MORTEM FINDINGS.

Open Foramen Ovale.

As a routine, in the post-mortem examination of all the dead lambs, the foramen ovale of the heart and the ductus arteriosus have been observed with scrupulous care. In some, the foramen ovale is found to be partially or completely open. When it is partially open it is covered by many strands of connective tissue, which shows that it tends to close or that it reopens at autopsy. In some, it is distinctly patent showing no tendency to close, which means that the patency is not due to reopening. In the like manner, the ductus arteriosus is open but constricted in some; and in others it is distinctly patent. However, it is only the foramen ovale that is seen wide open even after several days.

This condition has been observed in all breeds of lambs ranging in age from zero to 55 days. The following are a few of the recorded cases showing a distinct patency of foramen ovale with no tendency to close. These cases show their ductus arteriosus well obliterated.

In 1945, a Hampshire ram lamb No. 74, born twinned, died of pneumonia with a patent foramen ovale at the age of 55 days which is the longest period recorded in this college up to June 18, 1947.

In 1945, a Shropshire ram lamb No. 9, died of pneumonia with foramen ovale wide open at the age of 54 days.

In 1945, a Shropshire ram lamb No. 22, born twinned, died of pneumonia when it was 31 days old. A distinctly open foramen ovale was observed.

In 1947, an Oxford ewe lamb No. 361, born twinned, died of pneumonia and enlarged Thyroid gland at the age of 33 days. Open foramen ovale was noticed.

In 1947, a Hampshire ewe lamb, Notch No. 5, born twinned, died of undetermined cause at the age of 32 days when it exhibited open foramen ovale.

Freaks.

In 1945, a Hampshire ewe No. 100-42, produced a monster ewe lamb which died at birth.

In 1946, a Southdown ewe No. 137, produced a lamb "cyclops" with one eye; two eyes fused into one orbit which was unusually located midway between nose and mouth. Nose was long and pendulous. This freak was twinned with a normal ram lamb.

In 1946, a Cotswold lamb Notch No. 13, was an anomaly of nature born with five legs. Born dead. The additional foot came from the right side of the body at the junction of rib and abdominal wall.

Other abnormalities such as Premature birth, Still-birth, Mummified foetus and lambs born with Parrot mouth have been recorded. A few cases of congenital haemorrhage around umbilicus have resulted in immediate death. Very weak lambs unable to stand up have been born, and they died soon.

Possible Inherent Causes.

The various causes of lamb loss have been classified into two groups, namely, the inherent causes and the non-inherent causes, the former group comprising cases of all freaks, still-births, weakness,

undetermined causes, patent foramen ovale and pneumonia suspected to be due to patent foramen ovale. This group accounts for 65.06 per cent of the total lamb loss, which means that some hereditary factor such as a simple Mendelian recessive may be a possible inherent cause of lamb mortality. 40 per cent of the total inherent causes are due to patent foramen ovale with or without pneumonia complication. The non-inherent group of causes includes deaths of injury, accidents, pneumonia, enterotoxaemia due to overeating, bacteraemia, navel infection and coccidiosis, which account for 34.94 per cent of over-all mortality.

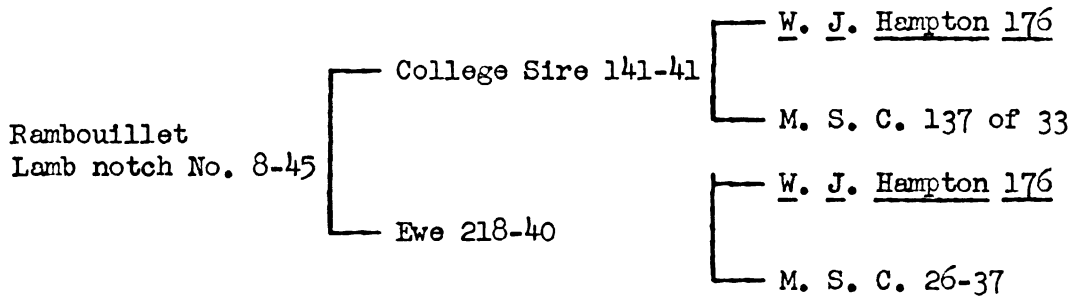
The following table illustrates the various percentages of inherent causes.

Total number of Lambs died	146
Number of Lambs died of possible inherent causes .	95
Number of Lambs showing open foramen ovale	38
Inherent Mortality Rate.	65.06%
Mortality due to open foramen ovale.	26.02%
Open foramen ovale alone	40.00% of the total inherent causes.

Tracing of Pedigrees.

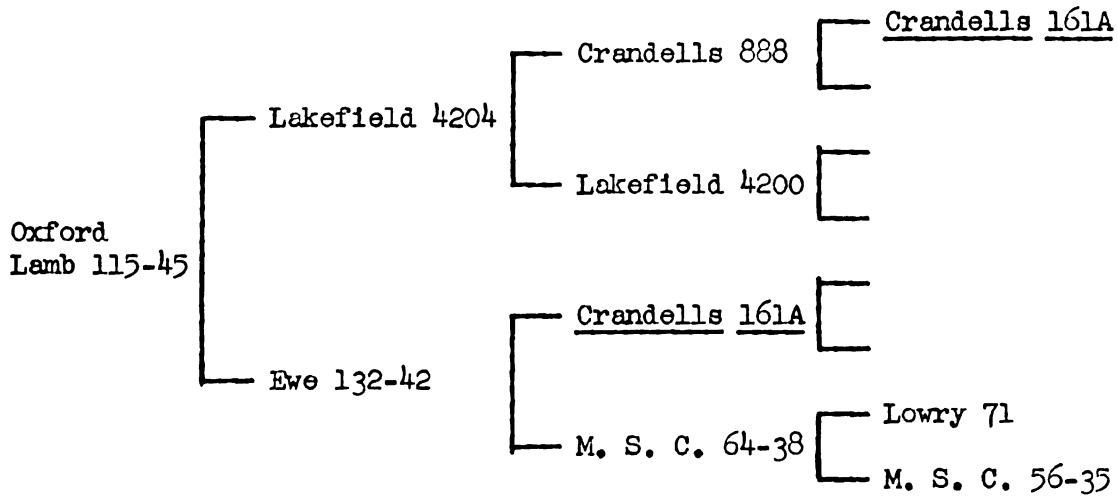
The idea that some of the congenital defects might be due to the practice of inbreeding led to the tracing of the pedigrees of suspected cases. The tracing of pedigrees was not very satisfactory, nor did it help in solving the problem of lamb loss since similar results were observed where there was no inbreeding at all. Vide pedigrees 1, 2, 3 and 4. A lot more work has yet to be done before arriving at a conclusion to this phase of the problem.

PEDIGREE 1.



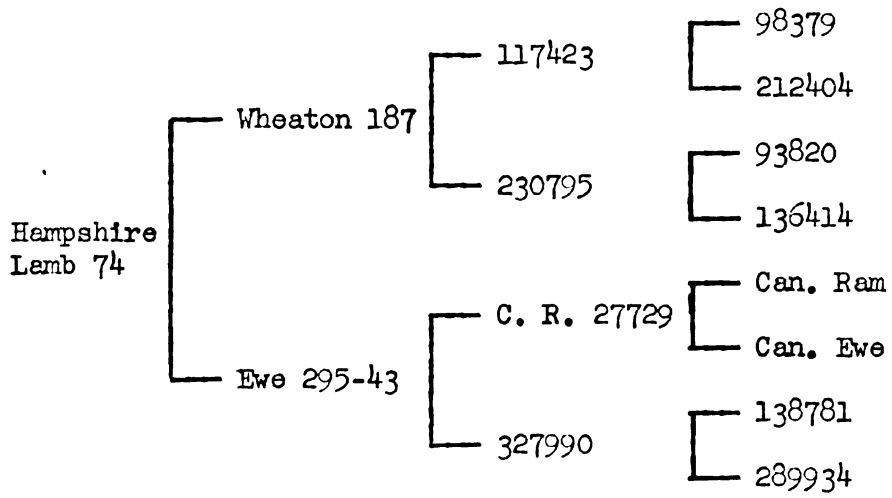
NOTE: This lamb was a ram lamb born as a triplet and died at the age of 18 days showing the patent foramen ovale as the only lesion. Fx = 12.5

PEDIGREE 2.



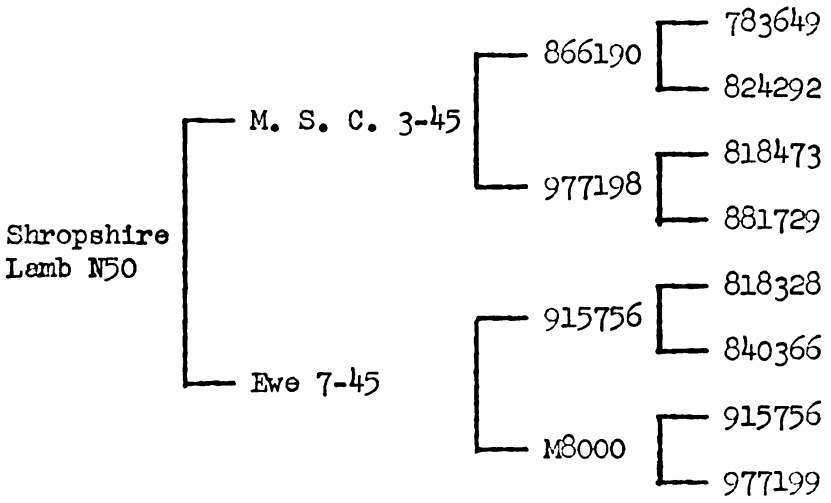
NOTE: This lamb was an ewe lamb born twinned; and died of pneumonia with a patent foramen ovale when 14 days old. The pedigree is not complete. Fx = 6.25

PEDIGREE 3.



NOTE: This was a ram lamb born twinned with a normal fellow; and died of pneumonia and broken ribs when 55 days old still showing the patency of foramen ovale. There was no inbreeding.

PEDIGREE 4.



NOTE: This was an ewe lamb born single, which died of weakness as the cause when 3 days old. There was no inbreeding as far as the pedigree extended. Foramen ovale and ductus arteriosus were both open because of young age.

DISCUSSION.

From the review of literature it has been noted that the foramen ovale can close before the navel cord is tied and while the ductus arteriosus is still patent. It is further said that the ductus can remain open as long as three months of life, but not the foramen ovale. Closure of the ductus follows the closure of foramen ovale. On the contrary, the reverse has been observed, that is, while the ductus is closed the foramen ovale is found wide open at a varying period of one to 55 days. This condition is definitely something unusual, and it calls for further investigation. There is also an apparent correlation between patent foramen ovale and pneumonia which condition invariably results in death. Patency of foramen ovale as late as 55 days of age cannot be considered normal unless it is proved so by further work on this line, which is possible in some of the slaughter houses where a large number of hearts of lambs of different ages would be easily and cheaply accessible to investigation.

Among the congenital abnormalities are found some freaks such as cyclops, five-footed lamb, monstrosity, parrot-mouth and mummified foetus which may well be attributed to a lethal factor. The possible inherent causes account for 65.06 per cent of mortality which means that hereditary factor plays a greater part than environmental factor in lamb mortality. This view is further evidenced by the fact that there is no significant year-to-year variation in the mortality rate. The belief that the practice of inbreeding might be responsible for the congenital defects has been proved inconclusive by the tracing of pedigrees, for you get almost the same results regardless of inbreeding or otherwise.

However, an intensive work on this line is yet to be done either to prove or disprove the point at issue.

The survey of the flock shows that too many breeds with unequal numbers in the classes are not quite desirable to do any more work on this line than what has already been dealt with herein. There seems to be breed difference in mortality rate. The Cotswold, Oxford and Hampshire breeds have all suffered twice as much as Shropshire, Southdown and Rambouillet have. So, it seems possible to have a more profitable flock by keeping a few selective breeds only. The sex difference reveals the truth that males fall an easier victim to nature than females. The ewes that give birth to twins or triplets are more handicapped than those that lamb single.

In general, this analysis mostly agrees with and slightly differs from the report on "Dead Lambs Do Tell Tales," by D. S. Bell, Ohio Agricultural Experiment Station. The most startling thing about lamb mortality is that no one cause stands out to be mainly responsible for death; and the over-all mortality appears to be the collective effect of numerous causes. The present work shows that 65.06 per cent of the mortality is due to the possible inherent causes, which is not very far from Bell's figure which is 75 per cent of the mortality traced to inherent factors.

According to his report, a relatively small percentage of the ewes contributed a high percentage of the total mortality. This is true in the case of the M. S. C. flock, because certain ewes yeaned and reared a single or pair of twins each year contributing nothing to the mortality table. For example, a Hampshire ewe No. 73-39 has raised 10 lambs without any loss for a continuous period of 7 years from 1941 to 1947.

However, there is great difficulty and danger, as well in selecting or culling ewes on this basis because some ewes are very irregular in their ability to yean and rear offspring each year - one year a living lamb, the next year a dead one. A few ewes give birth to twins successfully for two successive years and then, they start aborting or dropping weak lambs since third pregnancy, and vice versa. Individual rams might be getting progeny which show high mortality or its converse, high livability which is inheritable, but it is not made clear by this analysis. However, the indications are that disposition to abort, yean still-borns, drop deformed lambs, throw lambs of low vigour, and "get" ewes which show poor milk production, which lack mothering instinct, even to the case of consistently "over-laying" their lamb, have the aspect of being inheritable defects (Bell, 1947). Granting that this analysis is correct, there is a great hope for reduction of lamb loss by proper breeding.

SUMMARY AND CONCLUSIONS.

1. A study was made of the post-mortem reports of 146 dead lambs of six different breeds in the M. S. C. flock.
2. Patent foramen ovale as late as 55 days of age has been recorded in a Hampshire ram lamb which invariably died of pneumonia.
3. Patency of foramen ovale in 40 per cent of the total mortality due to inherent causes is suggestive of some congenital abnormality in the foetal heart of lamb, which may predispose toward pneumonia.
4. The lamb mortality rate in the M. S. C. flock is 30.22 per cent; and the possible inherent causes contribute to 65.06 per cent of that mortality.
5. There is no significant year-to-year variation in the mortality rate.

6. Although the lambs dropped is 154.87 per cent, the lamb crop is only 108.01 per cent.
7. Cotswold, Oxford and Hampshire breeds have each suffered almost double the loss experienced by Shropshire, Southdown or Rambouillet.
8. More of ram lambs than of ewe lambs have significantly contributed to mortality rate; male mortality being 34.32 per cent, and female mortality 23.69 per cent.
9. Again, the loss is more in multiple births than in single births. Twin mortality is as high as 34.95 per cent, and single mortality 20.12 per cent.
10. Tracing of pedigrees of some lambs is inconclusive to show that the practice of inbreeding has any effect on lamb mortality.

If the lamb mortality rate is high and if the shepherding is good and the feed is adequate the indications are that the flockmaster has a breeding problem (Bell, 1947).

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