The Environmental Factors on the Lamb Growth, Analytically Studied with Extra-Seasonal-Lambs

I. Extra-Seasonal-Production of Lambs by Artificial Light Treatment

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(Tables 1-9; Text-figs. 1-3; Plate 1)

(I) INTRODUCTION

In recent years many articles have been published on the environmental factors affecting the sheep production, with special reference to climatic effects, and many comprehensive reviews have been written by COOP (1950), HAFEZ (1954), WRIGHT (1954), FINDLAY (1954) and YEATES (1954) on the temperature, humidity and light affecting the sheep breeding and wool production. The Corriedale ewes in Japan do not come in breeding season until late August, and cease to do so some time in late winter, January to February.

As the period of the year during which ewes will be lambing is mainly restricted in spring, February to May, the climatic effects are confused with the effects by inherent factors in the general pattern of lamb growth.

In the growth and development of the Japanese Corriedale lambs, the probable importance of the age of three months old were stressed by MIMURA (1956), and MIMURA, although inconclusive, suggested that the growth rate of lambs might be modified by the light rhythm, nutritional changes and sexual maturity at the age. But this will be fully confirmed only, when these environmental factors and the growth pattern will be studied analytically on the lambs which are produced all over the years.

On the basis of an understanding of these points, the works of COOP (1953), YEATES (1953) (light rhythm and high temperature), WALLACE (1948), JOUBERT (1956), BURNS (1949～'55) (growth and wool growth) will also be reinvestigated.

After these investigations *e.g.* BISSONNETTE (1932), HAMMOND (1938), HOMMOND, Jr. (1944) and SYKES & COLE (1944), YEATES supplied final proof that light plays the major role in regulating the reproductive pattern of sheep. YEATES showed in 1949 that the Suffolk ewes came into oestrus in anoestrum period by artificial light treatments and lambed in October, a time of year quite outside the normal breeding season.

And then, subsequent detailed studies by HART (1950) and HAFEZ (1952) confirmed that the control of light environment would probably allow a year-round production.

In recent years, the efficiency of hormonal therapy for extra-seasonal-production of lambs has been shown by COLE, HART & MILLER (1945), ROBINSON (1951～'55), DUTT (1953), RAESIDE (1956), GORDON (1958) and others.

The primary object of our studies was again to find out how much effect the environmental factors had on the growth, as compared with normal lambs and extra-seasonal-lambs.

The present experiments were conducted mainly with the object of producing some extra-seasonal-lambs in the field of Japan, by the method of treatment proposed by YEATES (1949) and HAFEZ (1952) as being worthy.

In the present experiments, there were in some respects disagreements in design with those which YEATES, HAFEZ and other workers had used.

(II) MATERIALS AND METHODS

A. Selection of experimental animals

All experimental animals were selected from Japanese Corriedale ewes in the Experimental Farm of Hiroshima University at Fukuyama.

In the first season (1956) three yearling ewes and one 4-year-old ewe, averaging 44 kg in live weight, were used.

In the following season three 2-year-old ewes, one 5-year-old ewe and two yearling ewes, averaging 47 kg in live weight, were used. In the third year two yearling, two 2-year-old, three 3-year-old, and one 6-year-old ewes, averaging 48 kg in live weight, were used.

In all experiments one fertile Corriedale ram was employed, but in the first experiment it was necessary to employ another fertile ram with him.

B. Feeding and management

Ewes were running on pasture in the mornings and were housed in one light-proof pen according to the light treatments. In the first experiment rams were also housed in another light-proof pen. But in the second and third experiments the management of ram was in accord with the normal practice.

The diet of ewes was supplemented with 300 g concentrates per head daily during the period of investigation, but this was raised to 450 g during the last month of pregnancy. The mixture consisted of wheat bran, rice bran, fish meal and bean cake meal in the ratio 45:35:10:10. It was planned to increase the live weight of the ewes as much as possible during the whole period of investigations until lambing.

C. Light treatment

Artificial lighting and black-out treatment for controlling the breeding season of ewes were tried in a light-proof pen (Plate 1). The pen was 2.75×4.56 m with arrangement of four 100 Watt bulbs suspended from the roof at a height of 1.5 m above floor level. It had a slightly higher intensity than the pen used by YEATES (1949) and HAFEZ (1952).

Light treatment in the first season was described in Table 1.

Animals were shut in the light-proof pen before sunset, and then were exposed to artificial lighting. The hours of exposure to light was allowed daily for an actual day light to keep a gradually increasing light rhythm until 25 May, when the total light length was corresponding to summer solstice.

Table 1. Light treatment in the first experiment (1956)

Date	Hours of artificial lighting (min.)	Hours of artificial darkness (min.)	Total light length	Remarks
May 17～May 24	105→20			
May 25	20		14 hrs. 35 min.	corresponding to summer solstice
May 26～May 31	20→ 0			
June 1～June 20		10→240		
June 21		250	9 hrs. 45 min.	corresponding to winter solstice
June 22～Aug. 31		250→195	9 hrs. 45 min. const.	

By artificial lighting, and then by artificial darkness it was changed over from increasing to decreasing light and after 21 June, when the light length was corresponded to winter solstice, the constant day light was kept up by darkness treatment.

The details of light treatment in the second and third seasons were similarly described in Tables 2 & 3.

Table 2. Light treatment in the second experiment (1957)

Date	Hours of artificial lighting (min.)	Hours of artificial darkness (min.)	Total light length	Remarks
Mar. 20～Apr. 1	0→106			
Apr. 2	119		14 hrs. 35 min.	corresponding to summer solstice
Apr. 3～Apr. 11	114→ 16			
Apr. 12	2		13 hrs. 0 min.	
Apr. 13～June 21		9→275		
Apr. 30		215	10 hrs. 0 min.	min. light length
June 22～July 24		275→250	10 hrs. const.	

Table 3. Light treatment in the third experiment (1958)

Date	Hours of artificial lighting (min.)	Hours of artificial darkness (min.)	Total light length	Remarks
Feb. 20～Mar. 5	0→180		14 hrs. 35 min.	corresponding to summer solstice
Mar. 6	181			
Mar. 7～Mar. 16	162→ 7			
Mar. 17～Mar. 25		10→146		
Mar. 26		154	9 hrs. 45 min.	corresponding to winter solstice
Mar. 27～June 15		156→283	9 hrs. 45 min. const.	

It must be noted here that the rhythmical changes of light in these seasons were designed to elapse more rapidly than in the previous season.

In 1958 two ewes of 3-year-old and of 2-year-old were maintained to constant light rhythm (10 hrs.) under the artificial darkness treatment from 6 Jan. to 20 Feb., when the sexual activity in other ewes had been depressed under the unfavorable light condition.

D. Inspection for an oestrus and mating with fertile ram

After daily light rhythm was changed over from increasing to decreasing by artificial means, all the ewes were running with a fertile ram in a pen twice daily. At this running, inspection for evidences of oestrus was generally made, and the intensity of oestrus was graded as follows (Table 4).

Table 4. Grades of intensity of oestrus

Grade	Appearance of vulva	Behaviour of ewes
Oestrus (++)	reddish-yellow in colour, abundant vaginal mucus from opaque to light white, swelling up remarkably	searching for the ram, persisting in being close to him and readily accepting coitus
Oestrus (+)	no clear differentiation between Oestrus (++)	no attempt to approach the ram but accepted service when the latter made sexual approaches
±	changes were recognized in colour, mucus and swelling	following the ram but not accepted service

(III) RESULTS AND DISCUSSION

A. The incidence of oestrus

All treated ewes came in oestrus as a result of ligth treatments. The response of ewes in relation to the different seasons is given in Table 5. The results confirmed perfectly that the light plays the major role in regulating the reproduction of sheep.

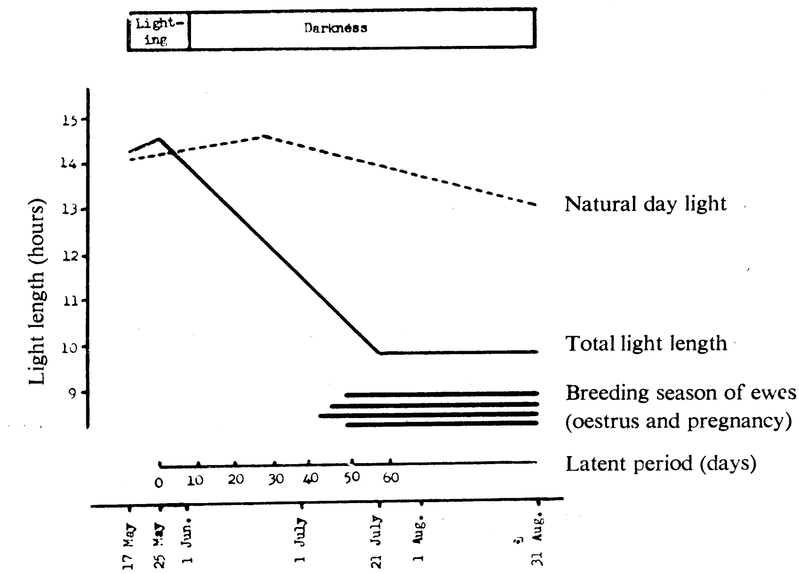
Table 5. The response of ewes in relation to the different season.

Season	No. of ewes treated	No. of ewes observed to come in Oestrus (++) ~ Oestrus (+)	Percentage of ewes that came in oestrus	Range of mean temp. (°C)
May-Aug. (1956)	4	4	100	21.0~32.0
Mar.-July (1957)	6	6	100	20.0~29.0
Feb.-June (1958)	6	6	100	4.0~26.5
Jan.-Feb. (1958)	2	2	100	2.0~12.0

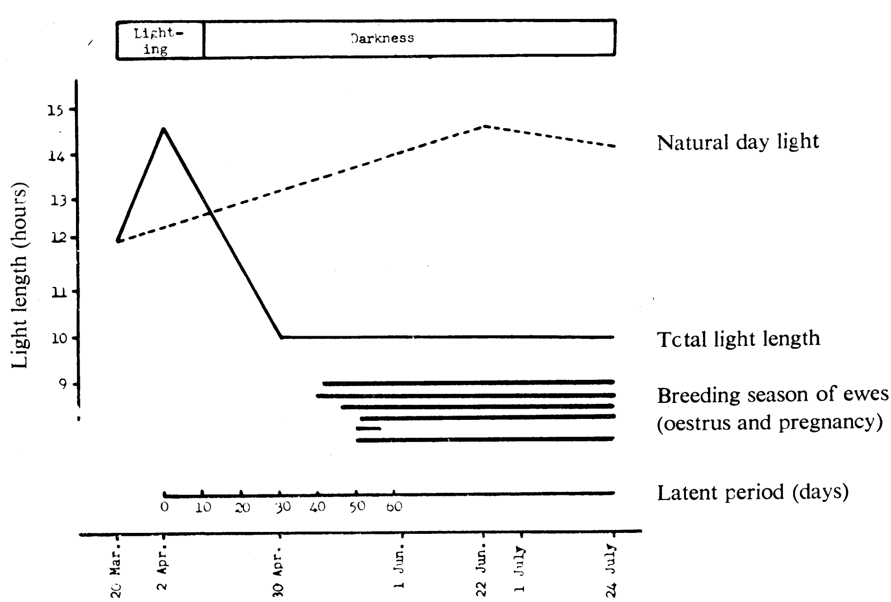
Oestrus (++)~Oestrus (+) : Same with it in Table 4.

YOSHIOKA *et al.* (1951) investigated the effect of the short day treatment for goat and suggested that there existed some other factors also effective for inducing oestrus cooperated with short day treatment. But in our results it was observed that the oestrous response had come with short day treatment, but that temperature, nutrition, age etc. did not modify the reproductive pattern of ewes under artificial light treatment.

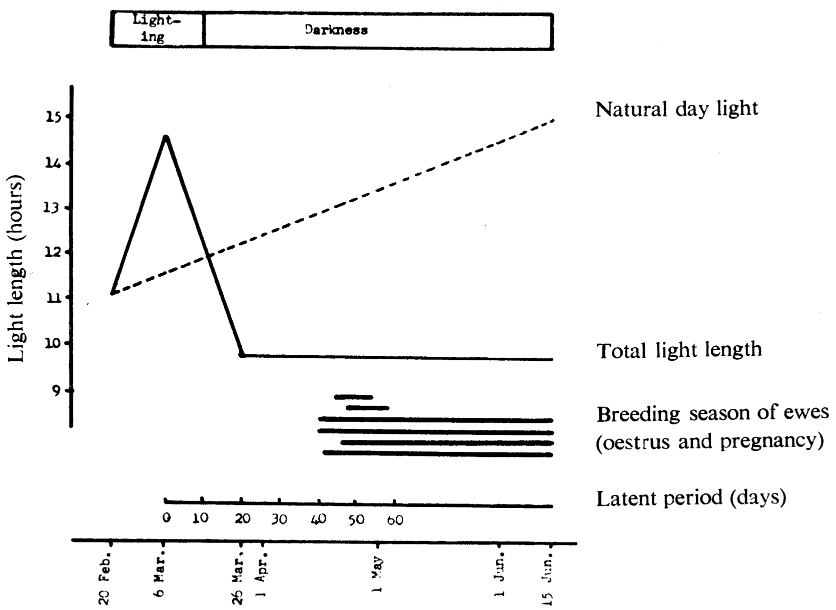
The relations between the incidence of oestrus and the artificial light treatment are shown on Text-figs. 1~3.



Text-fig. 1. Change of light rhythm under treatment and responses of ewes in the lst experiment.



Text-fig. 2. Change of light rhythm under treatment and responses of ewes in the 2nd experiment.



Text-fig. 3. Change of light rhythm under treatment and responses of ewes in the 3rd experiment.

HAFEZ (1952) reported that a fixed light: darkness rhythm is sufficient to hasten the onset of the breeding season, and a gradual decrease in the proportion of light is not necessary. His suggestion is at variance with the conclusion of YEATES (1949).

In the experiments described, the majority of ewes was observed to be in oestrus under constant rhythm. But two ewes (among four ewes) in the first season came in oestrus with the gradual decrease of light. Thus, it is not confirmed whether rhythmical change is necessary for light treatment or not.

The ewes treated in January, 1958 came in oestrus. From this result it should be difficult to recognize that with artificial darkness ewes could be successfully maintained under the favourable light condition. Therefore, those are excluded from the present discussion.

B. The latent period

In the present experiments the latent period was as follows (Table 6), which HART (1950) has explained as the period elapsed from the onset of short day treatment to the first oestrus of ewes.

Means of the latent period were 43.8 days in 1956, 46.0 in 1957 and 43.0 in 1958. On these available data it may be presented that there are some constant intervals in Corriedale ewes to come in oestrus under short day treatment in out-of-season, and that they support a suggestion that the latent period is more important than the light rhythm.

YEATES (1949) believed that ewes came into oestrus after approximately the same interval on a decreasing plane of light as they do under natural conditions, *i.e.* in all cases oestrus started 10～14 weeks after the change-over from increasing to decreasing light.

Table 6. The latent period in present experiments

Season	No. of ewes	First date of short day treatment	Latent period (days)	
			Individual	Mean
May～Aug. (1956)	4	May 25	41, 44, 48, 48	43.8
Mar.～July (1957)	6	Apr. 3	39, 41, 46, 49, 50, 51	46.0
Feb.～June (1958)	6	Mar. 26	40, 40, 41, 44, 46, 47	43.0

HART (1950) reported that the first oestrus was induced in Suffolk in the short average time of 30 days, the range being from 8 to 50 days for 10 ewes, when a daily treatment of 1 part light : 2 parts darkness (4L : 8D : 4L : 8D) was given.

In the experiment of HAFEZ (1952), the latency of initiation (comparable to HART's latent period) was 126 days in a group (8L : 16D) and 168 days in the other group (4L: 8D : 4L : 8D). He has claimed that these differences may be attributed to a different intensity of the solar light and to a different age of ewes, and that the latency of initiation is shown to be dependent on the light rhythm.

YEATES (1954) has reviewed on this question as follows: "It may be that the changes from light to darkness and *vice versa* every 24 hours provide a particular stimulus and that by increasing the frequency of these changes by artificial means, a stimulus which already operates in some limited way under natural conditions is being applied more intensively. On the other hand, artificial fractionation of the light (or darkness) periods may have no connection with any natural events and may be effective in producing such rapid gradual response, purely by chance."

From the present data (Tables 6 & 7), the latent period is the same with different season, age and light rhythm. It is constant intervals from 40 to 50 days after changeover from increasing to decreasing light. It is of some interest to say that those will be

Table 7. Effect of age on the latent period

Age of ewe	No. of ewes	Means of the latent period (days)			
		1956	1957	1958	Total
Yearling	7	45.7	40.0	45.5	44.0
2-year-old	4	—	48.7	40.0	46.5
Adult	5	44.0	50.0	42.3	44.2
Total	16	45.2	46.0	43.0	44.7

in accordance with natural intervals from summer solstice to onset of oestrus, if there may probably be a silent heat before onset of oestrus under normal condition.

Although there is no reason to believe that the latent period is affected by age of animals, there were some yearling ewes which sensibly responded to artificial light as suggested by HAFEZ (1952).

C. First oestrus and weak lamb

One 2-year-old ewe in 1957 and two yearling ewes in 1958, which were in undernourished conditions, were not run with fertile ram. Therefore, 13 out of 16 ewes became pregnant as a result of induced mating after one cycle interval. Details were described in Table 8.

Table 8. Numbers of oestrus of ewes under treatment

Season	No. of ewes	No. of oestrus until conception		No. of lambing	Remarks
		Individual	Mean		
1956	4	2, 2, 4, 6	3.0	4	2-year-old ewe was not mated
1957	6	2, 2, 4, 3, 3	2.8	5	
1958	6	2, 2, 2, 3	2.2	4	Two yearling ewes were not mated

Although there was no doubt that oestrous ewes had chances of coitus, all of them failed in conception in first oestrus. Why could they not be pregnant in first oestrus?

There is, furthermore, a question that some lambs were born weak in out-of-season. Details were described in Table 9.

Table 9. Numbers and birth weights of lambs produced in out-of-season

Lambing season	No. of ewes which produced lambs	No. of lambs	Mean of gestation period (days)	Mean of birth weights of lambs (kg)
Dec.-Jan. 1956-1957	4	4	146.5	3.9
Oct.-Nov. 1957	5	6	143.0	2.2
Sept.-Oct. 1958	4	4	142.8	3.2

As the average birth weight and the average gestation period of Japanese Corriedale are 3.5～4.0 kg and 147 days respectively (MIMURA, 1956), 5 out of 6 lambs that were produced in Oct.～Nov. 1957 were born weak in a short period of pregnancy.

YEATES (1953) has concluded that although high temperature is apparently without effect on the incidence of oestrus in sheep, it is inimical to satisfactory gestation. On the other hand, WALLACE (1948) found that when the ewes were undernourished in the last month of pregnancy the lambs were born smaller and weaker than the lambs that were produced under normal condition. But these suggestions can not yet bring the differences between the birth weight of lambs in1957 and 1958 to any conclusion. It may be confirmed by further investigations.

(IV) SUMMARY

(1) Trials involving a total of 18 Japanese Corriedale ewes were conducted in an attempt to gain several lambs under artificial light treatment over three out-of-seasons.

(2) Artificial lighting and black-out treatments for controlling the breeding season of ewes were tried in a light-proof pen.

(3) The hours of exposure to light were allowed daily for an actual day light to keep a gradually increasing light rhythm until the total light length corresponded to

summer solstice, and then it was changed over from increasing to decreasing light by artificial lighting and darkness. When the light length was corresponded to winter solstice the constant light length was kept up.

In the second and third seasons, the rhythmical changes of light were designed to elapse more rapidly.

(4) All of ewes under light treatment came in oestrus for 40 ~ 50 days' intervals after the change-over from increasing to decreasing light. It may, therefore, be considered that there are some constant intervals in Corriedale ewes to come in oestrus under short day treatment. And it is of some interest to say that these intervals will be in accordance with natural intervals, if there may probably be a silent heat before onset of oestrus under normal condition.

(5) 13 out of the 16 oestrous ewes became pregnant as a result of induced mating after one cycle interval. Several of 14 lambs which were produced in the present experiments were born weak.

It may be necessary for further investigations to set such questions at rest.

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(V) REFERENCES

BISSONETTE, T. H. 1932. Physiol. Zool., **5**: 92 (cited by YEATES, 1949).

BURNS, M. 1949. J. Agric. Sci., **39**, 64–79.

——— 1953. ibid., **43**: 422–431.

——— 1954. ibid., **44**: 86–99.

——— 1955. ibid., **46**: 389–406.

COLE, H. H., HART, G. H. & MILLER, R. F. 1945. Endocrinology, **36**: 370–380 (cited by ROBINSON, 1951).

COOP, I. E. 1953. J. Agric. Sci., **43**: 456–472.

DUTT, R. H. 1953. J. Animal Sci., **12**: 515–523.

FINDLAY, J. D. & BEAKLEY, W. R. 1954. Progress in the Physiology of Farm Animals, Vol. **1**: 252. London, Butterworth.

GORDON, I. 1958. J. Agric. Sci., **50**: 123–151; 152–197.

HAFEZ, E. S. E. 1952. ibid., **42**: 189–265.

HAMMOND, J. 1938. Aust. Vet. J., **14**: 171.

HAMMOND, J. JR. 1944. J. Agric. Sci., **34**: 97–105.

——— 1952. ibid., **42**: 293–303.

HART, D. S. 1950. ibid., **40**: 143–149.

JOUBERT, D. M. 1956. ibid., **47**: 382–428.

MIMURA, K. 1956. J. Fac. Fish. Anim. Husb. Hiroshima Univ., **1**: 203–266.

PARKES, A. S. 1952. MARSHALL's Physiology of Reproduction. 3rd ed., Vol. **2**. London, Longmans Green.

RAESIDE, J. I. 1956. Aust. J. Agric. Res., **7**: 591–607.

ROBINSON, T. J. 1951. J. Agric. Sci., **41**: 6–63.

——— 1954. J. Endocrinol., **10**: 117 (cited by ROBINSON, 1955).

——— 1955. J. Agric. Sci., **46**: 37–47.

SYKES, J. F. & COLE, C. L. 1944. Quart. Bull. Mich. Agric. Exp. Sta., **26**: 250 (cited by YEATES, 1949).

WALLACE, L. R. 1948. J. Agric. Sci., **38**: 93-153; 243-302; 367-401.

——————— 1954. ibid., **45**: 60-75.

WRIGHT, N. C. 1954. Progress in the Physiology of Farm Animals, Vol. **1**: 191. London, Butterworth.

YEATES, N. T. M. 1949. J. Agric. Sci., **39**: 1-43.

——————— 1953. ibid., **43**: 199-203.

——————— 1954. Progress in the Physiology of Farm Animals, Vol. **1**: 363. London, Butterworth.

YOSHIOKA, Z., AWASAWA, T. & SUZUKI, S. 1951. Bull. Nat. Inst. Agric. Sci. Series G, No. 1: 105-111.

Explanation of Plate 1

Fig. 1. Ewes under the artificial darkness treatment and the inside of a light-proof pen with an electric exhaust-fan (left side).

Fig. 2. Extra-seasonal lambs and yearlings at different ages on a pasture of the Experimental Farm of Hiroshima University (April, 1959).


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