STUDIES ON THE REPRODUCTIVE FAILURE OF RAM CAUSED BY UNDERFEEDING I. ON THE EFFECTS OF UNDERFEEDING UPON THE MATING POTENCY OF RAM, AND THE EFFECTS OF NORMAL FEEDING UPON ITS RECOVERY FROM IMPOTENCE

STUDIES ON THE REPRODUCTIVE FAILURE OF RAM CAUSED BY UNDERFEEDING

I. ON THE EFFECTS OF UNDERFEEDING UPON THE MATING POTENCY OF RAM, AND THE EFFECTS OF NORMAL FEEDING UPON ITS RECOVERY FROM IMPOTENCE

By

Akira MORI

Department of Animal Husbandry, Faculty of Agriculture, Tohoku University, Sendai, Japan

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1. Preface

While at the Zootechnical Experimental Farm (Peking), the author investigated, in June 1944, the reproductive condition of the rams that had been fed at the Shansi Branch of the Farm (Kucheng-tsun, in northern suburb of Taiyüan), and found that all the rams of the following breeds were impotent: the Corriedale breed, the Merino breed, the Shansi Improved breed (31) and the Shouyang Sheep (42). The 425 heads in total of all these four breeds showed such a reproductive difficulty that none of them would mount ewes without exception.

About the cause of the impotence of such a large group of rams, the author presumed that it must be based on nutritive deficiency (especially by low protein rations). Feeding them normal food, therefore, the author observed whether they recover their mating potency, and of those that recovered the potency were tested by mating with ewes.

I heartily thank Mr. Masanori Okubo, the head, and all the staff members of the Branch Farm in those days for their kindness in helping my study; and especially Mr. Chiao Tien-kuei and Mr. Kung Cheng-yin who helped me in my work of special feeding of the impotent rams.

2. Factors Leading to Reproductive Failure

Reproductive failure of the male animal is caused by many factors, which are generally divided into internal and external. Specific or generic hybridiza-

tion, succession of inbreeding, over-mating, hereditary sterility or other hereditary defects, psychological causes, immaturity or senility etc. are the internal factors. The external factors include high temperature (summer sterility and experimental cryptorchidism), insufficiency of light, various nutritional deficiencies, diseases, or malformations of genital glands and other genital organs, injurious physical stimulation (radiant rays), special chemical drugs and injection of female hormones.

The reproductive failure that is caused by experimental cryptorchidism (26), by feeding with protein-free food (27), and by injecting female hormones (28) has been already reported.

Among the above-mentioned factors, the nutritional factor has important significance on male fertility. When males are given proper quantity and quality of protein their genital glands grow normal, maintaining their functions and they display their reproductive potency. Although a feed good enough in quality and quantity for maintenance of fertility is of course sufficient for sustaining an adult male animal, yet in this case, protein and a certain kind of vitamin play exceptional parts. If the quantity of these nutritional elements are short of the required quantity for reproduction, no underfeeding but reproductive difficulty is sometimes caused (10).

The followings are the cases when reproductive difficulty is brought about by nutritive factors.

First, when male animals are put in a starving condition, the production of male hormone is diminished (25) and spermatogenesis is checked (20).

Feeding protein-free food causes reproductive difficulty. That is, the testicles and the seminiferous tubules degenerate, and abnormal spermatozoa increase, or else spermatogenesis is inhibited (27).

Reproductive defficulty also accompanies in many cases with underfeeding of low protein foods. Habu and Masuda (12) reported that when the bull is fed with low-nutritive foods, the living hours of their spermatozoa are shortened with the increasing number of deformed spermatozoa. Phillips and Andrews (36) observed degeneration of the boar's seminiferous tubules under the same food condition. However, reports on the conspicuous reproductive difficulty caused by such underfeeding have not been published, as far as the writer is a were.

Contrary to underfeeding, feeding high-protein foods often causes reproductive difficulty. Mckenzie and Phillips (22) reported on the deleterious effect of obesity on sperm production in rams. They state that in this case deformed spermatozoa increased in number, and that the percentage of deformation rose to as high as 76 percent in one ram, with whom 35 heads of ewes were mated without success in fertilization, but that when they were made to lose—their body weight by appropriate dieting the number of the

deformed spermatozoa decreased.

But in the case like this, the reproductive difficulty must be perhaps due to something else such as nutritional maladjustment or a failure of feeding and management, not to the feeding of high protein foods. Cunningham and Hopkirk (7) report that the male rats fed with foods containing excessive protein (65–85%) became sterile.

As mentioned above, the quantity of protein in foods has strong influence upon sperm production. But, as for the amino acids that compose protein, some are necessary for the reproduction and others are not. Lysine is indispensable for the maintenance of reproductivity according to Courrier and Raynaud (6), and concerning the result of deficiency of lysine Cunningham Hopkirk (7) and Cunningham *et al.* (8) state that the testicles become undergrown, the males become sterile, the spermatozoa's activity is weakened, their number is decreased and malformed spermatozoa are increased.

It is chiefly advocated by Soviet authors that the foods including some special grain are effective, and that animal protein is preferable to vegetable protein for the sperm production; their opinion seems to be based on that the amino acids, necessary for reproduction, are more plentiful in such foods. And many reports have been presented from this point insisting the preferability of animal protein to vegetable protein, as the former contains more amino acids required for reproduction than the latter, and the author also will treat the subject in the second report.

Millet, barley and oats are suitable as vepetable protein foods, and it is said that feeding these foods to the ram or bull causes an increase of the quantity, concentration and resistivity of the semen and the vivify its libido sustaining and revealing effectively its reproductive potency (5, 15, 32, 33, 37, 43).

Thus, protein has a great qualitative significance on the revelation of fertility, but at the same time a considerable quantity of it is required for this purpose. According to the Okuličev and Meščerjacova (32), 120–135 of digestible crude protein must be fed to a ram 70 kg in weight in the case he mates twice a day, and 145–160 g in the case he mates thrice a day. And Okuličev (33) states that 80 g of digestible crude protein is required for a ram to produce 1 ml of semen, while Pankovic (34) reports that a bull requires 162 g of it in order to ejaculate once. According to Tommé and Odinec (47), the quantity of digestible nutritions must be calculated by the rate of mating, not by the unit of 3 cm^3 of semen.

The other nutrients which are related to the reproductive potency are vitamins and inorganic salts. The vitamins, the want of which cause reproductive difficulty, are vitamin A and E, though B and C also have some relation to it. The necessary inorganic salts are those of calcium, phosphoric

acid, iodine, sodium and potassium.

In reproductive difficulty, the male gonads show degeneration, and the percentage of spermatozoon malformation is increased in most cases. And there is a close relation between the rate of spermatozoon malformation and the rate of fertilization, or between the rate of spermatozoon malformation and the degree of fertility in the male. On this relation many studies have been done (man-24; bull-1, 2, 3, 9, 14, 17, 41, 44, 48, 52, 53; stallion-50, 51; ram-21, 22, 46; boar-23, 35).

Besides the above-mentioned close relation between the rate of spermatozoon malformation and the rate of fertilization, a considerably close negative correlation exists between the rate of malformation and the nature of semen (quantity, motility, percentage of vitality of sperms), as HAFEZ *et al.* (13) report.

The factors of the malformed sperm production are generally similar to those that cause reproductive difficulty. Accordingly, malformed spermatozoa are also produced in the reproductive difficulty caused by dystrophy. Namely, either quantitative insufiiciency (12) or qualitative imperfection of protein-free foods cause a characteristic increase of the number of spermatozoa with curved middie-piece of coiled tail (7). Mori (27) has made it clear that such malformed spermatozoa are produced not in the testicles but in the ductus epididymidis during their afterripening. However, similar malformed spermatozoa are also produced by injection of femal hormones, and in such cases they are produced in the testicles (28).

Mckenzie and Phillips (21) observed in rams that malformed spmermatozoa were produced in obesity. Besides, deficiency of vitamin A is said to be a cause of the malformation.

As stated above, reproductive defficulties are caused by many factors, and in most cases they are accompanied by disorders in the testicles or the genital tracts. But few morphological studies have been done about spermatozoa under the influence of these individual factors.

3. Inferences on the Cause of Reproductive Difficulty (Impotence)

For the purpose of making inferences on the cause of impotence of 425 rams kept at the Shansi Branch Farm, the author made some investigations (including Corriedale, Merino, Shansi Improved Sheep and Shouyang Sheep).

1) Investigation in other farms

The author also investigated every breed of rams in the Shansi Provincial Farm (Nankwan, Taiyüan) and the rams (the Corriedale) put in charge of farmers' near Taiyüan City, and found all of them to be entirely impotent.

But upon investigating the rams (the Corriedale, the Merino and the Han-yang) in the Peking Branch, Zootechnical Experimental Farm (in the western outskirts of Peking), he found that their potency were in normality and that their semen samples ejaculated into artificial vagina were all satisfactory. Furthermore, the fact was known that the Corriedale rams had been in active service of reproduction in the private farms and in a few farmers' auound Peking City.

Summer season (June) is anything but a good season for a ram to reproduce (11). Yet, the impotence of those rams in Taiyüan cannot be attributed to season, considering that the potency of these rams in Peking was normal. In addition, when the author had investigated the reproductive conditions of the rams in the Shansi Branch Farm in October 1943, the preceding year, they had been also impotent (though they were not the same rams).

The impotence of the Shouyang Sheep alone should be attributed to the psychological factor, as will be stated later.

2) Feeding and management in the Shansi Branch Farm

The age of the rams of the Corriedale, the Merino and the Shansi Improved Sheep being three, four and two years respectively, their impotence seems to be free from the factor by age. Under the feeding and management in the Branch Farm, the follows are considered to be related to their impotence;

a) The rams had been under very bad conditions until June 1944. Most of the farm-workers and shepherds had been indifferent to them, and in some folds incessant cruelty had been practised.

b) Their feeds had been exceedingly unsatisfactory, considering their nutritional values. Dry weed and Italian millet straw by grazing had been their main feeds as roughages, and a little quantity of black-soy bean had given to them as concentrates until May. Since the early June, wild grasses by pasturing and concentrates consisting chiefly of maize-bran had been fed to them, but even the pasturing had become insufficient since the middle of June.

c) Scabies had prevailed there from October 1943 till the next April, the shearing season, and the sheep were gradually recovering from it when the author investigated at mid-June.

d) The author was taught in later year that the rams of Corriedale exported from Japan to Northern China had mostly been of inferior quality.

Considering the above-mentioned conditions of feeding and management and the likes, the chief factor of the rams' impotence may be infered to be due to the previously stated underfeeding (especially low protein rations). Besides, for instance, the want of vitamines may be added to this.

If the chief factor of their impotence was underfeeding, their mating

faculty should be recovered by feeding them normal foods, or at least by feeding them a normal quantity of protein. And if they could be cured by this, the cause of their importence would be more or less cleared up.

4. Materials and Methods

1) Materisls

As mentioned at the beginning, the total number of the rams presumed to have been made impotent by underfeeding was 425.

The Corriedale breed. Imported from Japan in 1943, when two years old.

The Merino breed. Imported from Manchukuo.

The Shansi Improved breed (31). Also called the Shansi Merino breed. They were Mongolian sheep improved by crossing with Merino breed, in the days of Mr. Yen Hsi-shan as governor of Shasi Province. This breed were kept in every post of the Shansi Province.

The Shouyang sheep (42). Produced all over the Shouyang District in Shansi Province, may be considered as a variety of Mongolian sheep, though standing lower. Their wool is of fine quality.

The numbers and ages of the above-described rams of the four breeds were as shown in Table 1.

Table 1. Number and age of the subject rams.

Breed	Number of rams	Age in years
Corriedale sheep	278	3
Shansi Improved sheep	84	2
Merino sheep	41	4
Shouyang sheep	13	3
Total	416	

The author used as the materials rams of three breeds, excepting the Shouyang sheep. Though there were nine sick rams of Corriedale breed besides but these were excluded from this table.

2) Selection of rams for re-rearing

The author selected some rams out of these impotent ones with their appearances, weights, nutritive conditions and health as criteria, and kept them under special feeding. About the considerably close relation between these conditions and their reproductive potency, the author has already reported (29).

These selected rams were accomodated in special folds as the specially fed group, and they were re-reared until December, although some of them were replaced during that periods. The rams kept under special feeding

throughout the whole periods were 15 heads of Corriedale breed, 14 heads of Merino breed and 7 heads of the Improved breed. But, the other rams that were not fed specially were also under similar feeding and management.

3) The methods of re-rearing by special feeding

The rams selected by the said conditions were specially fed since the 18th of June. A capable employee and a capable shepherd were engaged in their feeding and management. Here a shepherd's capability matters greatly.

From June to September, they were pastured in good grass lands limitedly in the cool hours of morning and evening, and in the other hours they were gathered under the shades of trees. Wild grass by the pasturing, raw lucern (lucern hay, later) and millets were given to them as roughages, and as concentrates 200 g of wheat-bran, 200 g of maize-bran and 100 g of black bean were also given. These concentrates are not necessarily agreeable to their reproductive potency, but more desirable feeds could not always be procured under the strict controls during the Second World War. However, the soil in Shansi Province was suited to the cultivation of lucern, so that its quality was excellent.

The rams were weighed every ten days, as attention was paid to their weights.

4) Evaluation of their mating potency

Releasing two or three heads of ewes (it matters little whether they are in estrus) among the rams, the mating potency of the latter was evaluated by their sexual behavior toward the former. According to their reproductive potency, some rams are indifferent to the ewes, others pursue, mount or ejaculate upon them. The author practiced this method sucessively until December and observed the following: If a ram is potent and not in psychological failure, he makes the above described sexual conducts toward an ewe, be the latter in estrus or not and be the latter a dummy of an ewe; and if he mounts, he in most cases ejaculates even into an artificial vagina.

5) Sampling and observation of semen

Seminal fluid of a ram was sampled with an artificial vagina by letting him mount on a meek, anoestrous ewe. The quantity and pH value (by "Toyo pH Test Paper Method") of the semen were examined by the naked eye, and the concentration, the motility, the vitality percentage, the number of malformed spermatozoa and germ-cellular elements of the semen were examined under a microscope.

6) Fertilizing test by the poetence-recovered rams

Four heads of the rams of the Corriedale breed whose mating potency were recovered by the re-rearing were put to the test of ferailization. The

ewes were of the same Corriedale breed in the second year of age and numberd 80. There ewes were in as unsatisfactory conditions as the rams.

Natural mating were made between the rams and estrous ewes discovered by use of teasers.

5 Results and Considerations

1) Changes in body weights

Details are omitted about the changes in their weights, and only the specially fed rams gained weights more than generally fed rams did.

2) Changes in reproductive potency—all rams

Here the changes in the reproductive potency during June to December are stated. Table 2 presents the monthly changes in the reproductive potency

Table 2. Changes in reproductive potency of all rams

Month and date	Breed	No. of rams	Mounting: No. of rams	Mounting: %¹	Mounting: %²	Mounting: Comparisons	Ejaculation: No. of rams	Ejaculation: %¹	Ejaculation: %²	Ejaculation: Comparisons	Good quality semen: No. of rams	Good quality semen: %¹	Good quality semen: %²	Good quality semen: Comparisons
June 7	Co	278	0											
	Me	41	0											
	Sh	84	0											
	Total	403	0											
July 2	Co'	278	0											
	Me²	41	0											
	Sh³	83	3	3.61	3.57	1 / 2—3	1	1.20	1.19	1 / 2—3	0			
	Total	402	3	0.75	0.74		1	0.25	0.25		0			
Aug. 3	Co'	275	7	2.55	2.52									
	Me²	41	2	4.88	4.88	1 / 2—3	1	2.44	2.44	1 / 2—3	0			
	Sh³	81	4	4.94	4.76		1	1.23	1.19		0			
	Total	397	13	3.27	3.22		2	0.50	0.49		0			
Sept. 3	Co'	250	7	2.80	2.51	1 / 2—3	5	2.00	1.80	1 / 2—3	5	2.00	1.80	1 / 2—3
	Me²	38	2	5.26	4.88		1	2.63	2.44		0			
	Sh³	81	9	11.11	10.71		6	7.41	7.14		6	7.41	7.14	
	Total	369	18	4.88	4.47		12	3.25	2.98		11	2.98	2.73	
Sept. 30	Co'	216	16	7.41	5.75	1 / 2—3	13	5.56	4.68	1 / 2—3	7	3.24	2.52	1 / 2—3
	Me²	32	1	3.13	2.44		1	3.13	2.44		0			
	Sh³	81	26	32.09	30.95		22	27.16	26.19		9	11.11	10.71	
	Total	329	43	13.07	10.67		35	10.64	8.68		16	4.86	3.97	
Dec. 1	Co'	197	58	29.44	20.86	1 / 2—3	25	12.69	8.99	1 / 2—3	16	8.12	5.76	1 / 2—3
	Me²	29	5	17.24	12.20		4	13.79	9.76		1	3.48	2.44	
	Sh³	71	43	60.56	51.19		26	32.62	30.95		16	22.54	19.05	
	Total	297	106	35.69	26.30		55	18.52	13.65		33	11.11	8.19	
Dec. 29	Co'	124	84	67.74	30.21	1 / 2—3	39	31.45	14.03	1 / 2—3	24	19.35	8.63	1 / 2—3
	Me²	28	5	17.86	12.20		4	14.29	9.76		1	3.57	2.44	
	Sh³	71	51	71.83	60.69		28	39.44	33.32		16	22.54	18.04	
	Total	223	140	62.78	34.72		71	31.84	17.61		41	18.29	10.17	

a. Co is the Corriedale, Me the Merino, and Sh the Sahnsi Improved sheep.
b. %¹ is ones for the number of same breed of rams in the every months, and %² the initital month (Jully).
c. Comparisons between breeds depend upon %², and the test of differences by means of χ squar method.
d. *...P<0.05, **...P<0.02, ***...P<0.01, ****...P<0.001.

of all the rams (except the Shouyang Sheep) including the specially fed group. Some rams with abnormal testicles (swelling, microrchidia, anorchidia) that did not mount ewes of the Corriedale breed or that did not ejaculate after mounting, are included in this table. The diminution in the number of the rams by months is due to natural selection, death and removal, and few, if any, of these rams disappearing from the table were expected to recover their mating potency subsequently.

As this table plainly shows, the rams gradually revealed their mating potency since July and considerably recovered it toward the end of December. That is to say, at the end of December nearly 35 persent of all the rams (the initial number) mounted ewes, about 17 percent of them ejaculated, and the seminal fluids of 10 percent of them were of good quality. However, they could not be regarded as in entirely normal reproductive condition.

3) Changes in the reproductive condition—comparison between the generally fed and specially fed rams

Table 3 presents the comparison of the reproductive potency by months of generally fed and the specially fed rams.

From this table, the superiority of the specially fed rams to the controls of the three breeds are observed in the rate of the number of the rams that mounted and ejaculated, and of the number of the rams that had good semen in quality.

4) Comparison among the three breeds

As shown in Table 2, it was the Shansi Improved breed of all the rams that recovered mating potency first, and it was also the rams of this breed that showed the highest rates of mounting and ejaculating, and of having good quality of semen. Although there are no statistical differences in most cases for comparing between the Corriedale breed and the Meriho breed, yet the Corriedale breed can be said to show a better tendency.

Similar tendencies as observed in Table 2 are also seen in Table 3.

5) Form of spermatozoa

For the purpose of observing the quality of semen sampled upon recovery of reproductive potency of rams by months, the quality and pH of the ejaculated seminal fluids, and the concentraton, the motility, the vitality, the deformation and the cellular elements of spermatozoa were put to record. But, though the seminal fluids slightly increased month after month, yet no obvious tendencies could be observed in the concentration and pH, and though the semen was sampled in an artificially warmed room in winter, yet the temperature treament was not satisfactory enough for recording the motility and vitality; so here the observations on the form of deformed spermatozoa alone will be mentioned.

Table 3. Changes in reproductive potency (comparison between generally and specially feed rams)

Month	Breed	No. of rams	Mounting				Ejaculating				Good guality semen			
			No. of rams	%[1]	%[2]	Com-parison	No. of rams	%[1]	%[2]	Com-parison	No. of rams	%[1]	%[2]	Com-parison
July	Co	263	0											
		15	0											
	Me	27	0											
		14	0											
	Sh	76	0				0							
		7	3	42.86	42.86	<0.001	1	14.29	14.29	<0.001				
Aug.	Co	260	5	1.92	1.90	<0.001								
		15	2	13.33	13.33									
	Me	27	0											
		14	2	14.29	14.23	<0.05								
	Sh	74	1	1.35	1.32		0							
		7	3	42.86	42.86	<0.001	1	14.29	14.29	<0.001				
Sept.	Co	201	12	5.97	4.56		10	4.98	3.80		6	2.99	2.28	
		15	4	26.67	26.67	<0.01	3	20.00	20.00	<0.01	1	6.67	6.67	<0.3*
	Me	18	1	5.56	3.70		0							
		14	2	14.29	14.29	<0.3*	1	7.14	3.70	<0.2*				
	Sh	74	20	27.03	26.32		16	21.62	21.05		5	6.76	6.58	
		7	6	85.71	85.71	<0.01	6	85.71	85.71	<0.001	4	57.14	57.14	<0.001
Dec.	Co	109	74	67.89	28.14		32	29.36	12.17		20	18.35	7.60	
		15	10	66.67	66.67	<0.01*	7	46.67	46.67	<0.001*	4	26.67	26.67	<0.02*
	Me	14	1	7.14	3.70		0				0			
		14	4	28.57	28.57	<0.02*	4	28.57	28.57	<0.05	1	7.14	7.14	<0.2*
	Sh	64	44	68.75	57.89		21	32.81	27.63		9	14.06	11.84	
		7	7	100.00	100.00	<0.02	7	100.00	100.00	<0.01	7	100.00	100.00	<0.001

a. The upper columns of every breed shows the generally fed rams, and the under ones the specially fed rams.
b. %[1] is ones for the number breed of rams in the every months, %[2] the initital month (Jully).
c. Comparisons depend on of χ squar method.
d. * is comparison for the initial number in same breed (Jully).

The deformed spermatozoa were extremely plentiful. In extreme cases most of the spermatozoa were deformed, and in some cases the deformed spermatozoa occupied one-third to half of the total spermatozoa. The representative form of the deformed spermatozoa was the tail-deformation, as shown in Fig. 1. Particularly, the forms 10–12 were the most numerous.

6) Examiration of fertilization by potency-recovered rams

Re-rearing with normal feed of the rams that were considered to have lost their mating potency on account of underfeeding was undertaken, and the four rams that consequently recovered their mating potency were examined for their fertility. The results of the fertilization tests were evaluated by the record of their mating in autumn 1944, and by the results of breeding in the next spring.

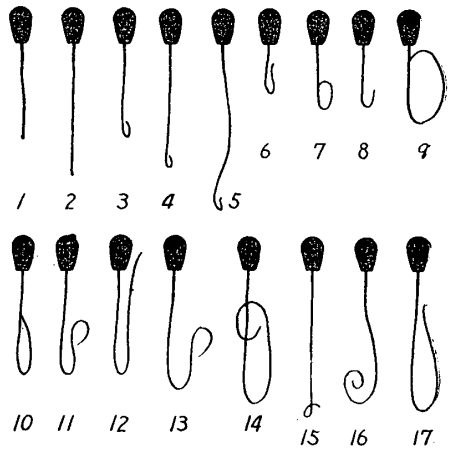

Fig. 1. Form of the deformed Spermatozoa.

The mating was done between the 2nd of October and the 12th of November. Table 4 shows the quality of the seminal fluid of the four rams. Though the record of mating in those days was lost, general inferences can be made.

Table 4. Quality of the collected semen

Ram No.	Month and date	Body wts. kg (date)	Quality of semen					
			Volume cc	Concentration	Motility	pH	Abnor. sperm.	Cells and cellular elements
2000	13th, Sept.	63.0(13th, Sept.)	0.8	100	100卅			
	2rd, Oct.		1.5	100	100卅			
	1st, Dec.	60.0(11th, Nov.)	0.9	100	100卅	6.8	+	−
	5th, Dec.		0.7	100	90卅	5.6	+	−
	10th, Dec.	60.0(9th, Dec.)	0.9	100	100卅	6.2	+	−
1829	13th, Sept.	56.4(16th, Sept.)	0.9	100	50+			
	5th, Dec.		0.4	90	100卅	6.0	+	
	5th, Dec.		0.4	100	100卅	6.0	++	−
	11th, Dec.	59.0(9th, Dec.)	1.0	100	100卅	6.5	+	−
2003	12th, Sept.	62.0(13th, Sept.)	1.4	100	10+			
	5th, Dec.		1.2	100	100卅	7.0	+	+
	6th, Dec.		0.8	100	75++	6.2	卅	++
	10th, Dec.	59.0(9th, Dec.)	1.2	100	70++	6.2	++	++
	11th, Dec.		1.5	100	60++	6·6	卅	−
1798	13th, Sept.	63.4(16th, Dec.)	0.6	0	0−			
	13th, Sept.		0.6	0	0−			
	22nd, Sept.		0.6	5	0−			
	5th, Dec.		0.5	70	20+		+	−
	11th, Dec.	59.0(9th, Dec.)	1.2	100	40+	6.4	++	++

From the results in this table, the seminal quality of the rams No. 2000 and No. 1829 was appreciated to be good, that of No. 2003 to be average and

that of No. 1798 to be bad. But it goes without saying that the "good" in this case does not mean qualitatively the normal semen. For instance, it contained many deformed spermatozoa and was insufficient in quantity.

The records of the fertilization are shown in Table 5.

Table 5. Results of fertilization tests

Ram No.	Quality of semen	No. of ewes	No. of partrition	Conception rate %
2000	fine	41	19	46.34
1829	fine	7	5	71.43
2003	common	10	3	30.00
1798	bad	29	5	17.24

The percentage of fertilization of the ram No. 2000 whose seminal quality was appreciated good was 40 percent, and this percentage is not entirely satisfactory. Yet, the number of the mated ewes might have been to many and many sterile ewes might have been there among them. At any rate, this percentage was still better than that of the ram No. 1798 ($P<0.01$); the records of No. 1829 and No. 2003 cannot be relied upon, for the mated ewes was not large enough. Yet, the percentage of the fertilization of the ram No. 1829 is higher than that of the rams No. 2003 and No. 1789 ($P<0.1$ and $P<0.02$ respectively). Therefore, it may be considered at least that the percentage of No. 1829 having semen of good quality was high, and that No. 1798 having inferior semen was low.

6. Discussion

Using as material animals 425 rams impotent chiefly on account of underfeeding and picking out of them a few heads each of the Corriedale breed, the Merino breed and the Shansi Improved breed, the author re-reared them by special feeding with special attention to nutrition, and at the same time the other rams were also improved in treatment, feeding and management. As the result, they began to recover their mating potency by degrees revealing their reproductive potencies therewith, and their conditions proved very much improved after six months of improved rearing.

In the following, the author will discuss the problem of the causes of nutritional difficulty which is presumed to be the factor of their impotence, presenting simultaneously the new knowledges acquired in the course of rereading them, and also refering to the past studies on the mating potency of ram. In addition, the difference among the breeds will be discussed in respect of the mating potency.

Factors causing impotence

There are many causative factors of mating impotence of a ram as

described first, and the factors on which the author chiefly laid stress were underfeeding, namely, feeding with coarse foods, and failure in proper management—the factors seemingly leading to the extremity of mating impotence of all troubles in reproductive functions. It is doubtful, however, whether they consitute all the factors leading to impotence, for it is considered that their impotence (the extreme reproductive difficulty) was too serious for assuming the failures of feeding and management only as the chief factors. Therefore, the author will discuss the matter from other angles, setting aside for a while the question whether underfeeding is the chief factor.

To begin with, there is the problem of season of reproduction, that is, the problem of relation between the sexual activity of ram and the season. Mckenzie and Berliner (21) on the Shropshire rams reported that their most suitable months for reproduction are October to January considering their quality of semen, and that their reproductive potency is weakened in spring, recovering gradually in June to September; on the Hampshire rams they also report that their reproductive potency is most weakened in June and strengthened during August to January.

It is well known that the season of reproduction of the improved sheep in the northern hemisphere is autumn, and that the rams' sexual activities show some degrees of differences according to the situations and months. However, it is not known and has not been observed that such a large flock of rams have ever been in mating impotence. This phenomenon cannot be explained from the seasonal fluctuation of their sexual activities, and accordingly the season cannot obviously be regarded to be the factor of the impotence in my case. Moreover, so far as the author investigated, the Mongolian sheep have no peculiar seasons for reproduction, breeding throughout the year. Therefore, the mating impotence of the Shouyang sheep, the indigenous breed, should not be attributed to the seasonal factor.

The age of rams cannot be considered as the factor of their impotence.

In general, the impotent rams had a certain degree of reproductive potency. That is to say, the sperm production was still going on in them. So, the questions arise as to are they unable to mate due to some their causes, and is their sperm production too poor to reveal their reproductive (mating) potency. The author will discuss these questions refering to the reports concerning them.

However, few studies have been hone yet on the mating impotence of males, while many have been done on their sterility. This fact seems to be due to the difficulty of obtaining adequate materials for such studies.

According to Marshall (19), the reproductive difficulty is divided into impotence and sterility. The former is owing to the lack of libido which is caused by anatomical (defect or deformation of the penis), physiological

and pathological factors, and the last causes are divided further into prenatal and acquired causes. He mentions diseases of the genital glands as an example of the acquired causes. The author also observed defective and undersized testicles among the impotent rams (29). But, no individual ram was without spermatozoa (29). Besides, such rams with defective gonads were few in number so that the malformation of gonads cannot be ihe main cause.

Lopirin *et al.* (18) state that the ram's impotence is due to psychological factors, occasioned when they are kept together with ewes for a long time or when they are not accustomed to the ewes. Also Roux and Hoffman (39) state that the ram's impotence is caused by psychological factors, and not physiological factors. Observing the impotence of rams for six months, the author thought that the factor of impotence of the Shouyang Sheep at least was mostly psychological, namely something like a fear or abhorrence not toward ewes but toward man. Thus, the psychologically impotent rams were found in observation, but they were few in number and were limited to a certain breed, so that the psychological factor cannot be the chief factor of impotence of the large number of rams.

Bludorov and Dubrova (4) report that the cause of sterility of rams originates in the abnormality of their genital glands. If impotence is interpreted as sterility in the broader sense, a few heads of rams with abnormal genital glands were indeed seen in my mating-impotent rams, as the author had stated in another report (29).

According to the report of Union Ovine (49), both feeding and management are effective for the recovery of ram's impotence. The author would like to attach importance to this opinion, for the author could make the impotent rams recover their mating ability with some success by improving the feeding and management of them.

Effects to recovery

Here, returning to the subject in the question, discussions are given to how the special feeding, particularly the improved feeding and management of the rams differed from the feeding till then.

Feeding and management were remarkably improved: especially food conditions both of roughages and concentrates were made normal at least in nutrition. Pasturing was regularly practised and the rams could feed on good grasses more plentifully. The other roughages (lucerne etc.) were satisfactory and the concentrates became fairly good both in quality and quantity in contrast to former times. Many other improvements were carried out but the fundamental factor was nothing but the nutrituve improvement of foods. Concerning the nutritive effects of foods upon the reproductive potency of males, many reports have been presented besides the above-mentioned one of Union Ovine (49).

Okuličev and Meščerjacova (32) report that the feeding of such foods as barley, oat and millet is effective for the sperm production of rams in their mating season, while Hudjakov (16) states that feeding cracked or germed cat, wheat, bran, millet, lucerne, roat and cow's-milk to impotent boars effected recovery of their reproductive potency. Popov and Okuličev (37) find that by feeding oat, barley, millet and corn to rams the quality of their seminal fluids became excellent, and that the best food was millet and the next was barley and oat in that case. Habu and Masuda (12) report that feeding of barley and millet to Japanese native bulls was highly effective in improving the motility and the vitality of their spermatoza. Smirnov-Ugrujumov (43) report that feeding of barley and plentiful concentrates to bull caused a rise in quantity, concentration and resistivity of their seminal fluids. Okuličev (33) reyorts that the quantity of rams' seminal fluids was increased by feeding with protein-rich grains. Herman and Swanson (15) report that when fed with millet, barley, sorghum and oat, the quantity of semen and the number of spermatoza of rams increased in the order named. Reid *et al.* (38) report that mingling various concentrations in feeds to bulls caused an increase of the seminal fluids in quantity and of spermatozoa in number, and also a decrease of deformed spermatozoa in number, compared with mono-feeding.

Although most of the above-cited seports were not based on observations of impotent males, yet there can be seen, on the whole, the high effectiveness of some special vegetable proteins on the reproductive potency of males. As for the effect of animal proteins many reports have been presented, which the author will treat in the next report.

It is evident that both vegetable and animal proteins have close relation to the male's reproductive potency and naturally to that of impotent rams. Here, concerning the recovery to some extent of the impotent rams' reproductive potencies as the result of re-rearing by special feeding, the most effective factors are inferred to lie, besides in the improvement of management, in the feeding of roughages such lucern that contains abundant excellent protein, and in the feeding of good concentrates such as bran and black-bean. And the fundamental cause of their impotence is considered, as presumed first, to be due the nutritive failure of foods, especially the nutritive difficulty caused by the extreme deficiency of protein. The weights and nutritive conditions of the rams which the author (30) observed for the purpose of evaluating their reproductive potency, had close relation to the reproductive potency. That is, the weights of rams that mounted ewes were heavier than those that did not, and the nutritive conditions of rams that ejaculated were more favorable than those that did not. Furthermore, the semen of heavy rams were plentiful in quantity, high in concentration, and

contained less deformed spermatozoa in number.

Many of the spermatozoa in semen sampled from potency-recovered rams were curved at the middle-piece or at the tail. These deformed spermatozoa particularly increased when the male animals were fed low-protein or protein-less foods (7, 12, 27). The cause of the appearance of the deformed spermatozoa cannot be always attributed to the food factor such as low-protein foods, but in this case at least the cause is presumed to be feeding of low-protein foods.

In brief, the rams' impotence in this report is considered to be due to the deficiency of protein contained in feeding foods, and the recovery of potency of the rams by the special re-rearing is considered to have been brought about by plentiful feeding of protein foolds. The reproductive potency of the rams was examined by the test of their fertilizing ability.

Difference among breeds

The Shansi Improved breed rams recovered their mating potency faster than those of the other two breeds in spite of their youngest age. The reproductive potency of the Shansi Improved breed in every month was superior to that of the Corriedale breed and the Merino breed. This superiority of the Shansi Improved breed seems to depend on the fact that they were inured to the climates of Shansi Province, since they had been bred there for long years.

7. Conclusion

By feeding normal foods, the author re-reared the rams that were presumed to have become all impotent mainly as the result of underfeeding. Six months later, about 304 of them mated with ewes and ejaculated. Therefore, their impotence is considered to be due to underfeeding as presumed at first, and the recovery of their mating potency is considered to depend upon the feeding of foods which contain normal quantity of protein.

8. Summary

Using as the material animals a large group of rams of three breeds (the Corriedale breed, the Merino breed, the Shansi Improved Sheep) which were presumed to have become impotent chiefly on account of underfeeding, the author observed the effectiveness of feeding normal foods upon the recovery of their mating potency. And the potency-recovered rams were tested for fertilization to make sure of their reproductive potency.

The author found these impotent rams in June 1944. Up to that time, the feeding and management for them had been quite unsatisfactory and especially their foods had been badly lacking in nutrition both in roughages and in concentrates. Accordingly, the cause of their impotence was presemed

not to be seasonal, but to be based on nutritive difficulty caused by underfeeding.

If underfeeding actually be the actual factor of this reproductive difficulty, the reproductive potency must be recovered to a certain degree by feeding normal foods. Acting upon this assumption, the author selected 15 rams of the Corriedale breed, 14 of the Merino breed and 7 of the Shansi Improved Sheep respectively with consideration to their appearance, weight and nutrition, and fed them specially till December. At the same time, also the other rams were subjected to similar feeding and management.

The results are summarized as follows:

1) Their mating potency gradually reappeared after July, and by December was recovered remarkably: 35 percent of all the rams mounted, 17 percent of them ejaculated, and the quality of semen of 10 percent of them were of good quality.

2) In comparison of the recovery of the mating potency of the specially fed rams with that of the rest, the former were obviously superior in this respect though every month.

3) Among the spermatozoa in the ejaculated semen, there were many deformed spermatozoa whose middle pieces or tails were coiled or curved.

4) From the observations, the author infers that the cause of their impotence depends upon underfeeding due to feeds deficient in protein.

5) The recovery of their mating potency by the re-rearing is considered to chiefly depend on the inrrease of normal foods, especially on the effect of protein.

6) The Shansi Improved sheep recovered the mating potency earlier and their reproductive potency by months was superior to that in the other two breeds.

7) The author examined the fertilizing faculty of four out of the potency-recovered rams and confirmed their recovered reproductive potency.

8) In this examination, the percentage of fertilization was higher in the rams that had good semen than in the others that had inferior one.

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