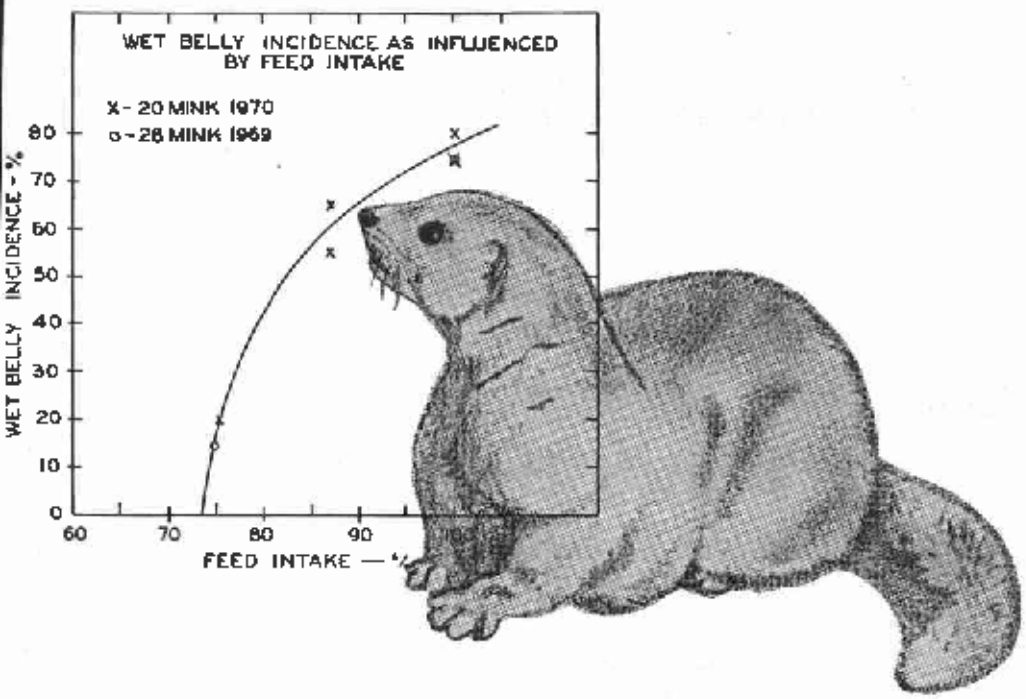
MINK RESEARCH

- Controlled Light and Fur Production
- Wet Belly Disease
- Fur Color and Quality

1970 Progress Report



AGRICULTURAL EXPERIMENT STATION
OREGON STATE UNIVERSITY, CORVALLIS

SPECIAL REPORT 353 MAY 1972

Contents

Introduction

This progress report differs from other reports of this series in that it covers the bulk of research with mink conducted at this station during 1970. Previously only certain aspects of the total research program have been covered (progress reports prior to 1968) or the attempt has been made to summarize information on one subject collected over a longer period of time (progress reports 1968-69). Studies included herein are not necessarily complete, but are part of continuing research projects.

Acknowledgments

Financial support, in part, for the three projects comprising this report was obtained from the Mink Farmer's Research Foundation, an organization which, in turn, derives its funds directly from the fur farmer.

Special recognition for significant contributions to this research is accorded Mrs. Nancy B. Wehr, chemist, Department of Animal Science. For assistance in conducting the various feeding trials involved, Ivan Scott and Clifford Thomson, Department of Animal Science, are gratefully acknowledged.

Authors

F .M. Stout is associate professor in charge of mink research and John Adair is superintendent of the Experimental Fur Farm, Department of Animal Science, Oregon State University.

Environmental Factors Influencing the Life Cycle of Mink

Overall objectives of this project are twofold:

1. To determine the effect of individual facets of the total environment on the physiology of the mink; including such factors as light and its various aspects of pattern, spectral emission, and intensity; temperature; humidity; air flow; etc.

2. To attempt to alter the life cycle of the mink so that maximum production can be achieved by controlling various aspects of the environment to which it is exposed.

Time Schedule for Optimum Growth and Furring

Objectives

1. To determine time schedules which will permit optimum body growth and fur development of kit mink raised under conditions of controlled lighting; i.e. can greater body size or improved fur characteristics be achieved by entering animals into light-controlled facilities later in the growth phase?

2. To determine if schedules for dark and mutation mink differ (1969 research indicated poorer fur quality for early furred sapphires and a reversal of fur development, with dark mink priming before sapphires).

3. To determine if there is a sex difference in response to time schedules employed.

4. To determine advantages gained by using controlled lighting to advance furring cycles of barren and low-producing adult females.

Methods

The experimental design in Table 1 gives the breakdown of trial groups by type and sex of mink and time of entry into the controlled light environment.

Each subgroup contained 10 mink kits for a total of 100 darks and 100 sapphires. Selection of animals was at random within type and sex categories except that only one littermate was permitted per group. Initial body weights were balanced for dark males and females. As pen space was not completely available until July 20, sapphire kits were not separated until they were scheduled to enter controlled lighting facilities. Consequently, groups 2A-D were balanced for body weight on July 2. Groups 2G-J were balanced with weights of 2A and B on July 20. (Groups 2E and F were not balanced as a result of an inadvertant failure to weigh the control groups (2A and B) on July 10).

Two light-control facilities were employed for this trial. One (LTC #4) is described in Oregon Agricultural Experiment Station Special Report 320, March 1971. The other (LTC #2) was converted from a conventional-type pelter shed, approxi-

Table 1. Experimental Design

		Time placed under controlled lighting				
		Control (outside)	July 2	July 10	July 20	July 30
Dark	*Male*	1A	1C	1E	1G	1I
	Female	1B	1D	1F	1H	1J
Sapphire	*Male*	2A	2C	2E	2G	2I
	Female	2B	2D	2F	2H	2J

mately 9 x 100 feet in dimension. The roof of the building was sealed to light with plywood and felt roofing paper underlaying aluminum roofing. The sides were of black (light-proof), nylon-reinforced plastic, which could be lifted up from the bottom for cleaning (Figure 1).

Air was forced into the building with a blower and distributed evenly through a plastic air duct running the length of the building. Air was exhausted from two tubes placed on each side of the building beneath and behind the pens. The pipe was open to the outside on either end and light was excluded from entering by use of light traps. The positive air pressure system held the plastic sides taut and prevented their whipping in the wind. Internal light was from a series of incandescent bulbs wired to a time clock. Sawdust was used beneath the pens as absorbent material. Water was provided semi-automatically from a pipe and cup arrangement.

Control groups (1A,B; 2A,B) were raised in a conventional, outside pelter shed. Animals raised in either of the light-controlled units were given six hours exposure to artificial light (9 a.m. until 3 p.m.) from the date they entered the facility until they were pelted. An exception to this occurred in LTC #2 when three 100-watt light bulbs were inserted into a second circuit not connected to the regular on-off cycle. These were in place from September 2-10 and provided partial illumination for 24 hours per day during this period.

All animals received the rations shown in Table 2 from July 24 until they were pelted.

Table 2. Control Ration Composition

Ingredient	July 24 to Oct. 21	Oct. 22 to Pelting
	%	%
Chicken offal	33	33.0
Tripe	10	10.0
Rockfish carcass	33	33.0
Lard	1	1.0
Molasses, cane	5	0
Oat groats	12	15.3
Wheat bran	6	7.7
	100	100.0
Water	12	21

Vitamin E (d-alpha tocopheryl acetate) was added at 0.010% initially and was increased to 0.013% with the ration change.

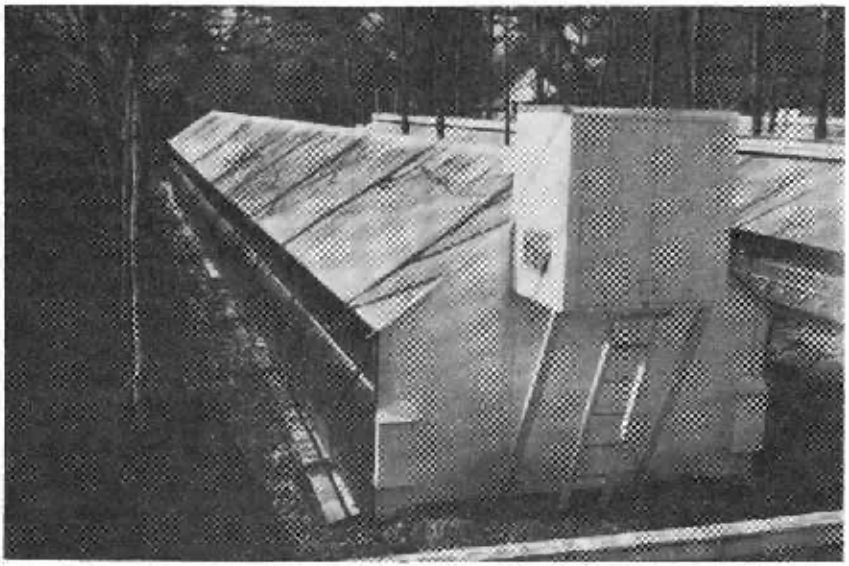


Figure 1

Feeding was *ad libitum* once daily in the afternoon. The following morning, feed not consumed was redistributed to all animals within each group. Daily feed consumption records were maintained with feed not eaten weighed and subtracted from the amount offered. Feed wastage and dehydration losses were not accounted for.

A separate group (70-3) composed of 43 standard, dark and 15 sapphire, adult female mink all of which were either not mated, did not produce kits or lost litters were placed into a light controlled facility (LTC #4) and exposed to 6 hours of light after July 2. On July 24 the attempt was made to change to the ration listed in Table 2 from the breeder ration containing 10 percent beef liver and 10 percent of a dry mixture composed of oat groats, wheat bran, wheat germ, Neo-terramycin, and vitamin E. Many of these animals refused to accept the new ration, so they were replaced on the breeder ration and changed over gradually.

Results

Table 3 gives pelting dates and length of treatment (days in outside and LTC facilities) for darks and sapphire mink respectively. Pelting dates were determined by inspection of live animals. In some cases where there were one or two animals within a group which were obviously not prime they were pelted nevertheless so that pelting dates were not staggered within groups.

Summarized results of these trials are provided separately for dark males, dark females, sapphire males, and sapphire females in Tables 4, 5, 6, and 7.

Growth data (body weight, body length, and pelt length) indicate that in almost every instance males (both darks and sapphires) raised outside under conventional conditions were larger than males reared inside under lighting conditions which accelerate the furring cycle. Further, there appears to be no particular pattern of growth associated with the date when animals were placed in light-regulated facilities. Female size (especially body and pelt lengths) was considerably less affected by accelerating the furring cycle than that of males. Pelt lengths of both dark and sapphire females reared under controlled lights were generally equivalent or longer than those of control females. The exception to this was found in females placed early into the light-controlled facilities. Before definite conclusions can be made further information is required, but these data indicate that

Table 3. Pelting Dates and Length of Treatment

Groups		Treatment	Period (dates)		Treatment length
			beginning	pelted	
Males	Females				Days
Standard Darks					
1A	1B	Control (outside)	Jul. 2	Dec. 10	162
1C	1D	6 hours light	Jul. 2	Oct. 19	110
1E	1F	6 hours light	Jul. 10	Oct. 27 (21)*	110 (104)
1G	1H	6 hours light	Jul. 20	Oct. 27 (22)	100 (95)
1I	1J	6 hours light	Jul. 30	Oct. 27 (22)	90 (85)
Sapphires					
2A	2B	Control (outside)	Jul. 2	Dec. 4	156
2C	2D	6 hours light	Jul. 2	Oct. 19	110
2E	2F	6 hours light	Jul. 10	Oct. 22 (21)	105 (104)
2G	2H	6 hours light	Jul. 20	Oct. 22	95
2I	2J	6 hours light	Jul. 30	Oct. 22	85

* Female values are given in parentheses if they differ from male values.

Table 4. Dark Males (10 each group)

Group No.	1A	1C	1E	1G	1I
Treatment	Outside Control	Light Control Housing 6 Hours Exposure			
Period	Jul. 2 Dec. 10	Jul. 2 Oct. 19	Jul. 10 Oct. 27	Jul. 20 Oct. 27	Jul. 30 Oct. 27
Feed consumption* (lbs/mink)	82.8	43.9	51.2	51.3	49.8
Final weight (g)	2100	1878	1954	1816	1860
Animal length (cm)	42.7	42.0	42.2	42.1	42.7
Pelt weight (g)	116	100	106	103	113
Pelt length (cm)	73.3	71.2	71.6	70.4	73.3
Fur color (score)	2.60	3.00	2.70	2.50	2.80
Fur quality (score)	1.90	2.40	2.50	2.20	2.10
Length, guardfur (mm)	24.4	24.6	24.5	23.8	23.7
Length, underfur (mm)	13.4	13.4	13.0	13.1	12.9
Wet belly incidence (%)	80	70	40	50	50
Wet belly severity (score)	2.25	2.14	1.50	1.20	1.20
Unprime-general (%)	0	30	60	30	20
Unprime-hip (%)	20	10	10	40	40
Unprime-specific area (%)	60	30	60	50	50
Losses (no.)	0	0	0	0	0
Est. pelt value ($)	12.69	11.67	10.26	12.22	14.04

NOTE: Values represent group averages.

* From July 28 to pelting.

Table 5. Dark Females (10 each group)

Group No.	1B	1D	1F	1H	1J	3*
Treatment	Outside Control	Light Control Housing 6 Hours Exposure				
Period	Jul.2 Dec. 10	Jul. 2 Oct. 19	Jul. 10 Oct. 21	Jul. 20 Oct. 22	Jul. 30 Oct. 22	Jul. 2 Oct. 20
Feed consumption** (lbs/mink)	56.1	29.7	33.2	35.2	49.8	.....
Final weight (g)	1150	1063	1030	1094	1077	1075
Animal length (cm)	35.9	36.0	36.2	36.7	35.8	36.1
Pelt weight (g)	62	55	61	61	63	66
Pelt length (cm)	59.2	58.5	58.3	59.2	59.5	60.0
Fur color (score)	2.60	2.80	2.30	2.70	2.00	2.35
Fur quality (score)	2.00	2.20	2.10	2.20	2.10	2.05
Length, guardfur (mm)	22.6	22.0	21.7	21.4	22.1	.....
Length, underfur (mm)	12.3	11.6	12.1	11.8	12.0	.....
Unprime-general (%)	10	10	20	30	10	30
Unprime-hip (%)	0	0	10	20	10	25
Unprime-specific area (%)	30	30	30	20	20	43
Losses (no.)	0	0	0	0	0	3
Est. pelt value ($)	7.75	6.76	6.66	6.14	7.04	7.37

NOTE: Values represent group averages.

* Group 3 differs from other groups and is comprised of 43 adult, dark females.

** From July 28 to pelting.

Table 6. Sapphire Males (10 each group)

Group No.	2A	2C	2E	2G	2I
Treatment	Outside Control	Light Control Housing 6 Hours Exposure			
Period	Jul.2 Dec.4	Jul.2 Oct.19	Jul. 10 Oct. 22	Jul. 20 Oct. 22	Jul. 30 Oct. 22
Feed consumption* (lbs/mink)	93.8	53.7	55.4	56.8	57.1
Final weight (g)	2267	1984	1884	1863	1913
Animal length (cm)	44.5	43.6	42.8	42.7	43.5
Pelt weight (g)	109	102	91	93	102
Pelt length (cm)	72.4	69.4	67.6	67.3	69.5
Fur quality (score)	2.11	1.80	1.80	2.20	1.80
Length, guardfur (mm)	25.3	24.7	24.3	23.9	24.4
Length, underfur (mm)	14.6	13.5	14.0	13.6	14.1
Wet belly incidence (%)	100	30	20	0	0
Wet belly severity (score)	2.40	1.00	1.50	0	0
Unprime-general (%)	0	10	0	20	0
Unprime-hip (%)	0	0	0	0	0
Unprime-specific area (%)	0	0	0	0	0
Losses (no.)	0	0	0	0	0
Est. pelt value ($)	13.21	14.04	14.60	13.61	17.12

NOTE: Values represent group averages.

* From July 28 to pelting.

Table 7. Sapphire Females (10 each group)

Group No.	2B	2D	2F	2H	2J	3*
Treatment	Outside Control	Light Control Housing 6 Hours Exposure				
Period	Jul. 2 Dec. 4	Jul. 2 Oct. 19	Jul. 10 Oct. 21	Jul. 20 Oct. 22	Jul. 30 Oct. 22	Jul. 2 Oct. 20
Feed consumption** (lbs/mink)	62.2	32.0	36.2	36.5	37.5	.....
Final weight (g)	1048	1044	1025	1078	1050	1029
Animal length (cm)	36.9	36.2	36.1	36.3	36.9	36.8
Pelt weight (g)	57	50	51	54	55	57
Pelt length (cm)	55.5	55.1	55.9	56.1	55.7	58.0
Fur quality (score)	1.90	1.90	1.90	1.70	1.80	1.67
Length, guardfur (mm)	23.0	22.2	22.5	22.9	23.0	.....
Length, underfur (mm)	13.1	13.0	13.0	13.3	12.8	.....
Unprime-general (%)	0	0	10	0	0	0
Unprime-hip (%)	0	0	10	0	0	0
Unprime-specific area (%)	0	0	0	0	0	0
Losses (no.)	0	0	0	0	0	0
Est. pelt value ($)	5.46	6.29	7.12	7.46	7.30	7.75

NOTE: Values represent group averages.

* Group 3 differs from other groups and is comprised of 15 adult sapphire females.

** From July 28 to pelting.

size of males (especially) is not improved by delaying entry into light-controlled facilities.

Fur characteristics of dark mink raised under light-controlled conditions were generally below those of control mink raised conventionally. Average fur color scores of dark males (as judged by professional fur graders) were variable but generally lower than for controls. Female color scores were inconsistent with two groups below and two groups above the controls. There was no consistent trend recorded that could be attributed to time of entry into controlled-light facility. Fur quality scores (rated subjectively) for both dark males and females were below control animals in every case. Previous data on this point has indicated that quality was equivalent in mink reared either way. Some of the present observations may be explained by the unintended continuous exposure of groups 1E, F, G, and H to light for a week. This had the effect of severely retarding priming in certain but not in all mink in these groups. Sapphire mink raised under light control, on the other hand, showed generally equal or improved fur quality as compared to animals raised conventionally, which is in opposition to results of 1969 (Mink Farmers' Research Foundation Progress Report, 1970) where darks were equal or better and sapphires poorer. Results of this trial indicate that the matter of fur quality is not fully settled and needs further investigation. A consistent observation, both with dark and with sapphire mink, is that fur tends to be shorter when the furring cycle is advanced. Guard and underfur length of dark males measured shorter as the time taken into the light-controlled facility was later. Fur length of dark females was also shorter, but length did not relate to time moved into light facility. Sapphire males raised inside averaged approximately 4 and 5½ percent shorter guard and underfur respectively and sapphire females 1½ and ½ percent shorter than control males and females. In neither case did fur length relate to the time the animals were placed under control lighting. An interesting but unexplained observation was that in every case, except for dark females, estimated pelt prices of animals taken into light-controlled facilities last (July 30) were higher than for other groups of the same type mink whether raised inside or outside. This effect cannot be explained entirely by size or fur characteristics, although a lessened wet belly incidence is no doubt involved.

There were no appropriate controls for the barren and low-producing adult females furred early (group 3), but results with these animals indicate advantages to be gained and no particular problems from this management scheme.

Determination of Light Intensity Threshold

Objective

This study was to determine the amount of extraneous light required to interrupt the furring cycle which has been accelerated by regulating the light environment of the mink.

Methods

Four groups of 5 each, randomly selected, standard-dark, male mink kits were placed in a light-controlled environment facility as described in Special Report 320 (Agricultural Experiment Station, Oregon State University, March 1971) and were subjected to the light treatments outlined in Table 8. A fifth group serving as a control was reared outside under conventional conditions.

Basic light exposure was well controlled but there were problems encountered with extended light exposure. Intensity differences were achieved using a rheostat dimmer control in the circuit. It was soon noted that ordinary line voltage fluctuations made it impossible to maintain a steady light intensity, espe-

cially at the lowest and to some extent at the intermediate intensity level. In many instances the lights of the lower intensity extended system would actually go out, exposing the animals to even less light than intended.

The ration and feeding management used for all animals were those described in the first part of this report.

Results

Animals in these groups were pelted at varying times according to Table 9. Group 6A, receiving 6 hours of light only, was pelted October 19, which corresponded to other, similar groups with accelerated furring cycles. Group 6B, receiving a minimal amount of extended light, was pelted on November 4 to demonstrate the interrupting influence of the minute amount of additional light. The three other groups were pelted on December 10, during the period when mink are normally prime. Data compiled from these groups are summarized in Table 9 and photographs of the dried pelts of each group are also provided (Figures 2-6).

The results of this trial are fairly well evident from the photographs. Group 6A animals served as a control representing mink exposed to a shortened daylight schedule in a facility with no source of extraneous light. These furred up as expected. One animal showed some general unprimeness on the belly side—a condition which probably would have improved with a little more time. Group 6B animals exposed daily to a minimal intensity of light for a period corresponding to normal daylight (although this extra light was provided somewhat spo-

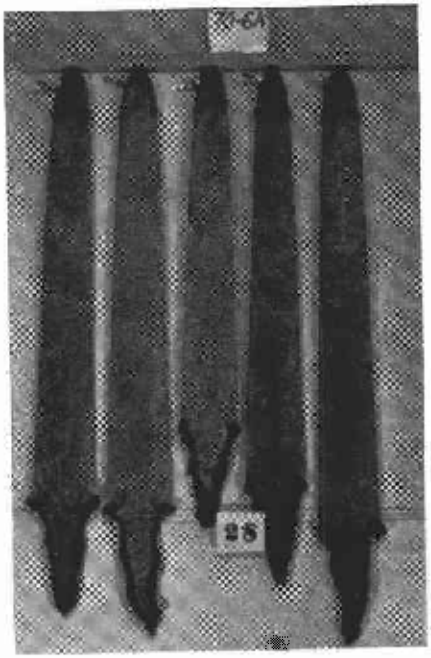


Figure 2-Group 6A. Six hours basic light (pelted October 19). Pelts extending below the 28" line are classed as no. 1's (International scale).

Table 8. Experimental Design

Group	Light Treatment
70-6A	6 hours basic light only*
70-6B	6 hours basic light plus extended light, intensity 1**
70-6C	6 hours basic light plus extended light, intensity 2**
70-6D	6 hours basic light plus extended light, intensity 3**
70-6E	Normal outside conditions

* The 6 hour basic light from 9 a.m. to 3 p.m. was from fluorescent bulbs controlled by a time clock.

** Extended light was from incandescent bulbs with on-off cycles programmed to normal daylight schedules of 45° N latitude.
Intensity 1 was equivalent to 1 foot candle of light measured at the bulb, intensity 2 was 16 foot candles and intensity 3 was 256 foot candles. These figures are relative only and considerably less light reached the mink which were located 2½ feet below and at varying lateral distances from the light source.

Table 9. Light Intensity Threshold
Dark Male Mink Kits
(5 each group)

Treatment	6A	6B	6C	6D	6E
Basic light	Six Hours				
Extended light* (Intensity)	None	1	2	3	Outside control
Time begun Time pelted	Jul. 2 Oct. 19	Jul. 2 Nov. 4	Jul. 2 Dec. 10	Jul. 2 Dec. 10	Jul. 2 Dec. 10
Final weight (g)	1742	1940	1968	1980	2058
Animal length (cm)	41.0	41.4	41.6	42.0	41.5
Pelt weight (g)	91	108	111	111	113
Pelt length (cm)	68.8	70.9	73.0	71.5	72.6
Fur color (score)	3.00	2.40	2.00	2.00	2.60
Fur quality (score)	2.40	2.80	2.40	2.00	1.80
Wet belly incidence (%)	60	60	100	40	100
Wet belly severity (score)	2.00	1.67	1.80	1.00	1.80
Unprime-general (%)	20	40	40	0	0
Unprime-hip (%)	20	20	40	20	20
Unprime-specific area (%)	0	60	80	40	60
Losses (no.)	0	0	0	0	0
Est. pelt value ($)	11.18	10.46	12.76	18.54	12.80

* Extended light, given for a period corresponding to normal daylength at 45° N latitude.

NOTE: Values represent group averages.

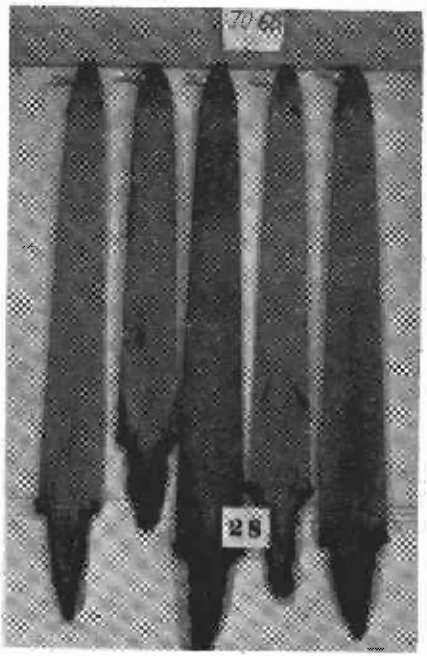


Figure 3-Group 6B. Six hours basic light + extended light intensity 1 (pelted November 4)

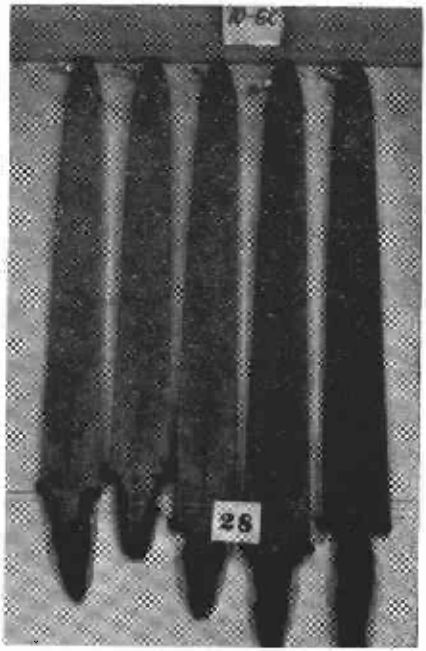


Figure 4-Group 6C. Six hours basic light + extended light intensity 2 (pelted December 10)

radically as mentioned previously) showed considerable variation in fur development. Two animals were classed as generally unprime and a third as unprime over the hip region. This experimental group indicates that even extremely minute amounts of light disrupt the accelerated furring cycle. There was 1 foot candle of light at the source and the amount reaching the mink was too low to be measured even with a light meter sensitive to 0.002 foot candles. This same effect is evident with animals in group 6C which received additional light equal to approximately 16 times the intensity of extended light provided to group 6B. Two of these mink were generally unprime and two showed specific areas of unprimeness; one was completely prime. A point of considerable interest is that these pelts remained unprime even in December when animals exposed to considerably more light intensity for an equivalent daily period (outside conditions) are normally prime. This is especially interesting in view of the results noted with group 6D, receiving the highest intensity of extended artificial light. Four of these pelts were completely prime and one showed a slight unprimeness in the area of one hip. These observations suggest that small amounts of extended light may interfere not only with the accelerated furring cycle but perhaps also with the normal furring cycle. Results noted with group 6E, raised outside and serving as a control, tend to obscure the issue to some extent as there was one animal showing severe unprimeness in the hip region and another with unprimeness in a specific area. These unprime pelts cannot be considered as normal for this late in the season, although late priming is somewhat characteristic of this dark herd.

Results of this limited trial are not conclusive, but do provide an indication that even minimal amounts of extended light may disrupt accelerated

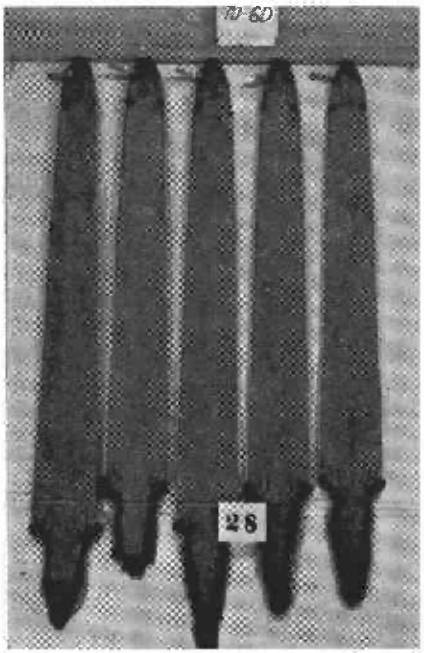


Figure 5-Group 6D. Six hours basic light + extended light intensity 3 (pelted December 10)

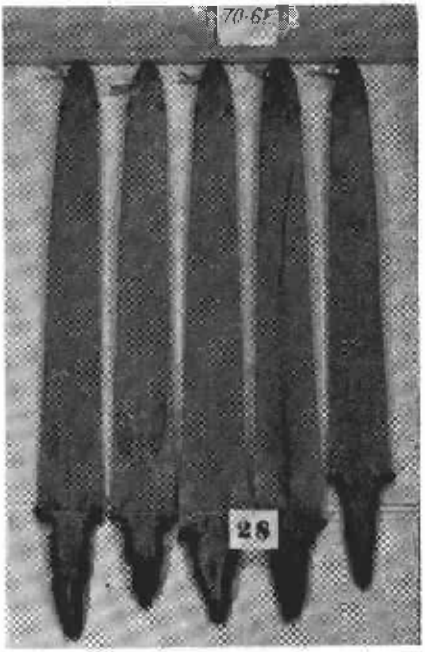


Figure 6-Group 6E. Control-outside light (pelted December 10)

and possibly normal furring cycles. Additional experiments should be conducted using equipment providing better control over experimental conditions.

Breeding Experiments

Objective

This experiment was designed to determine lighting patterns which will permit the return of young male and female breeder mink raised under conditions of shortened daylength using artificial light to a normal breeding cycle. One of the proposed major drawbacks of early fur production through light control is the disruption of normal breeding cycles in animals kept as breeders.

Methods

Ten standard-dark male (5 adult proven sires and 5 kits) and 50 standard-dark kit female mink were selected for this experiment at random from the OSU normal dark herd, except for adult males which were preselected. All animals were placed on July 2 into LTC facility #4 described previously and received 6 hours of artificial light daily until October 21 at which time they were in the winter pelage. Other experimental groups raised under these same conditions were pelted on October 19 (described previously). At this time the large group was subdivided and the smaller groups were subjected to the light treatments shown in Table 10.

Rations fed to all animals were those listed earlier in this report.

Results

Lighting patterns and mating periods for each of the three groups are illustrated graphically in Figure 7. The first attempt to mate females in groups 4A and 4B was made on November 10, 20 days after imposition of the changed lighting schedule. Matings were first obtained in group 4B on this date, although semen checks revealed no spermatozoa. It was possible to get only 6 matings from 17 females in group 4B. These matings were made between November 10 and December 3. It was noted that males appeared to be infertile until the latter part of this period. No kits resulted from these matings.

One mating was obtained in group 4A on December 3, 40 days after changing the light treatment. No further matings were made until January 25. Thereafter until February 24, 14 of 17 females were bred. The mating period lasted for 30 days not considering the initial mating made in December. Four single, 8 double, and 2 triple matings were made. Nine of the 14 females mated whelped during the seven-day period between April 8 to 15. Gestation period averaged 58.8 days with a range of from 49 to 67 days. Forty total kits resulted (4.44 kits/litter) with 39 born alive (4.33 kits/litter).

Group 4C, kept under 6 hours light until December 21 and then returned

Table 10. Experimental Design

Group	Animals	Light Treatment
70-4A	Males—2 adults, 1 kit Females—17 kits	Outside conditions on and after October 21
70-4B	Males—2 adults, 2 kits Females—17 kits	16 hours artificial light (LTC #4) on and after October 21
70-4C	Males—1 adult, 2 kits Females—16 kits	6 hours artificial light LTC #2, October 21-December 21; outside conditions after December 21

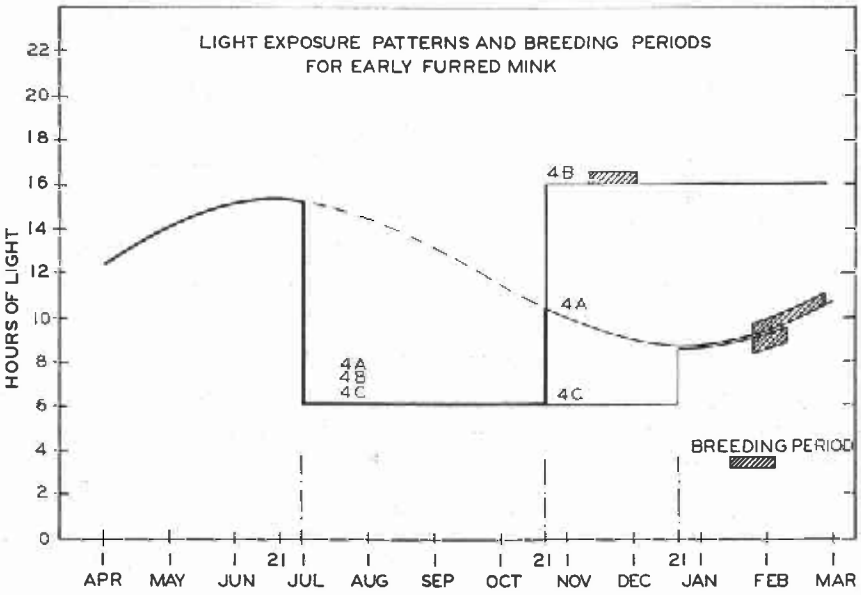


Figure 7

to a normal light environment, were first mated on January 25. The mating period was relatively short, lasting for 15 days until February 9 after which no further matings could be made. Thirteen out of 15 females were mated in this group; 6 were single matings, 6 were double, and 1 was triple. Seven out of the 13 mated females whelped between March 29 and April 6. One female died on April 7 which contained 11 kits *in utero*. Average gestation period was also 58.8 days and the range was 53 to 69 days. Thirty-seven kits resulted from these matings (4.62 kits/litter) with 25 born alive (3.57 kits/litter). These results are summarized in Table 11.

Table 11. Reproductive Performance

Group	Treatment	Mating Period	Length (days)	Whelping period	Ave. Gestation Length (days)
70-4A	Outside, Oct. 21	Jan. 25[1]-Feb. 24	30	Apr. 8-15	58.8
70-4B	Inside, 16 hours	Nov. 10-Dec. 3	23	.....	.....
70-4C	Outside, Dec. 21	Jan. 25-Feb. 9	15	Mar. 29-Apr. 6	58.8

Group	Total Females	Losses	Mated	Whelped	Total Kits	Kits alive
	No.	No.	No.	No.	No.	No.
70-4A	17	0	14	9	40	39
70-4B	17	1	6	0	0	0
70-4C	16	2[2]	13	7	37[3]	25

[1] See text for exception
[2] One female died immediately prior to whelping (11 kits were *in utero*).
[3] Includes 11 dead *in utero*.

In general, the concept of returning early furred breeder females to a normal light environment between the fur priming date of October 21 and December 21 as illustrated by groups 4A and 4C shows promise, although reproductive efficiency could be improved. Kits resulting from females exposed to these light patterns were born approximately two to four weeks prior to those of the unregulated herd. A drastic increase in the amount of light received by early furred females also resulted in matings, however these were not fertile. These data indicate that it should be possible to coincide the breeding activity of early furred animals with that of animals raised under a more normal environment, but that additional research on this problem is required.

Factors Causing Wet Belly Disease in Mink

Broad objectives of this research are to investigate the cause(s) of wet belly (WB) disease from the standpoint of fundamental biological and/or biochemical mechanisms involved and to develop practical means of control.

Practical Control of Wet Belly

Feed Restriction Studies

Objectives

It has been noted here repeatedly that the incidence and severity of WB increases in a linear manner with the body weight of the animal. Since body weight can be easily and effectively controlled by regulation of feed intake, this approach to WB control has been pursued. Experiments in 1969 indicated that restrictions of feed consumption by highly susceptible, dark male mink kits to 75 percent of a control group offered feed *ad libitum* reduced occurrence of WB by approximately 5 fold.

Objectives of current experiments were to confirm earlier results and to check the effect on WB of using feed levels intermediate to 75 and 100 percent. Since mink raised under conditions of lighting controlled to accelerate the furring cycle are smaller and appear to exhibit fewer WB symptoms, it was considered of interest to check the effect of feed restriction on further limiting WB under these conditions.

Methods

The experimental design for this study is shown in Table 12. Each of these 5 groups was composed of 20 dark, male mink kits selected randomly except that only one littermate was allowed per group. Average initial body weights for groups 7G, H, and I animals were balanced with each other. These were slightly higher than initial weights of groups 7J and 7K which were balanced with each other. Animals in groups 7J and 7K were raised in light-controlled housing, unit #4 (facility described under the section entitled Environmental Factors Influencing the Life Cycle of the Mink) and received only 6 hours daily illumination. Animals in the three other groups were reared in similar type pens but in open housing exposed to normal daylight.

Table 12. Experimental Design—Feed Restriction Study

Group No.	7G	7H	7I	7J	7K
Housing	Conventional (outside)			LTC (inside)	
Ration	Control			Control	
Feed Intake %	100	87	75	100	87
Period	July 2-Dec.15			July 2-Oct. 20	

Composition of the control ration used for all groups is given in the previous section dealing with controlled light. Note that animals furred early (groups 7J and 7K) were pelted before the ration change was instituted. The ration change was made in order to firm up the animals' droppings to prevent the possibility of dirty pens and stained pelts. This ration was fed daily in the afternoon and remaining feed was redistributed within the group the following morning. Groups 7G and 7J received the ration *ad libitum*. Feed consumption of group 7G served as a base level for groups 7H and 7I which were restricted to 87 and 75 percent of this amount respectively. Group 7J, also fed *ad lib.*, served as the base level for group 7K which received 87 percent of this amount. It was not considered desirable to have a group raised under light controlled conditions restricted to 75 percent intake in view of the stress already imposed from accelerating the life cycle. Water was available to animals constantly from an automatic watering system. All animals were pelted; those in groups 7J and 7K on October 20 and those in groups 7G, H, and I on December 15. Pelts were prepared leather side out so that the WB pigment spot would be readily apparent.

Results

Data from this study are summarized in Table 13. Photographs (Figures 8 through 12) of the belly side of pelts show the extent of WB for each group.

Restricted feed levels resulted in significantly reduced body growth rates and final body weight as is apparent from growth curves presented in Figure 13. Further data on final body size of animals within each group is shown in Table 14.

These data indicate that restriction of feed had a marked, though nonlinear, effect on final body weight. Final weight was lowered approximately 10 percent when feed intake was reduced from 100 to 87 percent. However, decreasing feed intake another 12 percent to 75 percent of the *ad lib.* level further reduced body weight by about 18 percent. This is to be expected since the first increment of restriction from an *ad lib.* level contributes primarily to fattening, whereas subsequent increments are more involved with development of muscle and other essential body tissues. Reducing feed intake has a similar curvilinear effect on reducing WB; i.e., the first increment of restricted feed has a considerably lesser effect on lowering WB occurrence than do subsequent increments. This curvilinear

Table 13. WB Occurrence—Feed Restriction Study

Group	7G	7H	7I	7J	7K
Housing	Conventional (Outside)			LTC (Inside)	
Feed intake %	100	87	75	100	87
Total No. Mink	20	20	20	20	20
No. Affected WB	15	11	4	16	13
% Affected WB	75	55	20	80	65
Ave. WB Severity*	2.00	2.00	1.50	1.75	1.38
Overall WB Severity**	1.50	1.10	.30	1.40	.90

* Severity of WB was scored from the pelt (dried leather side out) on a scale from 1 to 3; a 1 was assigned to cases of less than one inch in diameter, 2 was assigned to WB varying in diameter from one to two inches, and 3 for a WB area larger than two inches in diameter.

** Represents the average WB severity of all animals, affected or not, within the group.

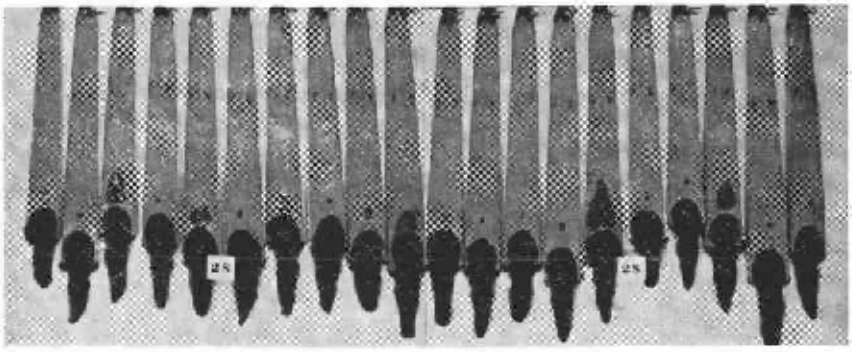


Figure 8-Group 7C. Raised conventionally, ration intake *ad libitum* (100%)

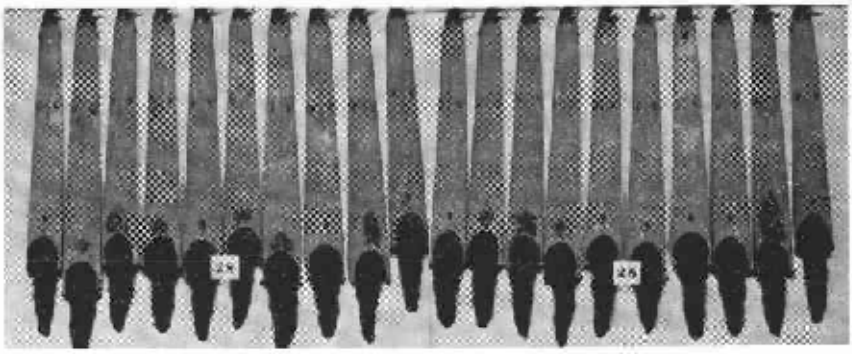


Figure 9-Group 7H. Raised conventionally, ration intake restricted to 87% of 7C

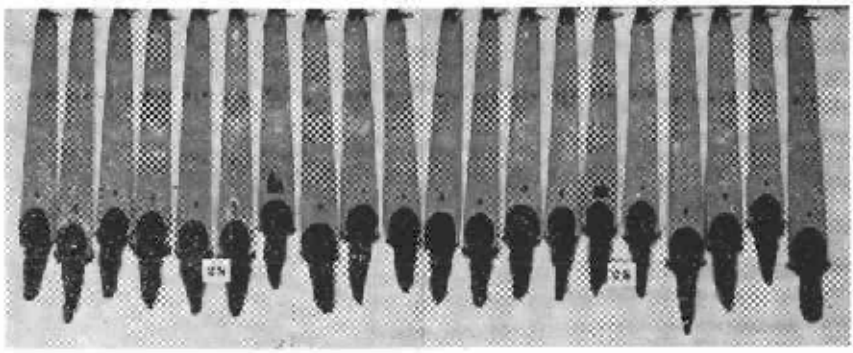


Figure 10-Group 7I. Raised conventionally, ration intake restricted to 75% of 7C

relationship is well illustrated in Figure 14 in which data on WB incidence are plotted against feed intake for both 1969 and 1970 experiments with feed restriction. The statistical analysis has not been completed, but note that the points fit the line very well.

Figure 15, plotted from the same two experiments, illustrates the almost perfect straight line relationship between WB incidence and final body weight. Actually the data describe two lines almost parallel to each other. These curves indicate that mink

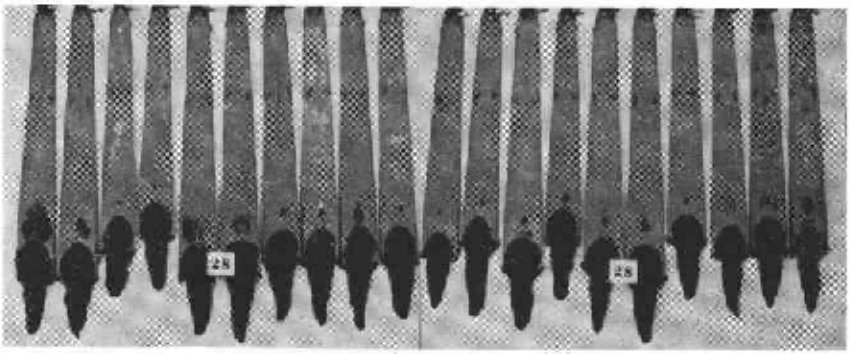


Figure 11-Group 7J. Raised under control lighting, ration intake ad libitum (100%)

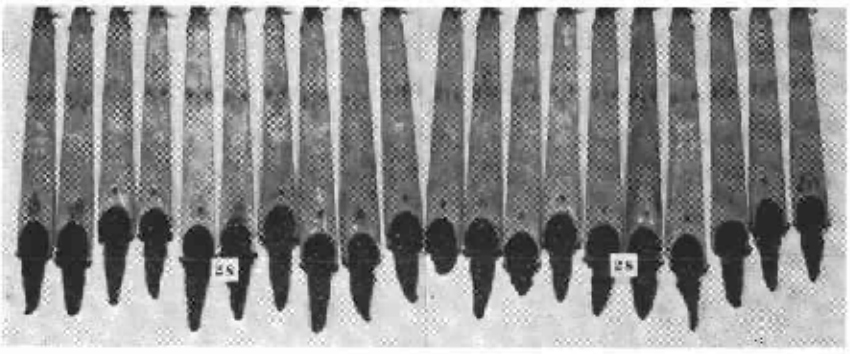


Figure 12-Group 7K. Raised under control lighting, ration intake restricted to 87% of 7J

Table 14. Body Size—Feed Restriction Study

Group	7G	7H	7I	7J	7K
Housing	Conventional (Outside)			LTC (Inside)	
Feed intake %	100	87	75	100	87
Final body weight (g)	2114	1903	1533	1902	1753
Weight gain (g)	820	639	332	759	592
Carcass length (cm)	43.3	42.5	42.1	41.5	41.2
Pelt length (cm)	73.9	71.7	67.4	72.0	70.5
Pelt weight (g)	118	107	91	99	94

placed under light-controlled conditions actually exhibit a higher level of WB per unit of body weight than do mink raised conventionally, although the severity of WB for the former group is reduced. This observation may provide a clue as to the fundamental cause of WB. By extrapolating these curves one could predict that all WB symptoms would disappear by restricting feed intake to approximately 73 percent or by raising males averaging 1,300 grams.

It is possible to conclude at this point with considerable assurance based on several years of confirmatory data that WB can be controlled by restricting the level of feed intake by the animal or by limiting certain nutrients, such as fat, in the diet so that

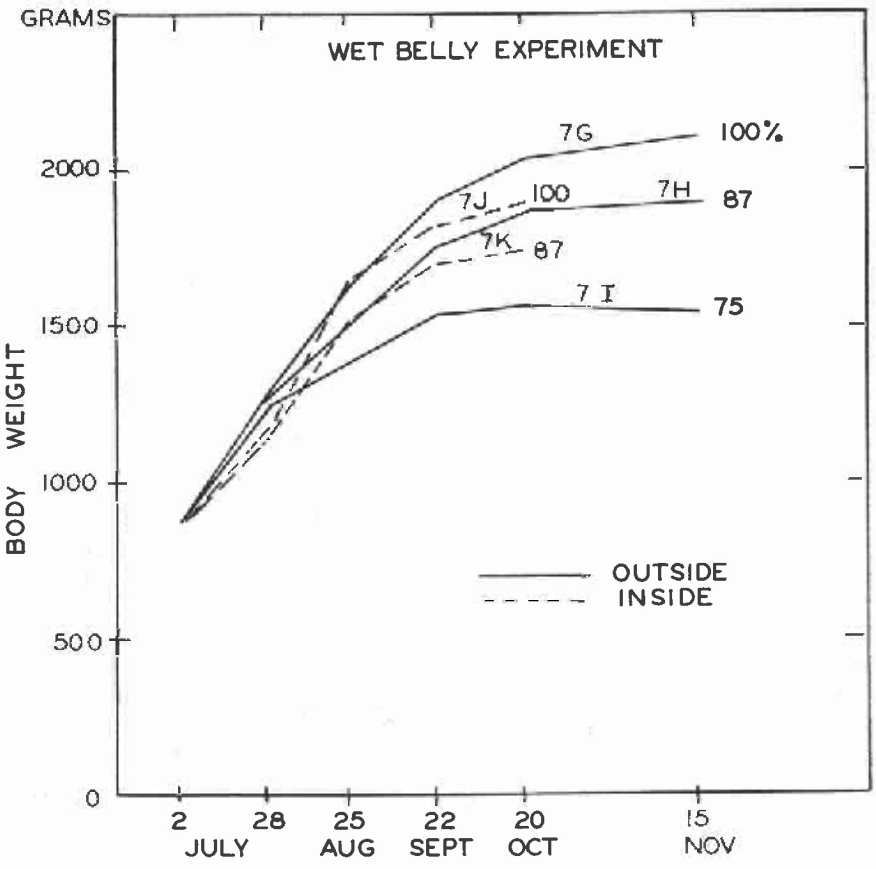


Figure 13

body weight will be lowered. This solution, though simple, may not be entirely satisfactory as compromises in pelt size have to be made. The effect of feed restriction on fur characteristics appears to be minimal and these data are presented in the section entitled "Factors Influencing Fur Color and Quality in Mink."

Salt Addition Studies

Objectives

Previous research data from this station (Mink Farmers Research Foundation Progress Report, 1969) indicate that male mink affected with WB excrete a lesser quantity of a higher dry matter, more viscous urine than do non-WB affected animals. In view of these findings it was considered worthwhile as a practical WB control measure to attempt to increase urinary output and thus lower urine dry matter and viscosity levels. The following experiment was conducted pursuant to these objectives.

Methods

Two experimental groups, 7A and 7B, consisting of 15 standard-dark, kit males each were set up. These animals were selected randomly except that only one littermate was allowed per group. All animals were housed and raised in a conventional manner. Water was constantly available from an automatic watering system and feed was offered *ad libitum* once daily. The ration fed to group 7A, which

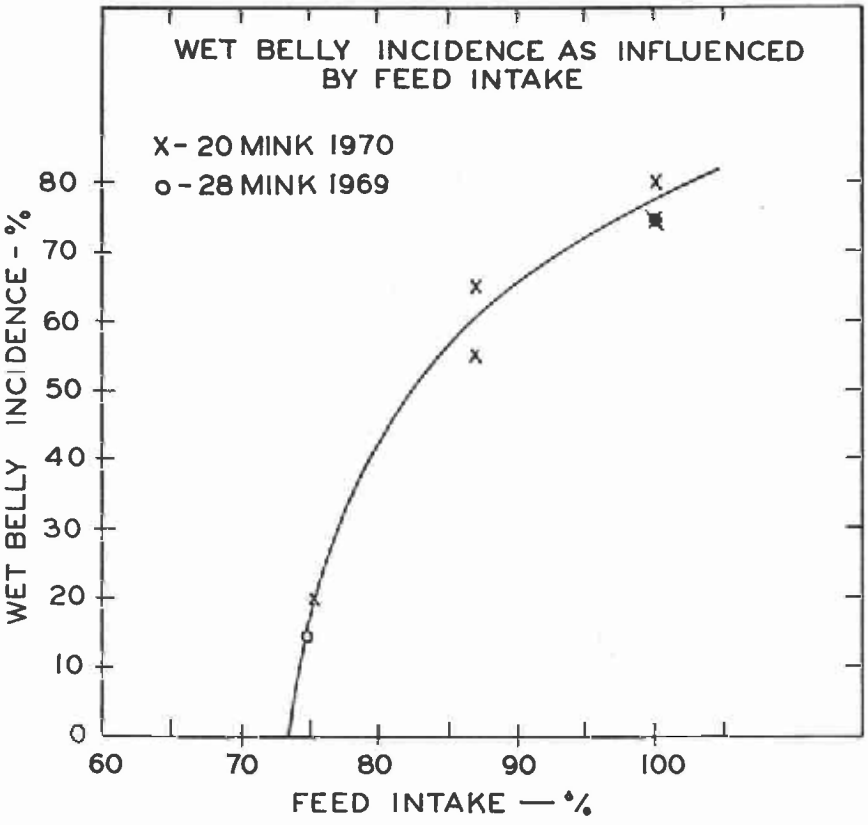


Figure 14

served as a control, was similar to that described earlier in this report. Ration composition for group 7B was identical to that fed 7A except that 1 percent of table salt (NaCl) was added.

Results

General results of this trial are summarized in Table 15.

Figures 16 and 17 are photographs of the belly sides of pelts of animals in each group showing the individual occurrence and extent of WB.

Growth curves of animals in each group are presented in Figure 18. Data collected show an average of 68.8 pounds of feed intake per animal from July 27 to December 15 for group 7A (control) animals as compared to 62.2 pounds intake per animal for the salt supplemented mink (group 7B) during the same time period. According to data presented earlier in this report this 7 percent reduction in feed intake would be expected to reduce average body weight by approximately 5 percent—a 4 percent decrease was observed. A probable conclusion then is that the difference in body weight observed results from the decreased feed intake of salt supplemented animals. It is presumed that the decrease in feed consumption noted relates directly to a lower palatability of the salt-containing ration.

Based on curves developed from data presented earlier in this report, a 4 percent decrease in body weight would be associated with a decrease in overall WB severity of from 1.67 to approximately 1.54, however the

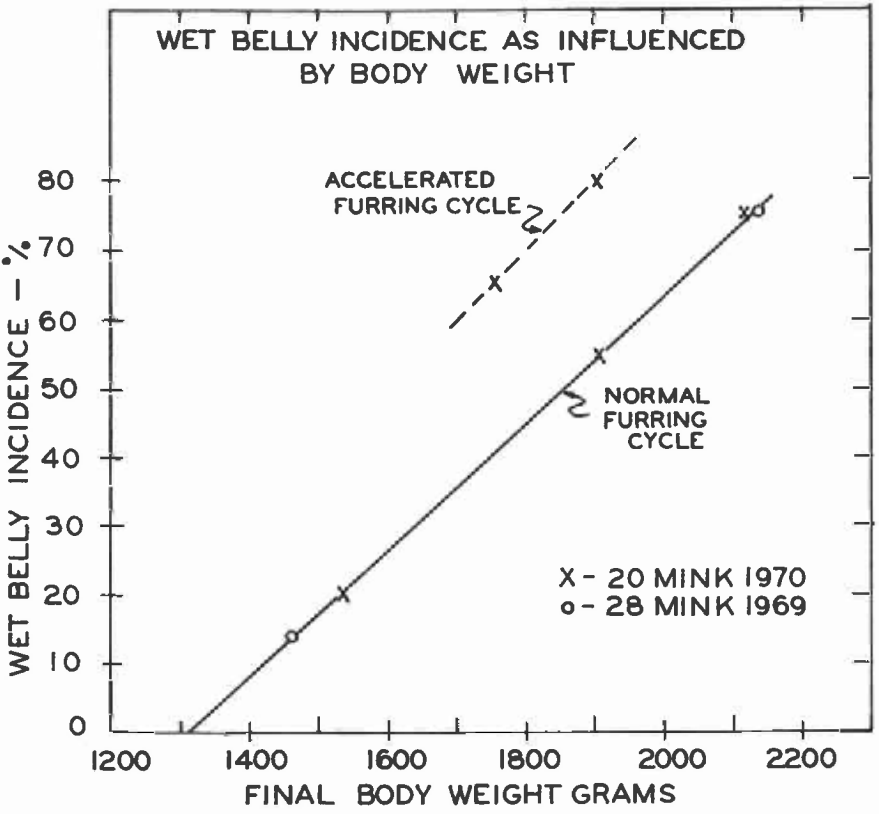


Figure 15

Table 15. Results—Salt Supplementation

Group	7A	7B
Treatment	None	1% Dietary salt
Total No. Mink	15	15
No. Affected WB	11	11
% Affected WB	73	73
Ave. WB Severity*	2.27	1.64
Overall WB Severity**	1.67	1.20
Final Body Weight (g)	2209	2127

* Taken from the dried pelt and visually assigned on a scale of 0-3 as noted before.
** Average WB severity of all animals in group.

WB severity level actually observed was 1.20. This indicates an effect greater than that due to merely lowering body weight to the level observed and may be considered as directly resulting from the addition of salt. However, since the ameliorative effect was partial and not complete and since numbers of animals were relatively few this point requires further investigation.

Urine samples were collected from each animal of groups 7A and 7B and preliminary to other tests contem-

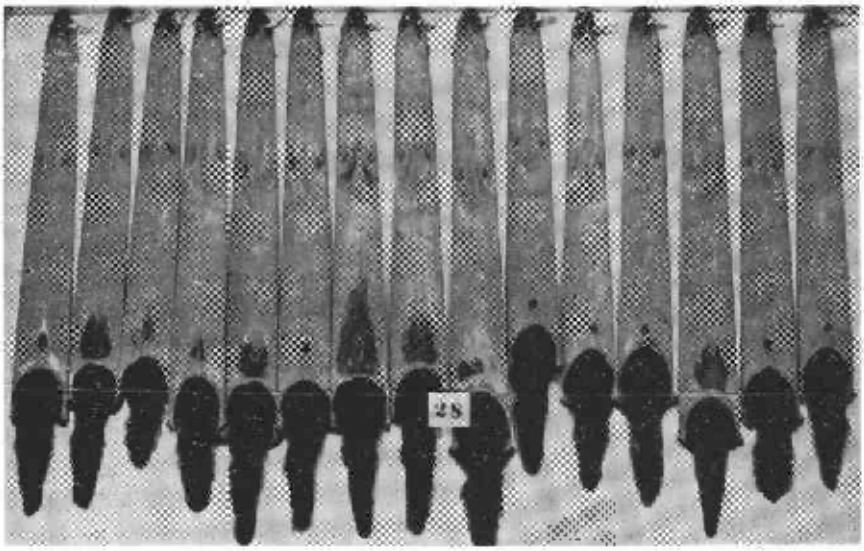


Figure 16-Group 7A. Pelts of dark, male, mink kits which received the control ration, unsupplemented. These were large animals and incidence of WB was high; 73 percent showed an average WB severity of 2.27.

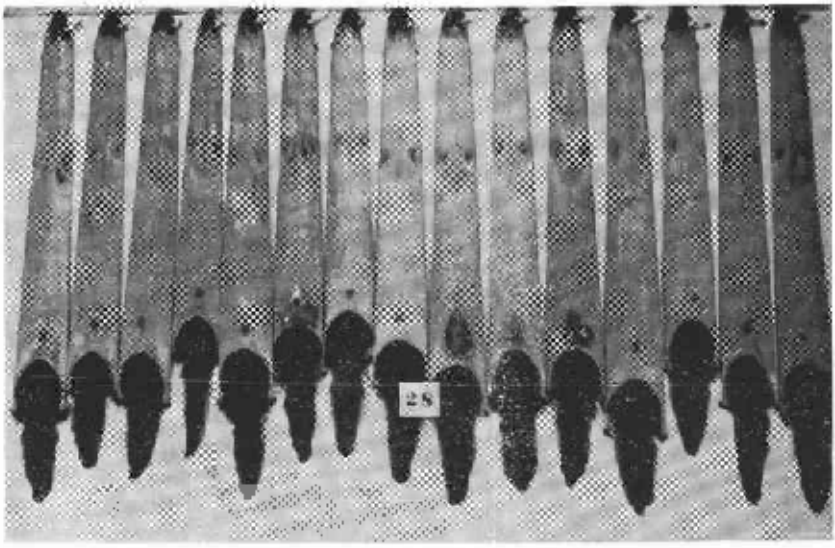


Figure 17-Group 7B. Pelts of dark, male, mink kits which received the control ration supplemented with 1 percent of salt. The percentage of animals affected with WB remained high, however the average severity was reduced to 1.64.

plated were analyzed for total output, relative viscosity, and specific gravity. Each sample represents a 24-hour collection period. Generally three samples were collected from each animal, however, in some cases additional collections were made. When samples were suspected to be contaminated with fecal material or with drinking water, results obtained were not con-

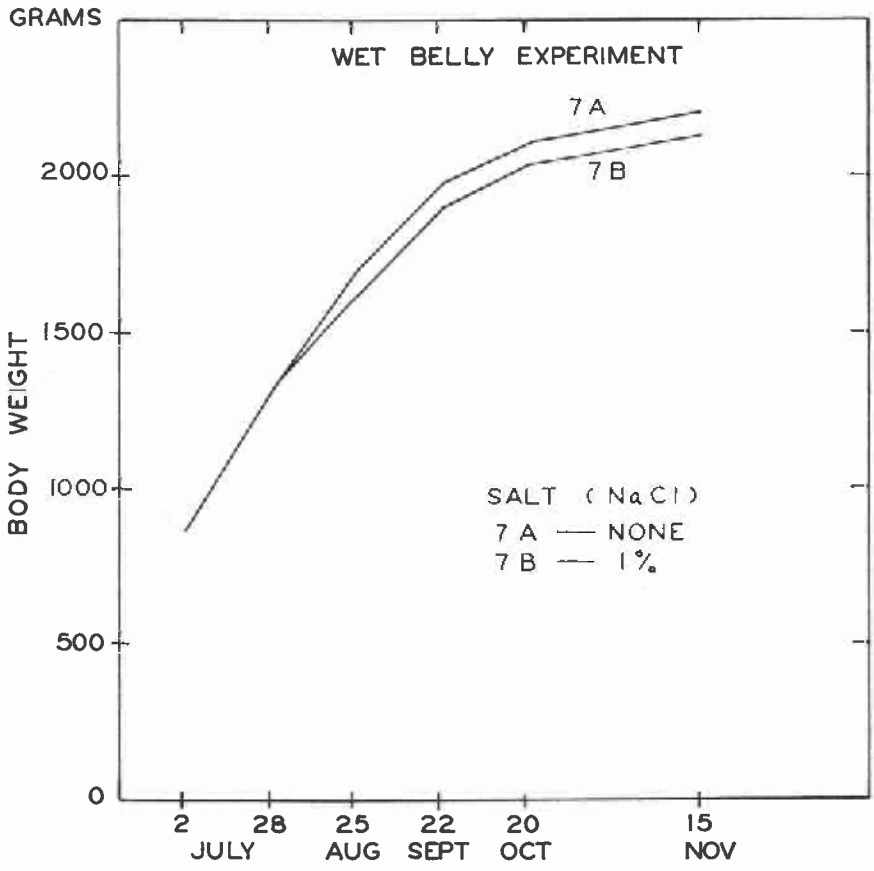


Figure 18

sidered in calculating averages. Collection methods are discussed later in further detail. Average values obtained for the three measurements taken appear in Table 16.

These data indicate that supplementation of the mink ration with 1 percent of NaCl did increase urinary output and decrease urine viscosity as desired. The effect of altering urine composition to this extent on WB control, however, was generally less than anticipated. This may possibly relate to the level of salt used and further experiments should check this.

Fundamental Cause of Wet Belly

Whereas the foregoing studies are oriented toward control of WB symptoms and to providing practical solu-

Table 16. Average Urine Data

Group	24 hour output (grams)	Relative viscosity	Specific gravity
7A (no salt)	40.2±17.0*	1.170±0.026	1.056±0.014
7B (1% salt)	64.5±27.5	1.106±0.030	1.044±0.010

* ± values represent standard deviations calculated on animals within the group.

tions to the problem, the ultimate goal is to determine the basic cause of WB. Only by fully understanding the biological and biochemical bases of WB can the problem be solved in a final sense. As a result of previous investigations we have accumulated sufficient evidence to maintain that variation in urine composition is the primary factor in WB causation. There appear, however, to be other factors of lesser magnitude such as time, skin sensitivity, etc. which may modify the effect of the urine. We have hypothesized that certain by-products of metabolism, especially abundant when the animal's metabolic rate is high, spill over into the urine and alter its normal composition. These chemical differences in turn alter physical characteristics of the urine and result in WB.

Objectives

This investigation was undertaken to examine urine samples of both mink known to be free from and affected with WB in order to confirm (using larger numbers of animals) results of last year which indicated increases in urinary dry matter and vicosity levels. A further objective was to thoroughly analyze these urine samples seeking out basic differences in chemical composition. This research is still in progress, but information collected so far is herein presented.

Methods

Ninety male mink were used for collection and comprised experimental groups 7A, 7B, 7G, 7H, and 7I. Rations fed and management procedures used are described in the foregoing section of this report. All urine samples were collected late in the furring cycle (between November 18 and December 15). A multiple tray arrangement enabling 44 samples to be collected at a time was used. A heavy, clear-plastic sheet served to funnel excreted urine into glass jars. Fine-mesh, fiber-glass screens were placed above the plastic as a barrier to feces and other solid materials. Animals were watered from an automatic system with nipples fitted with shields so that excess water was diverted away from the collection tray. Twenty-four-hour urine samples were collected on two or three successive days without cleaning trays between samples. After this period, before trays were moved to another group, the system was dismantled and washed with a detergent soap, thoroughly rinsed with tap water and dried. Urine samples, thus collected, were not always uncontaminated and those suspected, by color and/or volume, of contamination were not included in results presented. Some males routinely urinated to the outside of the pen, consequently no samples were obtained.

Urine samples were weighed and aliquots stored frozen for no more than two months prior to analyzing. Relative viscosity was measured with an Ostwald viscometer. Dry matter values were established by weighing and freeze drying. Animals were sub-

Table 17. Urine Data of Three Experimental Groups Exhibiting Different Levels of Wet Belly

Group	No. of Animals	No. of Samples	WB Incidence (%)	WB Severity	24 Hr. output (g)	Relative viscosity	Specific gravity
7G (*ad lib.*)	20	77	75	2.00	35.0± 12.0*	1.161± 0.022	1.053± 0.010
7H (87% intake)	20	96	55	2.00	36.7± 15.1	1.179± 0.046	1.051± 0.010
7I (75% intake)	20	78	20	1.50	40.6± 10.2	1.187± 0.046	1.052± 0.014

* ± values are standard deviations calculated on means of animals within each group.

Table 18. Urine Data Summarized by Wet Belly Severity Score on Pelt*

WB Severity score	No. of animals	24-Hour output (g)	Relative viscosity	Specific gravity
0	37	38.8±23.9**	1.176±0.077	1.052±0.068
1	18	54.4±42.3	1.138±0.054	1.048±0.015
2	16	38.3±36.6	1.158±0.067	1.052±0.011
3	16	37.7±26.8	1.165±0.072	1.053±0.018
1+2+3	50	43.9±35.5	1.153±0.064	1.051±0.015

* Scored according to system used previously.
** ± values are standard deviations calculated on means of animals within each group.

sequently pelted and wet belly occurrence and extent was taken from the dried pelt prepared leather side out.

Results

Tables 17 and 18 summarize currently available data.

The values presented obviously do not support those obtained and reported last year (Mink Farmers Research Foundation Progress Report 1969). In the first table average daily urine output is lower in groups with more WB, however urine viscosity values appear to increase with lower WB incidence. Data in the second table show an increasing relative viscosity with increasing WB severity, but animals not showing WB had the highest viscosity measurements. These results are unexplainable at this point. It is possible that time of sampling, sample collection methods or other factors confounded the picture as it relates to previously collected data. It is intended to reinvestigate this facet. Further analyses are being made to determine if there are measurable chemical differences among these samples.

Factors Influencing Fur Color and Quality in Mink

Broad objectives of this investigation were to identify and evaluate nutritional, genetic, environmental, and managerial factors which influence the development and expression of fur color and quality in the mink. Pursuant to these objectives, the following areas have been investigated: red hip and fur chewing as caused by multiple factors, cotton-fur from inclusion of formaldehyde in the diet, biotin deficiency related to presence of dietary avidin, and fur color and quality as influenced by feeding management.

Red Hip

Objectives

Experimental objectives were an extension of those of the previous year in which the effect on occurrence and extent of red hip (RH) of several variables including genetics, nutrition and physiology were studied. Genetic variables involved the type of mating (affected x affected and non-affected x non-affected) and percent of red hip susceptible strain; nutritional treatments imposed were *ad libitum* vs. restricted feeding levels and physiological differences involved accelerated and normal furring cycles.

Methods

Mink kits used in this study were from parental stock originating primarily from a RH susceptible strain of pastels but which also carried variable levels of a non-RH susceptible, sapphire strain. Parental stock were selected on the basis of falling either into one of two categories, i.e., affected or non-affected. All matings

Table 19. Experimental Design—Red Hip

	Accelerated Furring (Light Controlled Housing)	Normal Furring (Conventional Housing)
Ration	Group	Group
Ad libitum	9A (13 M, 13 F)	9C (12 M, 14 F)
Restricted	9B (12 M, 14 F)	9D (12 M, 14 F)

were on the basis of combining affected females with affected males and non-affected females with non-affected males. One hundred and four kits resulted from these matings and were allocated at separation on July 20 to experiment according to the design in Table 19.

Animals were selected so that each litter was distributed as evenly as possible to each of the four experimental groups. This provided a fairly even balancing of sex, mating type, and genetic background. All mink were separated into individual pens on July 20 and began to receive experimental rations on July 28. Groups 9A and 9B were reared in a light-controlled facility (LTC #2 as described under the section entitled "Environmental Factors Influencing the Life Cycle of the Mink") providing 6 hours of artificial light daily; groups 9C and 9D were reared in conventional type housing and received a normal light schedule.

Table 20. Ration Composition

Ingredient	July 24 to Oct. 21 %	Oct. 22 to Pelting %
Chicken offal	33	33.0
Tripe, beef	10	10.0
Rockfish carcass	33	33.0
Lard	1	1.0
Molasses, cane	5	0
Oat groats	12	15.3
Wheat bran	6	7.7
	100	100.0
Water	12	21

Vitamin E (d-alpha tocopheryl acetate) was added at 0.010 percent initially and was increased to 0.013 percent with the ration change.

Composition of the control rations fed to all groups is shown in Table 20.

The ration was changed on October 22 in order to correct a loose dropping problem prevalent on the former diet. Feed was mixed and fed on a daily basis in the afternoon. Feed remaining was redistributed within each group on the following morning. Animals in group 9A were fed *ad lib.* and group 9B received 87 percent of this amount of feed; those in group 9C were also fed *ad lib.* and group 9D received 75 percent of this amount. Since accelerated furring imposes stress sufficient to prevent optimum growth, light controlled animals were only restricted to 87 rather than 75 percent of the *ad lib.* level. Water was supplied free choice through an automatic watering system.

On July 29 the summer fur on the right hip of all mink in this experiment was removed by shearing. This was done in order to better assess the presence and extent of impaired fur development in the winter pelage. Animals raised in light controlled housing were pelted October 29 and those raised conventionally on December 4. Measurements on incidence and extent of RH and impaired furring were taken on the raw pelt prepared fur side out after pelting in the fall.

Results

Effects of the variables investigated are summarized in the following tables. As there appeared to be no effect of sex on RH and impaired furring (Table 21) this variable was not considered in presenting Tables 22, 23, 24, and 25.

Average initial and final body weights are provided in Table 26.

The results of this investigation are revealing and in most cases support research observations made previously. Again, the major variable affecting the basic problem of impaired furring (as manifest by RH) is genetics. Generally, affected parents beget affected offspring. Non-affected parents descending from this RH-susceptible strain produce offspring considerably less affected than those from affected parents, indicating that RH control can be accomplished most effectively by breeder selection. The effect of genetics is also apparent from stratifying data collected according to amount of RH strain carried by the young mink, but this is modified considerably, of course, by whether the parents were affected or not.

Table 21. Effect of Sex of Animal on Incidence of Red Hip and Impaired Furring

	Red Hip		Impaired Furring				
			Bare[2]		Weak[3]		Ave. Bare area
Sex	No.[1]	%	No.[1]	%	No.[1]	%	(sq.")
Males	22/47	46.8	31/47	66.0	11/47	23.4	6.64
Females	23/54	42.6	29/54	53.7	11/54	20.4	4.61
Overall	45/101	44.6	60/101	59.4	22/101	21.8	5.66

[1] Number affected/total number.
[2] Guard and underfur missing at pelting in definite area on right hip previously sheared.
[3] Guard and underfur sparse at pelting in definite area on right hip previously sheared.

Table 22. Effect of Type of Mating on Incidence of Red Hip and Impaired Furring and Impaired Furring

	Red Hip		Impaired Furring				
Mating Type Male/			Bare		Weak		Ave. Bare area
Female	No.	%	No.	%	No.	%	(sq.")
Non-affected/ Non-affected	9/53	17.0	13/53	24.5	21/53	39.6	2.02
Affected/ Affected	36/48	75.0	47/48	97.9	1/48	2.1	6.67

Table 23. Effect of Percent of Red Hip Susceptible Strain on Incidence of Red Hip and Impaired Furring

% RH-Suscept. Strain	Red Hip		Impaired Furring			
					Ave. affected area (sq.")	
	No.	%	No.	%		
43.75	0/1	0	0/1	0	0	3.38
50	2/3	66.7	3/3	100	4.35	
62.5	17/38	44.7	30/38	78.9	3.70	
68.75	2/12	66.7	10/12	83.3	2.14	
75	11/23	47.8	17/23	73.9	6.02	5.94
81.25	4/4	100	4/4	100	9.30	
87.5	7/17	41.2	15/17	88.2	4.82	
93.75	2/3	66.7	3/3	100	6.67	

Table 24. Effect of *Ad lib.* vs. Restricted Feed Intake on Incidence of Red Hip and Impaired Furring

Group	Red Hip		Impaired Furring				
			Bare		Weak		Ave. bare area (sq.")
	No.	%	No.	%	No.	%	
9A, 9C *Ad libitum*	26/52	50.0	29/52	55.8	11/52	21.2	5.93
9B, 9D Feed restricted	19/49	38.8	31/49	63.3	11/49	22.4	5.41

Table 25. Effect of Accelerated vs. Normal Furring Cycles on the Incidence of Red Hip and Impaired Furring

Group	Red Hip		Impaired Furring				
			Bare		Weak		Ave. bare area (sq.")
	No.	%	No.	%	No.	%	
9A, 9B (6 hrs. light)	15/51	29.4	28/51	54.9	14/51	27.5	6.41
9C, 9D (Normal light)	30/50	60.0	32/50	64.0	8/50	16.0	5.00

Table 26. Body Weight Data

Ration	Housing	Group	Ave. Initial Wt. (7-20)	Ave. Final Body Wt.*
			(g)	(g)
Males				
Ad. lib.	Inside	9A	1078	1872
Ad. lib.	Outside	9C	1068	2086
Restricted	Inside	9B	1062	1721
Restricted	Outside	9D	1065	1834
Females				
Ad. lib.	Inside	9A	759	1093
Ad. lib.	Outside	9C	761	1200
Restricted	Inside	9B	763	1047
Restricted	Outside	9D	757	930

* Groups raised in inside facilities were pelted on October 29 and those raised outside on December 4.

There was no apparent effect of nutritional plane on incidence of RH and impaired furring according to these experimental data. This verifies results of last year and of previous years and at this point it might be concluded that nutrition plays a minor role if any in causation of RH. There was a marked effect of controlling feed intake on body weights achieved,

especially where feed was restricted to 75 percent of *ad lib*. This tends to negate the hypothesis being tested that imposition of dietary stress sufficient to limit body weight influences the expression of RH.

In contrast to 1969 research findings, there was no apparent effect of accelerating the furring cycle on reducing the RH fur abnormality. The apparent difference in percentage (30 vs. 60 percent) of RH in inside and outside housing facilities is assumed to result from the lessened opportunity for bleaching of the old, unshed, summer fur to occur. Even though RH incidence appears to be decreased there is no effect on the basic priming defect as determined by incidence and size of bare and weakly furred areas over the right hip. One confounding circumstance occurred when three 100 watt light bulbs were inserted into a second circuit not connected to the regular on-off cycle. These were in place from September 2 to September 10 and provided partial illumination for 24 hours per day during this period. The effect of this extra exposure on these mink appeared to be minimal but cannot be entirely disregarded. (For further information on this point see the earlier section of this report entitled "Environmental Factors Influencing the Life Cycle of the Mink.")

The sex of the animal seems not to affect RH *per se* and the difference noted in size of bare area probably relates directly to the relative sizes of the two sexes.

Fur Chewing

Objectives

The broad objective of this research is to establish factors related to the cause of this sporadic and exasperating problem. Specific objectives for 1970 were to superimpose nutritional stress upon supposed genetic susceptibility. Previous research has implicated neither genetic nor nutritional bases for this anomalous condition.

Methods

Mink kits used were descendants of breeder animals propagated from the sole criterion of having exhibited some degree of fur chewing. In most instances in animals within this strain, the degree of inbreeding to fur chewing parentage is fairly high.

Forty-five kits from 16 breeder females of the fur chewing strain were allocated to experiment according to the data in Table 27.

Experimental groups were comprised of kits which had been balanced by litter, sex, and body weight. Procedures were essentially the same as in the section on red hip except that all animals were reared conventionally in outside facilities and fed *ad libitum*. Kits were separated into individual pens on July 2 and test rations began on July 28. Composition of the control ration was identical to that given in the previous section. Composition of ration 10B featuring low protein quality is shown in Table 28.

Proximate analysis showed the initial protein level to be 22.9 percent and the fat level 27.3 percent (which is higher than the intended 22.5 percent).

Composition was modified on August 20 to eliminate the lard making up the difference with chicken offal. This reduced the fat level to 22.4 and increased protein to 25.7 percent. As the ration continued to show poor palatability and since the animals fed it were rapidly losing weight, the level of linseed meal was lowered to 5 percent; this was offset by an increase in the level of tripe. On September 4, the ration was further modified to completely exclude linseed meal. Ration composition from this time until pelting, December 11, is given in Table 28.

Results

No fur chewing was noted in either group except for a minimal amount involving the tip of the tail, and this was equivalent generally to that found

Table 27. Experimental Design

Group	Ration	No. Mink		
		Males	Females	Totals
70-10A	Control (adequate protein quality)	11	11	22
70-10B	Low protein quality	11	12	23
				45

Table 28. Ration Composition (10B)

Item	From July 28 parts	From September 4 parts
Chicken offal	38	40
Tripe	20	25
Lard	2	0
Molasses, cane	5	5
Oat groats	20	20
Wheat bran	5	5
Linseed meal	10	0
Vitamin E*	.01	.01
Water	65	28

* (d-alpha tocopheryl acetate).

in the normal herd. Body weights of males and females within either group are presented in Table 29 to illustrate the effect of nutritional stress upon 10B animals. Weight losses in this group, especially among males, were very high and occurred in all except one animal prior to removal of linseed meal from the diet.

Animals in group 10B were exposed to severe nutritional stress and approximately 40 percent succumbed before the ration was changed. Even though this stress factor was coupled with high inbreeding to fur chewing ancestors, fur chewing was not observed. The absence of fur chewing in this trial further absolves both genetic and nutrition as factors responsible for triggering the fur chewing response.

One observation made repeatedly is that animals classed as fur chewers and saved as breeding stock tend to rechew their fur in subsequent years and that the pattern chewed is similar from year to year.

Cotton Fur

Previous research at this station has identified formaldehyde, present in

Table 29. Body Weight and Death Losses

Group	Sex	No. mink	Initial weight (g)	Final weight (g)	Death loss No.
10A	male	11	789	1931	0
10A	female	11	563	986	0
10B	male	11	785	1668	6
10B	female	12	564	949	3

raw, frozen Pacific hake and other cod species, including Atlantic whiting and Alaskan pollock, as the factor responsible for the high incidence of cotton-fur (CF) seen when mink are fed rations containing these fish species. It has also been firmly established that ingested formaldehyde acts within the animal to prevent the normal absorption of iron, thus giving rise to iron deficiency symptoms which include CF.

Objectives

Objectives of research accomplished in 1970 were twofold: (1) to provide final proof that the presence of formaldehyde *per se* in the mink ration can cause the CF syndrome in animals feeding upon it, and (2) to attempt to utilize Pacific hake in the mink ration on an alternate day basis.

Formaldehyde Addition

Methods

Two groups, each comprised of 15 randomly selected, standard-dark, female mink kits from the normal dark herd, were set up and began to receive experimental rations on July 29. Both groups were penned in conventional type housing and were managed by procedures generally similar to those described in earlier sections of this report. Both groups were offered feed *ad libitum*. Composition of experimental rations were:

Group 11A—Control ration (as described under Red Hip section).

Group 11B—Control ration plus 250 ppm of formaldehyde (37 percent formaldehyde solution weighed daily and mixed thoroughly into ration just prior to feeding).

This amount of formaldehyde is roughly equivalent to that contained in a diet containing 50 percent of Pacific hake. Formaldehyde assays indicated that the actual level supplied varied between 215 and 280 ppm. This variation was considered due to the volatile nature of formaldehyde. Immediately after mixing, formaldehyde levels would be about 280 ppm and after standing on the wire for 24 hours would be reduced to approximately 215 ppm.—a 24 percent loss. At the beginning of the experiment formaldehyde was included at twice this level but the ration proved so unpalatable that it was reduced.

Results

Four animals fed the formaldehyde-containing ration showed CF when the fur was examined in early December; none of the control animals were so affected. A three ml. blood sample was taken by cardiac puncture from each mink of both groups on December 7 and the blood picture analyzed. Results are presented in Table 30.

Group 11B animals were divided into affected and non-affected categories based on whether they exhibited a normal blood picture. Eleven of the 15 mink receiving formaldehyde showed a definite microcytic, hypochromic anemia, typical of iron deficiency.

As a continuation of this experiment, animals in group 11B were sequenced from low to high according to hemoglobin level and every other animal was given an injection of 1 cc. of a commercial iron preparation containing 100 mg of elemental iron as ferric hydroxide to determine if iron supplementation would overcome the anemia present. Results of this supplementation trial are shown in Table 31.

It is quite evident that the group unsupplemented with iron regressed even further during this period whereas the group receiving parenteral iron supplementation greatly improved.

These experiments offer conclusive evidence that formaldehyde present in the mink diet can result in CF, that it causes a microcytic, hypochromic

Table 30. Blood Values of Control and Formaldehyde-fed Mink

Group	11A	11B	11B
No. Mink	Control 14	Affected 11	Unaffected 4
Hemoglobin (gm/100 ml)	19.9	13.7	19.9
Red blood cells (million/cu.mm.)	9.01	7.95	9.14
Hematocrit (%)	50.6	36.7	50.4
Mean Corpuscular Vol.	56.1	46.6	55.2
Mean Corpuscular Hb.	22.1	17.3	21.8
Mean Corpus. Hb. Conc.	39.6	37.3	39.6

Table 31. Iron Supplementation of Anemic Mink Receiving Formaldehyde

	Before (Dec. 7)	After (Jan. 5)
Group 11B—Unsupplemented Control (7 mink)		
Hemoglobin	16.0	13.6
Red blood cells	8.37	8.09
Hematocrit	40.8	37.6
Group 11B—100 mg of Iron Injected December 14 (6 mink)		
Hemoglobin	14.3	17.6
Red blood cells	7.81	9.19
Hematocrit	38.8	48.6

anemia and that this anemia is correctable by supplementation with iron.

Alternate-Day Feeding of Hake

Objective

This trial was conducted in a more practical vein with the objective to attempt to utilize raw Pacific hake in the mink ration on an alternate day basis. It was theorized that sufficient iron absorption should occur to promote normal growth, fur pigmentation and blood formation, as the formaldehyde contained in the hake would only be present intermittently in the diet. This method has apparently been used successfully in the utilization of thiaminase-containing fish.

Methods

A third group (11C) of 15 dark, female mink set up in a manner parallel to groups 11A and 11B, previously described, received the following rations *ad libitum:*

item	parts
Pacific hake /sole	50
Chicken offal	16
Tripe	10
Lard	1
Molasses, cane	5
Oat groats	12
Wheat bran	6
Vitamin E	.01
Water	10

Hake was included in this ration on an alternate day basis with sole. Ration composition was changed on October 23 by eliminating molasses and making up the difference with the mixed cereal component (oat groats, wheat bran, and vitamin E). The hake was analyzed to contain 227.0 ppm of formaldehyde and the mixed diet including hake at 112.4 ppm of formaldehyde.

Results

These mink were pelted on December 14 after a 139-day feeding period.

Average body weight for group 11C animals was 1,099 grams as compared to 1,130 grams for the control group, 11A. No animal showed CF or anemia as determined from hematocrit levels (11C-53.4 percent; 11A-50.6 percent) of a blood sample taken from a clipped toe nail. Interpretation of these results is not entirely straight-forward. They indicate that either iron absorption was adequate during the days when sole was present in the diet or alternatively that insufficient formaldehyde was ingested to interfere markedly with iron absorption. It became quite apparent, especially during the latter part of the trial, that mink don't like raw hake when given a preference. Feed consumption was alternately up and down and records showed an 18 percent higher consumption of the sole—as compared to the hake—containing ration (average feed consumption per mink: hake-28.6#, sole-35.0#). It is very possible that this distaste for hake relates to the formaldehyde present. In this regard it was noted that ration palatability was significantly decreased for group 11B where purified formaldehyde was added.

Avidin-Biotin

Objectives

There has been evidence from field observations that avidin may still be active in baby chicks and poults. Some mink ranchers using rations containing baby chicks have suspected biotin deficiency symptoms in their animals. Objectives of research in this area this past year were to investigate these observations by feeding trials and by laboratory assay of baby chicks and turkey poults for avidin.

Methods

Two groups of 15 each, standard-dark, female kit mink were established, housed, and managed in a conventional manner as previously described. The rations shown in Table 32 were offered *ad libitum* from July 28.

Results

When these mink were pelted on December 11 there was no evidence of biotin deficiency symptoms; body weights were reasonable (8A-1089 g; 8B-1125 g) and fur color was normal in every case. The conclusion must be drawn that if avidin were present, the quantity was insufficient to cause a problem.

Microbiological assay of baby chicks and poults do reveal presence of avidin although results were quite variable. Table 33 gives the proximate composition of chicks and poults and an average value for avidin content as based on six assays.

Table 32. Ration Composition

Group	8A	8B
item	parts	parts
Rockfish carcass	33	33
Tripe	10	10
Lard	1	1
Molasses, cane	5	5
Oat groats	12	12
Wheat bran	6	6
Baby chicks	33[1]	....
Baby poults	....	33[1,2]
Vitamin E	.01	.01

[1] Ground and frozen newly hatched baby chicks and poults.

[2] Because of the extremely seasonal supply of poults, difficulty was encountered in obtaining ample quantity to continue group 8B with turkeys beyond August 27. After this date poults were replaced with baby chicks.

Amounts of avidin in these products remain questionable and these products will be reassayed using methods other than microbiological ones. Some variation in results could be expected, however, as it has been shown by researchers in China that the avidin content of chicken eggs increases with the order of lay. Eggs first laid are low in avidin and increase approximately three-fold after the first dozen or so.

Feeding Management and Fur Color and Quality

Data collected last year on fur color and quality incidental to wet belly research involving *ad lib.* and restricted feeding methods indicated no detrimental effect of restricting feed intake in the production of pelter mink.

Objectives

As feed restriction appears to be an effective method of wet belly control it becomes of considerable interest to know what to expect of fur characteristics as influenced by restricted feeding management. Objectives of the research reported herein were to provide further information on the effects of limiting feed intake on fur color and quality.

Methods

These are presented in detail in the companion progress report entitled "Factors Causing Wet Belly Disease in Mink." Briefly, five groups of 20 dark males each were fed *ad libitum* or restricted levels of a control ration. Three groups were raised conventionally and two groups were reared in light controlled housing according to the plan shown in Table 34.

Results

Animals were pelted and skins were prepared leather side out. Various measurements pertaining to the fur were made from the dried pelt (Table 35).

Both sets of data verify results of 1969. Fur color as subjectively assessed by professional fur graders showed an improvement in all cases. No objective measurements were made on this point, however. Fur quality as subjectively assessed was very similar whether animals were fed *ad lib.* or restricted. Length of guard and underfur was equal or longer when feed was restricted by 13 percent, but appeared to be slightly shorter when feed was restricted by 25 percent. This agrees well with values obtained the previous year.

Table 33. Percent Composition of Baby Chicks and Poults (dry matter basis)

	Chicks	Poults
Dry matter	12.9	13.0
Crude protein	57.9	57.1
Crude fat	26.3	27.9
Ash	6.1	6.3
Crude fiber	8.0	8.7
Avidin (units/gram)	1.97 (?)	2.48(?)
(Avidin-whole egg u/g)	1.72	3.39

Table 34. Experimental Design

Group No.	7G	7H	7I	7J	7K
Housing	Conventional (outside)			LTC (inside)	
Feed Intake %	100	87	75	100	87
Period	July 2-Dec. 15			July 2-Oct. 20	

Pelt unprimeness as determined from the location and extent of pigmentation in the leather appeared markedly reduced in pelts from animals restricted to 75 percent of the feed received by animals fed *ad lib.* This point was very apparent when pelts were viewed as a group; smaller pelts from restricted-fed mink seemed to be cleaner and have better appearing leather.

Overall, considering data collected for two years and involving 156 mink, average pelt size was considerably shorter, fur color and quality were equivalent and wet-belly significantly reduced for restricted-fed groups; consequently sale prices were improved. This, coupled with the reduced feed costs of limiting intake tend to favor this method of management.

Table 35. Fur Characteristics of Mink Fed *Ad Libitum* or Restricted

	Raised Conventionally (Pelted Dec. 15)			Light Controlled Housing (Pelted Oct. 20)	
Group	7G (100%)	7H (87%)	7I (75%)	7J (100%)	7K (87%)
No. Mink	20	20	20	20	20
Final body weight (g)	2114	1903	1533	1902	1753
Fur color (score)[1]	2.35	2.10	1.85	2.50	2.35
Fur quality (score)[1]	2.00	1.90	2.10	2.40	2.40
Guard fur length (mm)	25.0	25.1	24.4	24.0	24.5
Underfur length (mm)	13.3	13.6	12.8	12.5	12.4
Pelt length[2] (cm)	73.9	71.7	67.4	72.0	70.5
WB incidence (%)	75	55	20	80	65
Unprimeness[3]-general (%)	0	10	5	10	20
Unprimeness[3]-hip (%)	10	0	0	5	5
Unprimeness[3]-specific area (%)	55	40	10	45	30
Est. pelt value ($)	15.99	16.83	16.86	13.51	13.83

[1] Fur color and quality scores were assigned by professional fur graders on the basis of 1 best to 3 poorest.
[2] Base of tail to tip of nose.
[3] Area of pigmentation on leather (% refers to no. of animals affected).