NUTRITIONAL STUDIES ON RANCH-RAISED MINK

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This is to certify that the

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ABSTRACT

NUTRITIONAL STUDIES ON RANCH-RAISED MINK

by Hugh Farrant Travis

Investigations on ranch-raised mink were conducted at M.S.U. over a five-year period: (1) to evaluate diets containing no fresh animal products; (2) to determine requirements for various nutrients using semi-purified rations; and (3) to study any possible effects of certain antibiotics and hormones during the reproductive cycle.

Dry diets containing no fresh animal products, or supplemented with fresh liver or tripe, were fed through two growth and two reproduction periods. Total weight gains of the mink on dry diets were less than those of the mink on the ranch ration. Mink on dry diets grew more slowly than the controls during the period from 11 weeks to 16 weeks of age. However, from 16 weeks to 29 weeks the growth of the mink on dry diets was more rapid. Growth response of mink receiving the dry diet supplemented with 25 percent fresh liver was intermediate between mink receiving the ranch ration and those receiving the dry diet. Fur quality and length of the live mink were as good on the dry diets as on ranch rations.

Increasing the fat level in the dry rations from 12 to 20 percent improved the growth rate of kits. No beneficial effect was apparent from further increasing the fat to 28 percent. Male mink showed a greater response to changes in diets than females.

Adult mink fed dry diets prior to breeding and then dry diets with fresh liver during periods of breeding, gestation and lactation, were comparable in weight, breeding performance and number of kits whelped per female to mink fed a typical commercial ranch ration. However,

21-day kit weights of the controls were greater. The response from adding fresh liver or from adding fresh tripe to dry diets during lactation and early kit growth was similar. This indicates that perhaps the value of the fresh animal products may be due to palatability rather than the nutrient values it contributed.

Semi-purified diets were used to ascertain if adult mink require dietary vitamin K, whether dark mink differ in this respect from sapphire mink, and if the feeding of sulfaquinoxaline or certain antibiotics affect blood clotting time. The dietary requirement of vitamin K for normal adult mink was found to be less than 13 milligrams of menadione sodium bisulfite per ton of feed. Sulfaquinoxaline fed for six to eight days at 0.5 percent or higher, significantly increased whole blood prothrombin clotting time, while addition of aureomycin or terramycin at levels of 400 grams per ton of food did not.

Experiments were conducted during two growing seasons to determine the protein and amino acid requirements for growing mink. Depletion-repletion and growth study techniques were applied with partial success. Growing mink maintained their weights for short periods of time on semi-purified diets containing 15 percent protein and 20 percent fat when supplemented with appropriate amino acids.

Terramycin was fed at 400 grams per ton of feed during two lactation and early kit growth seasons. There was no beneficial effect in kit production, growth or mortality that could be attributed to the antibiotic treatment. Kit weights at 21 days from mothers receiving the antibiotics were significantly smaller than those of the controls during one year's study.

Thyroprotein containing one percent thyroactive iodinated casein was fed to pregnant females at levels of 0.53 milligrams per 100 grams of body weight, starting five days before the first litter was to be expected and continuing until the young were two weeks old. There was no effect on number of kits born or incidence of mortality of the young. Kits from treated mothers were significantly smaller at 14 days of age.

Diethylstilbestrol was fed intermittently to bred females, starting after implantation and continuing through late gestation, whelping and early kit growth. Results were almost complete failure of reproductive processes, and resulted in reabsorption, lowered kit production and kit weights, as well as greater kit mortality.

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by

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Introduction

Commercial mink ranching in the United States has developed into a sizeable animal industry during the past four decades. Although mink farming was first attempted commercially in the 1860's, when trappers raised mink from captured wild stock, it was not until the 1920's that mink farming achieved any economic importance (Kellogg, et al., 1954). At that time, mink were overshadowed by the more popular and established silver fox. Since then, fashion trends have shifted from the long-haired fox to the short-furred mink and the latter have been the most desired fur of the past decade.

Over five million domestic ranch mink were raised in the United States in 1958, representing an income to ranchers of 106 million dollars (Anon. 1959). The majority were produced in the Upper Lakes region, principally Michigan, Wisconsin, Minnesota and Illinois. Michigan has been consistently among the top-ranking states, producing 246,000 pelts valued at $5,156,000 in 1958 (Anon. 1958) and 270,000 pelts valued at $5,260,000 in 1957 (Anon. 1957).

In the early days, the principal sources of mink food were horse meat, whole fish and whole grain cereals. The decline in numbers of horses and the increasing competition for horse meat from pet food manufacturers has led to extensive use of fresh or frozen packinghouse, poultry and fisheries by-products. There also has been increased use of meat and fish meals, dried distillers solubles, brewers yeasts, and by-products from cereal manufacturing. The use of these feeds, which are of high intrinsic value but unnatural to mink, has led to many nutritional problems.

Mink research has not kept pace with the rapid expansion of the mink industry. This is partly due to the relatively small amount of research being conducted by the industry and public institutions. It also stems from differences between mink and other farm animals which make it difficult to adapt nutritional findings of other species to mink. Through trial and error, ranchers have developed diets upon which mink will grow and produce well. These rations are formulated without knowledge of the nutrient requirements of mink. Thus, they are not the most efficient nutritionally, the most economical nor do they make maximum use of ingredients readily available. In many cases, the effects on mink of feed additives, preservatives, and growth promotants which are commonly fed to other species for more efficient husbandry are unknown.

Therefore, because of the diversity of the needs of the industry and the desire at Michigan State University to answer pressing questions of applied, as well as fundamental nature, studies have been conducted into several different aspects of mink nutrition. The studies presented in this thesis will be considered under three general categories.

The first of these was the development of dry diets for mink. Study I consisted of an evaluation of dry rations compared to ranch-type rations conducted through two growth and two reproductive periods.

The second general category of study was the use of semi-purified rations by which diets can be produced containing known amounts of dietary ingredients. Study II was an evaluation of the nutrient requirements of the mink for vitamin K and the effects of certain antibiotics and medicaments upon blood clotting time. Study III was an attempt to define the amino acid requirements of growing mink.

Ranch-type rations containing fish and meat products were used in several practical studies upon effects of feed ingredients and feed additives on the reproductive performance of mink.

Study IV evaluated the effect of intermittent feeding of stilbestrol. Study V concerned itself with the effects of feeding thyroprotein, and study VI determined the effects of high level antibiotics upon the lactation and early kit growth performance of mink.

General Review of Literature

The purpose of this section is to review what is known of the nutrient requirements of mink and to consider specific characteristics, such as anatomy, rate of food passage and digestibility which might affect the nutrition of these animals. Even though it undoubtedly plays an important role, there is no information available on enzyme activity in specific digestive processes in mink. A review of literature pertaining to each of the different studies will be reported as these subjects are presented.

Anatomy

There are no published reports on the histology of the digestive tract of mink and only scattered reports on its gross anatomy. Kainer (1954), in the most comprehensive anatomical study, utilized 77 mink ranging in weight from 400 to 1,450 grams. He described the stomachs as being about 0.5 percent of the body weight and being able to contain from 40 to 70 ml of liquid. The small intestine was divided into a duodenum with a mean length of 10.6 cm and a jejuno-ileum with a mean length of 120 cm. The mean pancreas weight was 3.0 gms and the mean liver weight 35.4 gms (4.9 percent of the body weight). No cecum was present. The average length of the combined colon, rectum and anus was 10.1 cm. In the above mink, the ratio of intestinal length to body length ranged from 3.60:1 to 4.38:1 with a mean ratio of 3.97:1. Wood (1956) reported that in mink ranging from 1.5 to 2.7 lbs., the mean length of intestine was 46.8 in. with a range from 43.5 to 51.0 in. The

intestine was about one-half the length of the intestine of the average cat and one-fifth the length of that of the average small dog. From these comparisons, it can be readily seen that the digestive tract of the mink is small in proportion to its body size - even when compared to other carnivores.

Digestibility

Bernard, Smith and Maynard (1942), when studying the digestibility of cereals by minks, reported that cooked starch present in wheat, corn and oats was digested 90 percent or more, even when the starch constituted from 45 to 50 percent of the dry matter fed. Raw starch was poorly digested (54 percent). Raw corn meal when composing 20 to 25 percent of the wet ration was somewhat more digestible (75 percent), but produced loose feces. Starch fed as folled oats and raw wheat meal was apparently well digested (78 and 93 percent). However, both these products produced a slight scouring. Wheat bran fed as 10 percent of the wet ration depressed the over-all digestibility of the diet, probably due to its laxative effect. Fiber in the form of lettuce, carrots or cellophane did not adversely affect the digestibility of other constituents of the diets. Fats were found to be highly digestible (93 percent).

In studies with raw meat products (Smith and Loosli, 1940), digestibility of raw meats when fed as 80 percent of the ration was reported as follows: liver 93 percent; horse muscle 86 percent; and spleen 84 percent. Cooking and drying reduced the digestibility to about 72 percent.

The protein of soybean meal was found by Ahman (1959) to be 60 percent digestible, cod meal 79, and meat meal 57 percent. He also determined that the carbohydrate digestibility of uncooked grains was 65 percent, cooked grains 75 percent, and the carbohydrate of cooked soybean meal was 57 percent digested. These ingredients were all fed as 30-40 percent of the diet.

Leoschke (1960) reported the protein digestibility of horse meat to be 92 percent, chicken entrails 89 percent, chicken heads 78 percent, and chicken feet 52 percent. He believed the lowered digestibility of heads and feet to be related to their high mineral content.

Rate of Food Passage

Food passage in mink is very rapid when compared to that in other species. The appearance of feed in the feces 6 hours after ingestion was reported by Bernard et al. (1942) and complete elimination within 15 hours after ingestion was reported by Loosli and Smith (1940). Wood (1956) reported the rate of food passage as varying from 1½ to 2 hours in starved mink.

Nutritive Requirements

What is known of the nutritive requirements of mink was summarized in a National Research Council bulletin (1953). The results of this compilation plus what has been learned of the nutrient requirements since that time are listed in table 1. These, then, are the known nutritional characteristics of this unusual "domestic" animal about which so little is known and which offers so many challenges of a nutritional nature.

Table 1. Estimate of minimum nutrient requirements for growth and fur development of mink (per pound of moisture-free food).

	Unit	Amount	
Protein			
7-23 wks. of age	%	22	Bassett *et al.* (1951A)
23+ wks. of age	%	16	" " " "
Vitamin A	I.U.	780	NRC*
Vitamin D		0**	Bassett *et al.* (1951B)
Vitamin E	I.U.	12	Stowe *et al.* (1960)
Vitamin K	mcg	< 6.5	Travis *et al.* (1961)
Thiamine	mg	0.5	Leoschke (1959)
Riboflavin	mg	0.9	NRC
Pantothenic acid	mg	3.6	NRC
Niacin	mg	4.5	NRC
Pyridoxine	mg	0.5	NRC
Folic acid	mg	0.09	NRC
Vitamin B_{12}	mcg	4	Leoschke *et al.* (1953)
Salt	%	0.5	NRC
Calcium	%	0.4	NRC
Phosphorus	%	0.4	NRC
Ca:P ratio		1:1	Bassett *et al.* (1951B)
Energy for maintenance per pound body weight		124	Hodson and Smith (1942)

* NRC estimates of National Research Council, Publication 296 (1953)
** Diet of natural feedstuffs was found adequate without added vitamin D

General Materials and Methods

Animals

Mink used in these studies came from three sources. The dark mink used in the 1956, 1957 and 1958 studies consisted of progeny of mink originally donated by mink breeders of the state and progeny of mink obtained from Kellogg Feed Research Project in 1953. In 1957, 40 female and 10 male sapphire mink were purchased from Mr. Charles Wilbur of Traverse City, Michigan, with 20 sapphire female mink being added in 1958. In 1958, 40 female and 10 male dark mink were obtained from Mr. Rudy Menzel, Glendale, Michigan. These mink were uniform with better than average pelt quality and comprise the nucleus from which came the current mink herd. However, since the principle of randomization for experimental treatments is incompatible with the principle of preserving the better animals for breeding, there has been some deterioration in pelt quality from that of the original animals. To maintain quality in an experimental mink herd, either there must be a periodic infusion of good quality commercial animals or about one-third of the herd must be segregated from use as experimental animals and maintained as a breeding herd. Part of the progeny from this segregated herd may be used for experiment and part should be used to perpetuate the breeding herd.

Housing and Management

The animals were confined in individual covered pens of uniform size. Each pen was equipped with a water cup, feed door and nest box.

Animals fed dry diets during freezing weather were assured of adequate water supplies by an electrically heated watering system which was turned on periodically by a time clock. Management methods were similar to those of a well-run commercial ranch. Animals were fed twice daily starting in May when the young were born and continuing throughout the summer. They were fed once daily during the fall, winter and spring. Weights and measurements were taken periodically, the intervals between measurements depending on the type of experiment.

Evaluation of Response

Response to dietary treatments was evaluated primarily in terms of body weight. Length gains and pelt quality were also used to measure differences, but because of the difficulty of gathering uniform data were given less consideration. Number of females whelping, litter size, weights and kit mortality were used in the reproduction studies.

Observations were made on mortality, general health and appearance of all animals. Where pertinent, casualty animals were necropsied and the cause of death determined.

Standard statistical methods were employed. Data were analyzed by analysis of variance (Snedecor, 1956) and the differences between groups were determined by Duncan's multiple range and multiple F tests (Duncan, 1955).

In an effort to adjust kit weights to litter size, the largest and most homogeneous group of kits (1957 fat reproduction study) was analyzed to determine the relationship between birth weight of individual kits and the size of the litter. A straight line was fitted to the data (201 male and 176 female initial weights and 189 and 165 female 21-day weights). It was found that the slopes of these lines were not significantly different from zero. This means that in this population the litter size did not significantly influence the initial or the 21-day weights of the offspring. Correlation coefficients for males and females between litter size and offspring at 1- and 21 days were also run and in both cases it was found that the correlation coefficients were not significantly different from zero.

From these calculations, it was concluded that for purposes of these analyses, size of litter was not compensated for and analyses of variance were run on 1-day and 14-day or 21-day weights in all reproduction tests. Although it was not statistically significant, there was a tendency for the animals of larger litters to be smaller and it is possible that with larger numbers of kits a straight line relationship between litter size and kit size might be demonstrated. It is also possible that there is some biological explanation for the lack of correlation, such as smaller litters of 1, 2 and 3 coming from biologically weaker animals. The data available were insufficient to determine this.

Studies of Dry Diets

Introduction

Fresh meat and fish ingredients which currently comprise from 65 to 85 percent of the commercial mink ration have the disadvantages of seasonal shortages and gluts and also the need for refrigeration. Costs of transportation are high since up to 80 percent of the fresh material is water. The dangers of spoilage and feed poisoning such as botulism are ever present. Costs of refrigeration equipment and labor for food mixing are also high. The elimination of the need for using fresh or frozen animal products would lead to greatly improved efficiency of mink production.

Success has been achieved in feeding completely dry foods to other carnivores such as the fox and dog, so it is not inconceivable that satisfactory dry rations for mink could be developed. The ultimate in dry diet foods would be dry pellets which would give optimum nutrition during all phases of the life cycle. However, any information that leads to the use of dry rations during any portion of the life cycle or that leads to increased use of dry ingredients is of great economic importance to the mink rancher.

For these reasons, investigations on dry diets have been conducted by the Michigan State University Fur Animal project since 1948. The work being reported here is a continuation of the investigations conducted by Drs. Schaible and Kifer from 1952 to 1956.

Review of Literature

The principal studies on dry diets for mink reported in the literature have come from the Michigan State University Fur Animal Project. Travis et al. (1949) reported on the initial attempt to formulate a completely dry ration for mink. Feed trials with six adult and 15 kit mink showed that the diet employed was inadequate for promoting optimum growth in young mink started on experiment at 10 to 12 weeks of age, but did appear to maintain body weight in adults over a period of 111 days. The primary defect of the diet was shown to be concerned with protein, particularly one or more of the amino acids, methionine, lysine and/or tryptophan.

Howell (1952), in a continuation of this work, reported limited progress. Growth and reproduction were subnormal in animals fed solely on dry rations. This was believed to be a protein rather than a vitamin deficiency. Methionine, lysine and tryptophan apparently were not involved.

Both Travis and Howell believed palatability and digestibility to be limiting factors in the successful use of their experimental rations.

Kifer (1956) and Kifer and Schaible (1955a, 1955b, 1956) demonstrated further improvements in the dry-type ration. They obtained increased growth and reproductive responses by pelleting and by adding fat to the rations. Palatability was not a factor under the conditions of their experiments. While performance was comparable during maintenance, results were not equal to those obtained on typical ranch rations during the reproductive cycle or during lactation and early growth.

Gunn (1960a) conducted an interesting experiment in which he fed to growing mink a dehydrated ration composed of the identical ingredients as the fresh meat control diet. The dehydration was carried out in a steam-jacketed drier at 250° F. with one atmosphere of vacuum. Growth performance and feed consumption were poorer in this group than in the mink receiving the control ranch ration. Gunn (1960b) believes that the experiment might have succeeded if the prepared complete wet ration could have been dried in a vacuum-freeze drier.

The research reported here consists of two growth and two reproduction studies. The performance of mink on the dry rations was compared to that of mink on a typical ranch ration which consisted principally of fresh meat and fish products (Table 2).

Growth Studies - 1956

These studies were conducted with a total of 180 kit dark mink allocated to nine treatments consisting of 10 males and 10 females in each group. Dry rations used were modifications of the most successful of the 1955 growth rations. Diet 1 was the control ranch ration. Diets 2, 3 and 4 were designed to test different fat levels and were fed as a meal to which water was added to produce a hamburger-like consistency. Diet 2 was comparable to the best dry ration of the 1955 studies (ration 55-6) and contained 12 percent fat. Diets 3 and 4 had yellow grease added to produce diets of 16 and 20 percent fat, respectively.

Diets 5 through 9 were fed as pellets (3/16-inch in diameter and averaging 3/8-inch long). Diet 5 contained 12 percent fat, the added fat consisting of yellow grease. Diets 6 and 7 compared torula and brewers dried yeasts, respectively. Diet 8 contained no yeast, the difference being made up by fish meal and soybean oil meal. Diet 9 was identical to Diet 2 but in pellet rather than meal form.

Mink were placed on experiment when they were 11 weeks old and weight and length measurements were taken when they were 11, 16 and 30 weeks of age, representing approximately 60, 80 and 100 percent of their final body weight, respectively. Body length measurements were determined by stretching the mink on a ruler and measuring the distance from the tip of nose to the base of the tail.

Experimental rations, their chemical analysis and the performance of the animals on different rations are shown in tables 2 through 8. Analysis of variance of the weight gains from 11 to 30 weeks shown in table 6 indicate that mink on diet 1 grew significantly better than mink on diets 2, 5 and 7 but not significantly better than mink on the other experimental rations.

From the results of this analysis, it was decided to analyze the gains from 11 to 16 weeks and from 16 to 30 weeks to determine where the greatest difference in the experimental treatments occurred. Results of analysis of variance and multiple range and multiple "F" tests of the weight gains from 11 to 16 weeks are shown in table 7. Comparison among lots of this test show the mink receiving the control ranch ration to have had a growth rate significantly greater than those on any of the dry rations. Among the dry diets at this period, weight gains of mink of lots 8 and 9 are significantly greater than those of mink in lot 5.

Analysis of variance of the weight gains from 16 to 30 weeks did not demonstrate a significant difference in the rations. Analysis of variance of length gains did not show a significant difference in length gains due to dietary treatment.

An attempt was made to evaluate the pelt quality of 5 males and 5 females from each of the different experimental rations. Table 8 shows the results of such an evaluation. An analysis of variance did not demonstrate any difference that could be attributed to different dietary treatments. Thus, the control ration was shown to be superior to the dry rations during the period from 11 to 16 weeks, with the weight gains of the mink on dry diets being comparable to the controls from 16 to 29 weeks. Significant differences between treatments in length or in pelt quality were not demonstrated.

Growth Studies - 1957

During the summer and fall of 1957, an effort was made to further improve those dry diets that were most effective when fed during the growth period in 1956. Since improved responses were achieved by increasing the fat level, it was decided to test 20 percent and 28 percent fat levels. These levels are in the average and high range of commercial ranch rations, respectively. The effects of adding 25 percent fresh liver to the dry ration were also determined. The objectives of this addition were twofold. The first was to determine if there were nutrients in fresh liver which would make the performance of mink on dry diets comparable to that of those on typical ranch rations. If liver, a rich source of high quality protein, vitamins and unknown nutritional factors, did improve the performance, then by determining what was in the liver that improved the performance, it could be determined what was deficient in the dry diets. The second objective was to improve, if possible, the performance of the dry rations by a rather simple addition to the point where they would be comparable in performance to typical ranch rations. This would be of immediate practical value to commercial ranchers.

One hundred and fifty kit dark mink were used in this experiment (15 males and 15 females per treatment). Mink were placed on experiment

Table 2. Composition of control ranch ration -- 1956 dry diet studies

Ingredient	%
Horse meat	26.7
Tripe	26.6
Ocean fish	26.7
Liver	5.0
Cereal mix, supplemented[1]	15.0
Total	100.0

[1] Mink cereal mix 1001, Kellogg Company, Battle Creek, Michigan

Table 3. Composition of dry rations -- 1956 dry diet growth studies

Ingredient	Ration 2	3	4	5	6	7	8	9
Cereal mix[1]	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7
Dried yeast, torula	7.5	7.5	7.5	7.5	15.0	- -	- -	7.5
Dried yeast, brewers	7.5	7.5	7.5	7.5	- -	15.0	- -	7.5
Soybean oil meal, 50%	20.0	20.0	20.0	20.0	20.0	20.0	25.0	20.0
Fish meal[2], 55%	20.0	20.0	20.0	20.0	20.0	20.0	25.0	20.0
Herring meal[3], 70%	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Meat scraps, 65%	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Liver product[4]	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Dried skim milk	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Cottonseed oil	6.0	- -	- -	- -	6.0	6.0	6.0	6.0
No. 2 yellow grease	- -	11.0	16.0	6.0	- -	- -	- -	- -
Vits. E and B_{12} supp.[5]	.85	.85	.85	.85	.85	.85	.85	.85
Vit. B complex supp.[6]	- -	- -	- -	- -	- -	- -	0.2	- -

1 Mink mix 1007, Kellogg Company, Battle Creek, Mich.
2 Vitaproil, Maine Marine Products, Inc., Portland, Me.
3 Maine Marine Products, Inc., Portland, Me.
4 Ritaliver, Imperial Products Co., Wadsworth, Ill.
5 Vitamin E (20,000 IU/lb) 23 gms., B_{12} supplement (6 mg/lb) 363 gms.
6 Fortafeed 249C, Lederle Laboratories, Pearl River, New York

Table 4. Proximate analyses of ration - 1956 dry diet growth study (%)

Diet	H_2O	Prot.	Fat	Fiber	N.F.E.	Ash	Ca	P
"as fed"								
Control	68.2	13.2	6.6	0.8	8.6	2.7	.48	.39
56-2	9.3	42.1	13.1	1.9	23.4	10.3	1.74	1.39
56-3	6.9	39.5	17.7	1.8	24.5	9.6	1.58	1.30
56-4	7.2	37.4	22.2	1.6	22.8	8.8	1.33	1.15
56-5	9.0	41.9	12.6	1.8	24.9	9.8	1.45	1.26
56-6	9.8	41.1	12.7	1.9	24.9	9.9	1.50	1.28
56-7	9.3	41.3	12.6	1.7	25.6	9.6	1.31	1.26
56-8	9.0	43.4	13.8	1.4	21.5	10.9	1.74	1.36
56-9	9.5	41.1	12.7	2.0	25.1	9.6	1.42	1.26
Moisture-free basis								
Control	-	41.5	20.6	2.4	27.1	8.4	1.51	1.22
56-2	-	46.3	14.4	2.1	25.7	11.3	1.91	1.53
56-3	-	42.3	19.0	1.9	26.2	10.3	1.69	1.39
56-4	-	40.4	24.0	1.7	24.7	9.5	1.44	1.24
56-5	-	46.1	13.9	2.0	27.4	10.8	1.60	1.39
56-6	-	45.6	14.1	2.1	27.7	11.0	1.66	1.42
56-7	-	45.4	13.8	1.8	28.2	10.5	1.44	1.39
56-8	-	47.7	15.2	1.5	23.7	12.0	1.91	1.43
56-9	-	45.2	14.0	2.2	27.6	10.6	1.56	1.39

Table 5. Average weights and lengths — 1956 dry diet growth study

			Weight in grams			Length in inches	
			11 wk.	16 wk.	Nov. 21	11 wk.	Nov. 21
Lot 1 -	Males	Control	908	1297	1546	13.5	16.3
	Females		638	844	927	12.4	14.4
	Average		773	1070	1236	12.9	15.3
Lot 2 -	Males	12% meal	902	1092	1263	13.8	16.3
	Females		653	729	829	12.5	14.2
	Average		778	910	1046	13.2	15.2
Lot 3 -	Males	16% meal	915	1151	1394	13.6	16.3
	Females		660	735	867	12.5	14.4
	Average		788	943	1130	13.0	15.4
Lot 4 -	Males	20% meal	921	1201	1488	13.5	16.6
	Females		645	676	797	12.4	14.2
	Average		783	938	1142	13.0	15.4
Lot 5 -	Males	12% pellet,	899	1048	1273	13.6	16.2
	Females	animal fat	668	716	805	12.6	14.1
	Average		784	882	1039	13.1	15.2
Lot 6 -	Males	12% pellet,	895	1094	1334	13.5	16.1
	Females	torula yeast	624	700	752	12.2	14.1
	Average		760	897	1042	12.9	15.1
Lot 7 -	Males	12% pellet,	927	1100	1295	13.6	16.2
	Females	brewers yeast	643	697	793	12.4	14.2
	Average		785	898	1044	13.0	15.2
Lot 8 -	Males	12% pellet,	947	1201	1404	13.8	16.4
	Females	soy	632	731	803	12.5	14.0
	Average		790	966	1104	13.1	15.2
Lot 9 -	Males	12% pellet,	922	1158	1386	13.8	15.8
	Females	dry control	618	738	845	12.3	14.2
	Average		770	948	1116	13.1	15.0

Table 6. Results of analysis of variance of the weight gains from 11 to 30 weeks — 1956 dry diet growth study

Source of variation	Degrees of freedom	Mean square	F values		
			Calculated	P = 0.05	P = 0.01
Total	179	63,216			
Sex	1	29,497	172.8**	3.84	6.63
Diet	8	468.7	2.75**	1.94	2.51
S x D	8	288	1.68	1.94	2.51
Error	162	170.7			

** Significant ($P < 0.01$)

Comparison among lots at 1 percent level of probability

Lot	2	5	7	6	9	3	8	4	1
Av. wt. gains (gms)	224	231	245	276	290	292	296	319	380

Table 7. Results of analysis of variance of the weight gains 11 to 16 weeks -- 1956 dry diet study

Source of variation	Degrees of freedom	Mean square	F values Calculated	P = 0.05	P = 0.01
Total	179				
Sex	1	9,684	168.5**	3.84	6.63
Diet	8	638.9	11.9**	1.94	2.51
S x D	8	97.62	1.70	1.94	2.51
Error	162	57.46			

** Significant (P 0.01)

Comparison among lots at 1 percent level of probability

Lot	5	7	2	6	3	4	8	9	1
Av. wt. gains (gms)	98	114	133	137	156	156	176	178	298

Table 8. Numerical score* of mink pelt grades on November 29, 1956 -- 1956 dry diet growth study

Lot	1	2	3	4	5	6	7	8	9
	Fresh	Meal			Pellets				
	Control	12% Fat	16% Fat	20% Fat	12% An. fat	Torula yeast	Brewers yeast	Soy oil meal	Control
Males	6	6	4	8	6	4	6	8	4
	8	6	6	6	6	8	4	8	6
	6	6	6	2	6	6	2	6	6
	8	8	8	2	6	6	2	6	8
	8	8	2	4	6	10	6	10	6
Total	36	34	26	22	30	34	20	38	30
Females	8	8	8	6	8	2	8	8	6
	8	8	6	10	8	4	6	10	8
	6	2	8	6	8	6	6	8	6
	4	2	6	2	4	6	2	8	4
	4	2	4	4	8	2	8	6	4
Total	30	22	32	28	36	20	30	40	28
Males and females Total	66	56	58	50	66	54	50	78	58

* Mink graded on over-all quality in relation to each other. Highest possible score 12, lowest 0. Size and condition (fatness or thinness) not considered. Pelts graded by Mr. Joseph Stuekerjuergen, Madison, Wisconsin.

when they were 11 weeks old and weights and length measurements were taken at 11 weeks, 16 weeks and on November 21. November 21 was used as a final weigh data in 1957 due to unseasonably cold weather which would have caused irregular weights if the animals had been carried to the 29-week weighing.

The control ranch ration consisted of horse meat, tripe, ocean whiting, liver and cereal as previously shown in table 2. Water was added to the dry diets to attain a hamburger-like consistency.

Experimental rations, their chemical analyses and the performance of the animals on different rations are shown in tables 9 through 16.

Analysis of variance of the weight gains from 11 weeks of age to November 21 showed a significant interaction ($P < 0.01$) between sex and diet, in that the males on high performance diets gained much more proportionally than the females on high performance diets. For this reason, the weight gains were analyzed by sexes in order to obtain the maximum information available from the data.

Table 12 shows the results of the analysis of variance of the male gains. At the one percent level of probability, lot 1 was better than lots 2, 4 and 5, lot 3 was better than lots 2 and 4, and lot 5 was better than lot 4. At the 5 percent level of probability the mink on the fresh meat control gained significantly more than all other diets, and the mink that received the dry diet with fresh liver gained significantly more than those that did not receive the liver.

In the case of the females (table 13), analysis of variance gain showed the mink on the control ranch ration to have the greatest gains. In this case, the gains of controls were not significantly greater than those on the dry diets plus liver, but the gains of the control were

Table 9. Composition of rations -- 1957 dry diet growth studies

Ingredient	Ration 57-6	57-7*	57-8	57-9*
Cereal mix[1]	14.66	14.66	14.66	14.66
Dried yeast, torula	5	5	5	5
Dried yeast, brewers	5	5	5	5
Soybean oil meal, 50%	15	15	15	15
Fish meal[2], 55%	30	30	30	30
Liver product[3]	3	3	3	3
Skim milk powder	4	4	4	4
Sucrose	4	4	-	-
Corn starch	4	4	-	-
Vitamins**	.34	.34	.34	.34
Choice white grease	15	15	23	23
Total	100.0	100.0	100.0	100.0

* 25% fresh liver added

** Per 100 pounds: Vit A (10,000 USP/gm) 12 gms; Vit. D (3,000 IU/gm) 6 gms; Vit E (20,000 IU/gm) 6 gms; Vit K Menadione (8.6 gm/lb) 22 gms and choline Cl (25%) 110 gms.

1 Kellogg Mink mix 1007

2 Vitaproil - Maine Marine Products, Inc.

3 Ritaliver - Imperial Products Co.

Table 10. Proximate analysis of diets — 1957 dry diet growth study (%)

Diet	H_2O	Prot.	Fat	Fiber	N.F.E.	Ash	Ca	P
"As fed"								
1	72.8	11.5	5.4	.62	7.2	2.5	.58	.39
2	49.2	20.0	11.9	.94	13.7	4.3	.72	.61
3	55.2	18.7	10.0	.70	12.0	3.5	.54	.54
4	49.0	19.4	16.2	.91	10.3	4.2	.66	.59
5	57.4	17.2	13.3	.75	7.9	3.4	.49	.49
Moisture-free basis								
1	-	42.2	19.7	2.3	26.6	9.1	2.13	1.43
2	-	39.3	23.4	1.8	27.0	8.5	1.42	1.20
3	-	41.8	22.2	1.6	26.6	7.8	1.20	1.20
4	-	38.0	31.8	1.8	20.2	8.2	1.29	1.16
5	-	40.4	31.3	1.8	18.5	8.0	1.15	1.15

Table 11. Average weights and lengths — 1957 dry diet growth study

			Weight in grams			Length in inches	
			11-wk.	16-wk.	Nov. 21	11-wk.	Nov. 21
Lot 1 -	Males	Control	951	1346	1569	14.5	16.3
	Females		700	886	909	13.4	14.4
	Average		828	1116	1239	13.9	15.3
Lot 2 -	Males	Dry, 20% fat	979	1075	1285	14.5	15.9
	Females		698	723	813	13.4	14.3
	Average		839	899	1049	14.0	15.1
Lot 3 -	Males	Dry, 20% fat +	984	1179	1491	14.5	16.2
	Females	25% liver	687	742	855	13.3	14.2
	Average		836	961	1173	13.9	15.2
Lot 4 -	Males	Dry, 28% fat	987	1118	1274	14.4	15.7
	Females		688	712	802	13.2	13.9
	Average		838	915	1038	13.8	14.8
Lot 5 -	Males	Dry, 28% fat +	959	1141	1389	14.3	15.7
	Females	25% liver	705	777	907	13.4	14.3
	Average		832	959	1148	13.9	15.0

Table 12. Analysis of variance of male weight gains from 11 weeks of age to November 21 -- 1957 dry diet growth study

Source of variation	Degrees of freedom	Mean square	F values		
			Calculated	P = 0.05	P = 0.01
Total	74				
Diet	4	5437.8	34.96**	2.53	3.65
Error	70	155.5			

** Significant ($P < 0.01$)

Comparison among lots at the 1 percent level of probability

Lot	4	2	5	3	1
Av. wt. gain (gms)	287	306	430	507	618

Comparison among lots at the 5 percent level of probability

Lot	4	2	5	3	1
Av. wt. gain (gms)	287	306	430	507	618

Table 13. Analysis of variance of female weight gains from 11 weeks of age to November 21 -- 1957 dry diet growth study

Source of variation	Degrees of freedom	Mean square	F values		
			Calculated	P = 0.05	P = 0.01
Total	74				
Diet	4	317.0	4.20**	2.53	3.65
Error	70	75.36			

** Significant ($P < 0.01$)

Comparison among lots at the 1 percent level of probability

Lot	4	2	3	5	1
Av. wt. gain (gms)	114	115	168	202	209

Comparison among lots at the 5 percent level of probability

Lot	4	2	3	5	1
Av. wt. gain (gms)	114	115	168	202	209

Table 14. Analysis of variance of male weight gains from 11 to 16 weeks -- 1957 dry diet growth study

Source of variation	Degrees of freedom	Mean square	F values: Calculated	F values: P = 0.05	F values: P = 0.01
Total	74				
Diet	4	1987.8	327.6**	2.53	3.65
Error	70	60.68			

** Significant ($P < 0.01$)

Comparison among lots at the 1 percent level of probability

Lot	2	4	5	3	1
Av. wt. gain (gms)	96	131	182	195	395

Table 15. Analysis of variance of female weight gains from 11 to 16 weeks — 1957 dry diet growth study

Source of variation	Degrees of freedom	Mean square	F values		
			Calculated	P = 0.05	P = 0.01
Total	74				
Diet	4	673.0	24.0**	2.53	3.65
Error	70	28.04			

** Significant ($P < 0.01$)

Comparison among lots at the 1 percent level of probability

Lot	2	4	3	5	1
Av. wt. gain (gms)	25	25	55	72	186

Table 16. Analysis of variance of weight gains 16 weeks to Nov. 21 -- 1957 dry diet growth study

Source of variation	Degrees of freedom	Mean squares	F values		
			Calculated	P = 0.05	P = 0.01
Total	149				
Sex	1	7,590	51.25**	3.84	6.63
Diet	4	443.2	2.99**	2.37	3.32
S x D	4	255.0	1.72	2.37	3.32
Error	140	148.1			

** Significant (P < 0.01)

Comparison among lots at the 5 percent level of probability

Lot	1	4	2	5	3
Av. wt. gain (gms)	123	123	150	189	212

significantly greater than those of the females receiving the dry diets without added liver.

In order to determine if the greater differences appeared in the period from 11 to 16 weeks, or from 16 weeks to November 21, an analysis of variance was run on the gains during these periods. In the former interval, there again was a highly significant interaction between sex and diet, and because of this the analyses of variances were run separately for each sex. Results are shown in tables 14 and 15. Mink on the control diets did best, those on dry diets with liver, next best and mink on the dry diets without liver gained the poorest.

Analysis of variance of weight gains from 16 weeks to November 21 (table 16) shows a reversal, with mink on the meat control gaining the least, mink on the dry diets plus liver gaining the most, and mink on the dry diets without liver in an intermediate position. This apparently is due to the fact that mink on the control ration had achieved most of their weight by 16 weeks, while those on the dry diets, being smaller, were still growing and compensating for their poorer earlier gains.

Reproduction Studies - 1957

During 1957, a trial was conducted comparing the reproductive performance of mink receiving the control ranch-type ration to that of mink feed a dry ration during winter maintenance, and supplemented with 25 percent fresh liver during gestation, parturition, and lactation.

Twenty dark female mink were fed the control ration and 15 dark and 5 pastel females were fed the dry diets. The experiment was initiated January 18th and continued until the kits were 21 days old. The addition of fresh liver was started on March 11. Water was added to the dry diets to make a mixture of hamburger-like consistency.

Experimental rations, their chemical analyses and the performance of the animals are shown in tables 17 through 23.

Table 19 indicates that there was no significant difference in adult weights or breeding performance on the different treatments. Tables 20 and 21 show the number of kits whelped to be comparable with a slightly higher mortality and slightly smaller kit weights at 21 days of age for those on the dry diet plus liver. In table 22 the analysis of variance of the initial weights indicate a significant difference between sexes but not between diets. Table 23 shows a highly significant difference ($P < 0.01$) between sexes and between diets. From this, it can be concluded that the production and initial weights of mink on the dry diets + 25 percent fresh liver was not significantly different from the controls, but that the 21-day weights of the kits from mothers on the dry diet with liver were significantly lower ($P < 0.01$).

Reproduction Studies - 1958

Since the dry diets plus fresh liver gave good results during gestation and lactation in 1957, it was decided to attempt to feed complete dry rations during gestation, and to supplement them with fresh animal products during the lactation period only. During lactation, the dry diets were fed in two ways - with 25 percent liver or 25 percent tripe. The objective of this work was to determine whether the beneficial effects observed in 1957 were due to the nutrient effects of liver or to added palatability furnished by fresh animal products. Control mink received the ranch-type ration of table 24 throughout the experiment.

Ten dark females were allocated to each of the three treatments. The experiment was started on January 21, 1958 and continued until the

Table 17. Composition of rations used in 1957 dry diet reproduction experiment

Control diet	%	Dry diet	%
Horse meat	26.7	Cereal mix[2]	17.2
Tripe	26.6	Soybean oil meal (50%)	19.0
Ocean perch	26.7	Dried yeast, torula	7.2
Liver	5.0	Dried yeast, brewers	7.2
Cereal[1], supplemented	15.0	Fish meal[3] (55%)	19.0
Total	100.0	Herring meal[4] (70%)	9.6
		Meat scraps	4.8
		Liver product[5]	2.8
		Skim milk powder	2.8
		Choice white grease	10.4
		Vitamin A and D suppl.	*
		Total	100.0

* Vitamins added/100 lbs. feed: Vit. A (10,000 IU/gm) 8 gms; Vit. D_3 (1,500 IU/gm) 80 gms.

1 Kellogg mink mix No. 1001
2 Kellogg mink mix No. 1007
3 Vitaproil - Maine Marine Products, Inc.
4 Maine Marine Products, Inc.
5 Ritaliver - Imperial Products Co.

Table 18. Proximate analysis of rations— 1957 dry diet reproduction study (%)

Diet	H_2O	Prot.	Fat	Fiber	Ca	P
<u>"As fed"</u>						
Control	72.4	12.1	6.3	.7	.57	.41
Dry diet + 25% liver	60.8	20.2	7.4	.7	.46	.52
<u>Moisture-free basis</u>						
Control	-	43.5	22.8	2.5	2.06	1.48
Dry diet + 25% liver	-	51.6	19.0	1.7	1.17	1.33

Table 19. Female weights and breeding results -- 1957 dry diet reproduction study

	No. females	Weights			No. bred	No. repeat matings
		Jan. 18	Mar. 11	July 11		
Control	20	1.71	1.56	1.79	20	14
Dry ration	19	1.79	1.62			
Dry ration + liver	19		1.62	1.64	17	11

Table 20. Whelping results -- 1957 dry diet reproduction study

	No. females	No. that whelped	Kits born	No. kits alive at		Mortality %	Kits alive at 1 day	
				1 day	21 days		per female kept	per female that whelped
Control	20	17	97	92	87	10	4.6	5.4
Dry ration	19	16	91	85	75	18	4.5	5.3

Table 21. Average 1-day and 21-day weights of mink kits -- 1957 dry diet reproduction study

	1-day weights (gms)			21-day weights (gms)		
	Male	Female	Av.	Male	Female	Av.
Control	10.5	9.9	10.2	111	105	108
Dry ration + liver	10.2	9.4	9.8	100	90	95

Table 22. Analysis of variance of 1-day kit weights -- 1957 dry diet reproduction study

Source of variation	Degrees of freedom	Mean square	F values		
			Calculated	P = 0.05	P = 0.01
Total	173				
Sex	1	.49	7.2**	3.84	6.63
Diet	1	.16	2.3	3.84	6.63
S x D	1	.23	3.4	3.84	6.63
Error	170	.068			

** Significant (P < 0.01)

Table 23. Analysis of variance of 21-day weights -- 1957 dry diet reproduction study

Source of variation	Degrees of freedom	Mean square	F values		
			Calculated	P = 0.05	P = 0.01
Total	162				
Sex	1	62	13.41**	3.84	6.63
Diet	1	169	25.76**	3.84	6.63
S x D	1	6	1.29	3.84	6.63
Error	159	4.62			

** Significant ($P < 0.01$)

kits were 14 days old. Starting on April 25th (about 5 days before the first litter was expected to arrive), the animals were changed to their respective diets containing tripe or liver. These rations were continued to the end of the trial. Water was added to the dry diets to make a mixture of hamburger-like consistency.

Formulation of the rations, their chemical analyses, breeding results and whelping results are given in tables 24 to 29.

Table 29 illustrates the extreme difficulty of demonstrating significant differences between the production of two experimental groups with small numbers of females. Table 27 shows that there was an average difference of 2.6 kits per litter per female kept or 1.2 kits per female that whelped between the females receiving the control diet and those receiving the dry diet containing liver. However, even this large difference in the number of kits per female kept could not be demonstrated to be significantly different, although the "F" value in this case came very close to being significant at the 5 percent level. Analysis of variance of the 1-day and 14-day weights did not show a significant difference between treatments.

Discussion

A summary of certain relationships between ranch rations, dry diets and dry diets plus liver taken from the 1957 growth study is shown in table 30. Since there was no significant difference between the fat levels, the two groups on dry diets alone and supplemented with liver were separately averaged.

At the end of the experiment, both males and females fed the dry diet weighed substantially less than those on the control diet. When

Table 24. Rations for 1958 dry diet reproduction study

Control	%	Dry ration	%
Horse meat	26.7	Cereal mix[2]	17.7
Tripe	26.6	Dried yeast, torula	7.5
Ocean fish	26.7	Dried yeast, brewers	7.5
Liver	5.0	Soybean oil meal, 50%	15.0
Cereal mix, supplemented[1]	15.0	Fish meal[3], 55%	30.0
		Liver product[4]	3.0
Total	100.0	Skim milk powder	4.0
		Vitamins**	.3
		Choice white grease	15.0
		Total	100.0

** Vitamins added per 100 lbs. feed: Vit. A (10,000 USP/gm) 12.0 gms; Vitamin D_3 (3,000 IU/gm) 6.0 gms; Vit. E (20,000 IU/gm) 6.0 gms; Vit. K (Menadione 8.6 gms/lb) 22.0 gms and choline chloride (25%) 110.0 gms.

1 Kellogg mink mix No. 1001
2 Kellogg mink mix No. 1007
3 Vitaproil - Maine Marine Products, Inc.
4 Ritaliver - Imperial Products Co.

Table 25. Proximate analysis of rations -- 1958 dry diet reproduction study (%)

Diet	H_2O	Prot.	Fat	Fiber	N.F.E.	Ash	Ca	P
"As fed":								
Control	73.6	11.3	6.0	.7	6.4	2.2	.50	.35
Dry ration*	8.4	35.3	24.4	1.9	22.1	8.0	1.21	1.15
Dry + 25% tripe	63.4	15.8	10.1	.7	6.9	3.0	.42	.42
Dry + 25% liver	60.6	17.8	10.1	.7	7.5	3.2	.44	.49
Moisture-free basis:								
Control	-	42.2	22.7	2.5	24.2	8.4	1.90	1.33
Dry ration	-	38.5	26.6	2.0	24.1	8.7	1.32	1.25
Dry + 25% tripe	-	43.4	27.7	1.8	18.9	8.2	1.16	1.16
Dry + 25% liver	-	45.2	25.6	1.7	19.2	8.2	1.12	1.24

* Analyzed before water added

Table 26. Female weights and breeding results -- 1958 dry diet reproduction study

Ration	No. females	Weight (gms) Jan. 2	Weight (gms) Feb. 3	Weight (gms) Mar. 20	No. bred	No. repeat matings
Control	10	696	942	895	10	7
Dry	20	756	806	772	19	14

Table 27. Whelping results -- 1958 dry diet reproduction study

Ration	No. females	No. that whelped	Kits born	No. kits alive at		Mortality %	Kits alive at 1 day	
				1 day	14 days		Per female kept	Per female whelped
Control	10	10	62	59	55	10	5.9	5.9
Dry[1]	20	16	89	80	--	--	4.0	5.0
Dry[1] + 25% liver	10	7	36	33	29	19	3.3	4.7
Dry[1] + 25% tripe	10	9	53	47	41	23	4.7	5.2

1 Dry rations ended April 24 (about 5 days before first litter whelped) after which supplement was added

Table 28. Kit weights in grams -- 1958 dry diet reproduction study

Ration	At 1 day			At 14 days		
	Male	Female	Av.	Male	Female	Av.
Control	8.8	8.5	8.6	53	58	55
Dry + 25% liver	8.6	7.6	8.1	57	53	55
Dry + 25% tripe	8.4	7.6	8.0	54	53	54

Table 29. Analysis of variance of kits alive at 1-day -- 1958 dry diet reproduction study

Source of variation	Degrees of freedom	Mean square	F values		
			Calculated	P = 0.05	P = 0.01
Total	29				
Diets	2	17.4	3.22	3.33	5.42
Error	27	5.4			

Table 30. Weights and weight gains on dry diets in comparison to the control ration -- 1957 growth study

	Total weights			Gains in weight					
				11 wk.-16 wk.		16 wk.-Nov. 21		11 wk.-Nov. 21	
	Init. wt. (gm)	Final wt. (gm)	Final wt. as % of controls	Amount (gm)	% of Control	Amount (gm)	% of Control	Amount (gm)	% of Control
Control:									
Male	951	1569	100	395	100	223	100	618	100
Female	700	909	100	186	100	23	100	209	100
Dry diets:									
Male	983	1280	82	114	29	183	82	297	48
Female	693	807	89	24	13	90	391	114	55
Dry diet + 25% liver:									
Male	972	1440	92	188	48	280	126	468	76
Female	696	881	97	64	34	121	526	185	89

the dry diet was supplemented with liver, growth was intermediate between the other two diets. Females, however, did better proportionately than the males on the dry diet, alone and with liver. To analyze how the growth occurred, the gains were evaluated for the two periods shown.

From 11 to 16 weeks, weight gain on the dry diets was poor compared to that on the control with males gaining more than females on a percentage basis. During the period from 16 weeks to November 21 both males and females did better than during the earlier period when compared to the controls. The females gained four to five times as much as those on the control ration. Over-all, the absolute gain of the males on the dry diets was greater than that of the females but the rate of growth of the females was proportionately better than that of the males when compared to the controls.

It is possible that the difference between performance of the controls and the animals on dry rations is due to need for adjustment of the animals to the dry diets. This took a week to ten days and, of course, did not occur with mink on the control diet. It is possible that the animals on dry rations were unable to regain the weight lost during this adjusting period. Because of this, the increased response to the dry rations during the second period may have been due either to compensatory growth or to less critical nutritional demands at that time. To decide this point, it would have been necessary to start additional mink on dry diets at 16 weeks of age.

A question which has never been adequately answered, and which is pertinent to this study, is the animal's reaction to growth retardation. In many species slower gains in early stages of growth are compensated for by increased gains later in the growth period. However, unpublished work by the author and colleagues at Ithaca, New York, shows that the epiphyses of the long bones close at about 16 weeks of age in the mink, which would preclude any further gains in length. If so, requirements for late growth should be less critical. This may help explain why dry diets did well during this period.

The significance of fat deposition in the growing mink also needs further clarification. Adult mink have a cycle of gradual fat deposition during the fall and winter and gradual loss of fat during late winter and spring. Much of the weight gain in kit mink after 16 weeks of age is fat. Whether fat is necessary for optimum pelt development, or whether an excess or an insufficiency of fat depositions can cause damage to the pelt, has never been adequately determined.

In the 1958 reproduction study, analysis of variance did not show a significant difference in 1-day or 14-day kit weights between the different diets. The litter size may have been a factor. At 14 days, mothers on the control ranch ration were nursing an average of 5.5 kits, mothers on the dry diet plus liver were nursing 4.1 kits, and those on the dry ration plus tripe, 4.6 kits.

Kifer (1956) indicated that a limiting factor in the dry diets in his studies was digestible energy, as he obtained greater growth responses with higher fat levels. To investigate this possibility, the digestible energy values of the ranch-type rations and several of the dry rations containing different fat levels were calculated as shown in table 31. Nutrient digestibility was assumed as follows: for the dry rations - protein 70 percent, N.F.E. 80 percent and fat 90 percent; for the ranch rations - protein 85 percent, N.F.E. 90 percent and fat 90 percent. Crude fiber was ignored as it probably approaches zero. Energy values were

Table 31. Estimated caloric values of rations used in some 1956-57 growth studies

Ration	Actual % fat in ration	Total calories per lb.	Total calories per 100 gms.	Digestible calories per 100 gms.
1956 Control	20.6	2088	460	405
1957 Control	19.7	2056	453	399
1956 12% fat meal	14.4	1898	418	328
1956 16% fat meal	18.6	2016	444	356
1956 20% fat meal	24.0	2161	476	386
1957 20% fat meal	23.4	2157	475	385
1957 20% fat meal + 25% liver	22.2	2152	474	382
1957 28% fat meal	31.8	2356	519	429
1957 28% fat meal + 25% liver	31.3	2347	517	426

calculated on a basis of nine calories per gram for fat and four calories per gram for protein and carbohydrate.

Table 31 shows that the higher fat-dry diets used in the 1957 growth studies contained comparable levels of digestible calories to the control ranch-type rations. Since performance was not as good for the males on dry diets as for those on dry diets plus liver, and for the latter with respect to the ranch-type rations, it might indicate that there is a factor present in fresh food necessary to obtain maximum response from dry rations. However, some investigators (Travis, 1949; Howell, 1952; Gunn, 1960a) have reported less food consumption by mink on dry rations than by those on control rations. Whether this is due to smaller animals needing to eat less, or whether the animals were smaller because they ate less, has never been determined. So far, no digestibility studies have been published on dry rations. A combined study of rate of food consumption and digestibility should be conducted to determine the cause and effect of the poorer growth of male mink on dry rations. Since the females did better than the males on the dry diet alone, and on the dry diet supplemented with liver, it would seem that either females do not need as much of the fresh food factor or they consume more of the dry feed in relation to their total weight. Thus, it is possible that dry rations will be developed for females before they are attained for males.

Length and weight help to characterize growth but the attribute of greatest economic importance in mink is pelt quality. Evaluations based on subjective judgments used exclusively by fur graders leave much to be desired. Objective methods have been developed (Wentz and Hunt, 1951; Dolnick, 1959) but they are so time-consuming that they are impractical

for routine use. In general, if a diet produces better growth than another, it usually also produces at least as good and possibly a better pelt. In fact, many of the problems in mink nutrition are in such an early stage of study that growth responses are probably also indices of the relative values of the treatment insofar as they affect pelt quality. This is believed to be true in the case of the current dry diet studies. At least, there was no indication that dry diets had detrimental effects on pelt quality.

Summary and Conclusions

Experiments were conducted with mink during two growth and two reproductive periods to find out if dry rations could perform as well as fresh ranch-type rations. A total of 739 mink were used in these trials: 9 groups of 20 mink in 1956 and 5 groups of 30 mink in 1957 in the growth studies; 40 adults and 188 kits in 1957 and 30 adults and 151 kits in 1958 in the reproduction studies.

Dry rations were fed in the form of pellets or meal moistened to hamburger-like consistency. Brewers yeast and torula yeast gave comparable results when constituting 15 percent of this ration.

Increasing the fat level from 12 to 20 percent in the dry rations improved the rate of growth of kits. No added beneficial effect was apparent from increasing the fat to 28 percent.

In certain growth trials, sex x diet interactions were evident; males gave a greater response to changes in diet than females.

The dry diet gave somewhat inferior growth compared to the control ranch ration. From 16 to 30 weeks of age, dry diets produced comparable or greater gains than the control.

There was no significant difference in fur quality or length gains of the live mink among the diet treatments.

Adult mink fed dry diets during the winter, and dry diets with 25 percent of fresh liver during breeding, gestation and lactation, were comparable in adult weights, breeding performance and number of kits whelped to mink that received a typical commercial ranch ration. There was no significant difference in 1-day kit weights, but 21-day weights were in favor of the control ranch ration. There was a significant sex difference in both 1-day and 21-day kit weights in favor of the males.

Mink given dry rations through winter maintenance, breeding and gestation until April 25th, and then given dry diets with 25 percent liver or tripe averaged over four kits per female kept. This performance, while about equal to the national average, was not as good as that of the controls (5.9) which was exceptional.

The response to the dry diets from adding fresh liver or fresh tripe was similar, indicating that the value of the fresh products may be due to palatability rather than nutrient value.

Vitamin K Studies

Introduction

Most mammals obtain part of their vitamin K requirements from synthesis by their own intestinal bacterial flora. However, the anatomical and physiological limitations of the mink leave doubt as to its ability to obtain sufficient vitamin K in this manner. The digestive tract is only four times the body length, there is no caecum, and the relatively undifferentiated large intestine is only about one-third of the body length (Kainer, 1954). Food passage is rapid, averaging less than two hours in mink with empty digestive tracts and slightly more than two hours when food is continuously available (Wood, 1956). Thus, the conditions for bacterial synthesis in the gut would appear more limited in mink than in most mammals.

It has also been established that some mink containing the Aleutian genes for color (aa) have an unexplained bleeding from the mouth and digestive tract (Helmboldt and Jungher, 1958) which could be associated with a deranged blood clotting mechanism.

This study was, therefore, initiated for the following reasons: (1) to determine if mink require a dietary source of vitamin K; (2) to observe what effects certain antibiotics and medicaments would have upon blood clotting time; and (3) to compare the whole blood prothrombin time of dark mink to that of mink containing the Aleutian genes (aa) for color.

Procedure

The procedure followed was to place the animals on the experimental ration for a period sufficient to deplete their body stores of vitamin K, and then to evaluate the effects of vitamin K in the ration by observing the increase in prothrombin clotting times.

The method of determination was the whole blood prothrombin clotting time as modified by Frost et al. (1956), using lyophilized extracts as the source of thromboplastin. To obtain more uniform results, animals were bled by heart puncture using siliconized needles, tubes and syringes.

Mink were housed individually in conventional outdoor pens of 1 x 1-inch wire mesh with aluminum feeders and waterers. Chicks used in the biological assay of the basal mink ration for vitamin K were raised in electrically-heated batteries with a wire floor mesh of 1/3 x 1/3-inch. In order to prevent possible coprophagy and/or bacterial synthesis, the pens, feeders and waterers of the mink and chicks were cleaned daily and the purified rations were kept refrigerated until fed. Data were subjected to analyses of variance, multiple range and multiple F tests.

Results and Discussion

In the first experiment 30 female sapphire (homozygous for the Aleutian gene) and 30 female dark mink were used. Ten dark and 10 sapphire mink were placed on each of the following treatments: (1) control ranch ration (table 32); (2) basal semi-purified mink ration with no added vitamin K (table 33); and (3) basal semi-purified mink ration plus 7 grams of menadione sodium bisulfite per ton of feed. After 28 days, the whole blood prothrombin clotting times were obtained with the results shown in table 34.

These data show that there were no significant differences in whole blood prothrombin times due to treatment or genetic strain. Three mink receiving the purified ration without added K were continued for two additional weeks with no appreciable increase in clotting time; their average clotting times being 17.3 seconds at the end of four weeks and 18.3 seconds at the end of six weeks.

It is evident, therefore, that mink require no more vitamin K than was present in the control ration. To ascertain this value, a chick assay test was conducted on the semi-purified ration which had been fed to the mink. A total of 100 male Single Comb White Leghorn chicks were allocated equally to the following: lot 1, the mink semi-purified basal ration; lot 2, vitamin K-free assay ration (Quick, 1957); and lots 3, 4 and 5, vitamin K-free assay ration plus 22.5, 90 and 360 milligrams of menadione sodium bisulfite per ton, respectively.

Using the method of Almquist and Klose (1939) of plotting mean reciprocal prothrombin times against the logarithms of the vitamin K dosage, this test showed that the semi-purified ration fed the mink contained 13 milligrams of menadione sodium bisulfite activity per ton (chart 1). This demonstrates that adult mink need less vitamin K than 13 milligrams per ton of feed, air dry basis. A level as low as this would be virtually impossible to attain in a practical ranch ration.

In another phase of the investigation, the effects of certain medicaments and drugs upon blood clotting time were studied. Where sulfaquinoxaline was fed to mink as a coccidiostat, it upset the normal blood clotting process and caused severe hemorrhages in many cases (Hartsough and Gorham, 1960). Since sulfaquinoxaline affects the bacterial flora of the gut so that vitamin K is not produced (Kornberg, et al., 1944), aureomycin and terramycin which are also used in mink therapy were investigated. Results of this study are shown in table 36.

It can be seen that terramycin or aureomycin at levels of 400 grams per ton did not significantly increase blood clotting time. Sulfaquinoxaline at levels of 0.05 percent or more significantly increased clotting time. Menadione sodium bisulfite fed at a level of 10 grams per ton decreased the clotting time when administered in the presence of 0.06 percent sulfaquinoxaline, but did not lower it to the normal range. Menadione sodium bisulfite fed at the rate of one gram per ton did not significantly decrease blood clotting time in the presence of 0.05 percent sulfaquinoxaline. In preliminary studies, levels of sulfaquinoxaline of 0.1 percent or more caused death by cardiac tamponade in about one-half of the mink from which blood was drawn by heart puncture.

Summary and Conclusions

Experiments were conducted to ascertain (1) if normal adult mink require vitamin K; (2) whether dark mink differ in this respect from sapphire mink which contain the Aleutian gene; (3) if sulfaquinoxaline or certain antibiotics affect blood clotting time.

The dietary requirement of normal adult mink was established as being less than 13 milligrams per ton of menadione sodium bisulfite or 6.5 micrograms per pound of feed. Practical ranch rations would contain much higher levels.

The whole blood prothrombin times of the sapphire mink tested (16.8 $\pm$ .4 seconds) were similar to those of normal dark mink (17.8 $\pm$ .4 seconds).

Sulfaquinoxaline fed for 6 to 8 days at the 0.05 percent level or higher significantly increased the whole blood prothrombin clotting times.

Vitamin K fed at levels of 10 grams per ton reduced the clotting time of mink fed sulfaquinoxaline at a level of .06 percent.

Addition of aureomycin and terramycin at a level of 400 grams per ton did not significantly increase whole blood prothrombin times when fed for 6 or 8 days.

Mink fed a semi-purified ration had comparable blood clotting times to those fed a typical ranch ration.

Table 32. Composition of control ranch ration*

Ingredient		Percentages
Horse meat		26.7
Ocean whiting		26.6
Beef tripe		26.7
Liver		5.0
Cereal mix, supplemented[1]		15.0
	Total	100.0

*Sufficient water added to make a hamburger-like consistency

[1] Mink cereal mix 1001, Kellogg Company

Table 33. Composition of semi-purified basal mink ration*

Ingredient	Percentages
Vitamin-free casein	32
Stripped lard[1]	14
Cod liver oil	1
Cellulose[2]	5
Salts[3]	4
Choline chloride (70%)	1
Sucrose	43
Total	100

1 Donated by Distillation Products Industries, Rochester, N. Y.
2 Solka-Floc, Brown Company
3 Phillips and Hart (1935), cobalt chloride 0.005 percent added
* Water added to produce a thick syrup consistency for mink. Ration fed dry to chicks.

Vitamin and amino acid per 100 grams of feed added at the expense of sucrose.

	Milligrams		Milligrams
Arginine HCl	500.0	Para aminobenzoic acid	100.0
DL-methionine	300.0	Folic acid	0.2
Thiamine HCl	0.5	Biotin	0.05
Pyridoxine HCl	0.5	Alpha tocopherol	8.0
Riboflavin	1.0	Vitamin B_{12}	0.015
Nicotinic acid	5.0	BHT	20.0
Ca pantothenic acid	3.6		
I-inositol	50.0		

Table 34. Whole blood prothrombin clotting times of mink after receiving the specified experimental rations for 28 days

Rations	Type of mink	No. mink	Mean clotting time in seconds with standard error
Control ranch	Dark	10	17.8 ± .36
	Sapphire	10	16.8 ± .42
Semi-purified without vitamin K	Dark	10	18.1 ± .37
	Sapphire	10	17.2 ± .28
Semi-purified plus 7 gms. per ton vitamin K	Dark	10	17.4 ± .33
	Sapphire	10	17.6 ± .43

Table 35. Whole blood prothrombin clotting times of 9 to 10-day old chicks receiving mink basal, chick basal, and chick basal plus graded levels of menadione sodium bisulfite from hatching time

Ration	No. chicks	Whole blood prothrombin clotting time in seconds with standard error
Mink semi-purified basal	10	67.5 ± 6.8
Vitamin K-free chick basal	10	93.9 ± 9.4
Chick basal + 22.5 mg/ton	10	53.0 ± 5.6
Chick basal + 90 mg/ton	10	26.5 ± 1.5
Chick basal + 360 mg/ton	10	22.1 ± 1.1

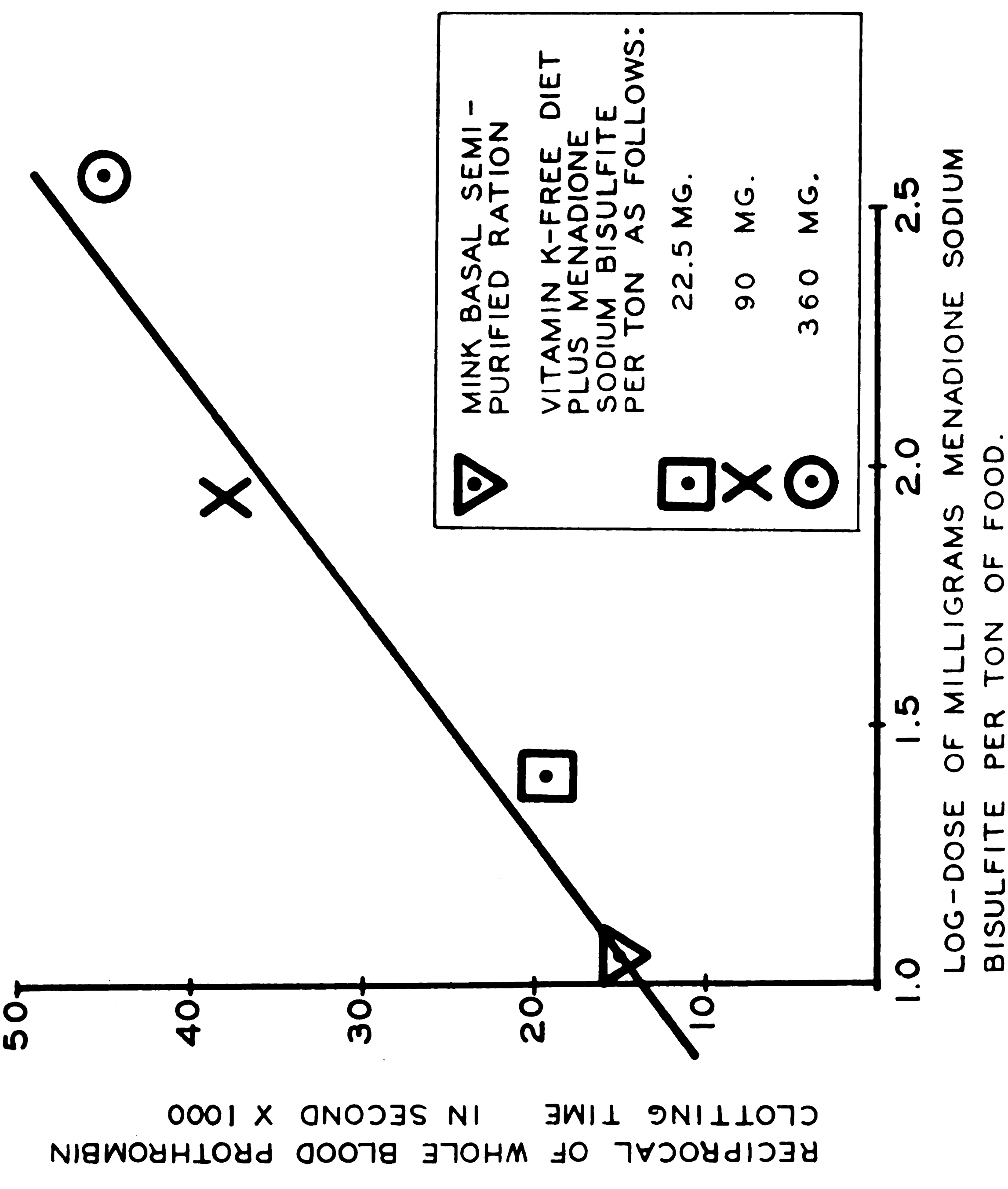
Table 36. The effect of terramycin, aureomycin, or sulfaquinoxaline (SQ) alone and in the presence of vitamin K on whole blood prothrombin clotting times of mink

Lot	Ration	No. mink	Days on exp.	Whole blood prothrombin clotting time in seconds with standard error
1	Mink ranch diet	20	8-9	18.9 ± .15
2	Terramycin 400 gms/ton	10	8-9	19.6 ± .27
3	Aureomycin 400 gms/ton	10	8-9	19.3 ± .35
4	SQ 0.05%	10	8-9	21.6 ± 1.02
5	SQ 0.06%	10	8-9	26.6 ± 3.0
6	SQ 0.05% + vitamin K (1 gm/ton)	10	8-9	21.2 ± .98
7	SQ 0.06% + vitamin K (10 gms/ton)	10	8-9	21.2 ± .83

Comparisons of means by analysis of variance and Duncan's multiple range and multiple F tests (P 0.01).

Lot	1	3	2	6	7	4	5
Mean	18.9	19.3	19.6	21.2	21.2	21.6	26.6

Figure 1. Determination of vitamin K (menadione sodium bisulfite) concentration of the mink semi-purified basal ration. Log of vitamin K concentration plotted against reciprocal of whole blood prothrombin clotting time.


MINK BASAL SEMI-PURIFIED RATION
VITAMIN K-FREE DIET PLUS MENADIONE SODIUM BISULFITE PER TON AS FOLLOWS:
22.5 MG.
90 MG.
360 MG.
1.0
1.5
2.0
2.5
LOG-DOSE OF MILLIGRAMS MENADIONE SODIUM BISULFITE PER TON OF FOOD.
10
20
30
40
50
RECIPROCAL OF WHOLE BLOOD PROTHROMBIN CLOTTING TIME IN SECOND X 1000

Studies of Amino Acid Requirements of Growing Mink

Introduction

The rising price and scarcity of high quality meat and fish by-products have made the problems of protein supply and quality among the most critical facing the mink rancher. Nevertheless, this area has attracted little attention from mink nutritional investigators. Based on the report of Bassett *et al.* (Unpub., 1951), the National Research Council (1953) has suggested that the requirements for protein are 22 percent for mink from 7 to 23 weeks of age and 16 percent from 23 weeks to maturity. In this study, the diets were comparatively low in fat and the mink used were of a strain much smaller than those currently found on mink ranches.

Leoschke and Elvehjem (1959a) claim normal growth for mink receiving 19 percent casein, plus added arginine and methionine with a diet containing 10 percent fat. However, their November weights of 1200 grams for male kits fall far short of the normal growth curves established by Travis and Schaible (1960) which show that average weights for male kits are 1470 grams or more in November.

The high levels of meat, fish and animal by-products fed on commercial ranches result in rations containing from 35 to 45 percent protein and 15 to 25 percent fat. Whether the reason these high protein levels are fed is merely a reflection of natural food of the wild mink is necessary to balance the high fat levels, to supply certain amino acids at critical times, or to provide unknown nutritional factors has not been determined.

Procedure

The objective of this study was to determine the quantitative requirements of protein and the essential amino acids for growing mink. The general method was: (1) to ascertain the amino acid requirement for one essential amino acid (specifically lysine); (2) to determine the amino acid composition of the mink carcass; and (3) using the knowledge of the requirements for the specific amino acid and the known proportion of the amino acids to each other in the carcass, to estimate the quantitative dietary requirements for all the essential amino acids. This method was devised by Mitchell and Albanese (1950) and has proven quite satisfactory for rats, chickens and pigs (Williams et al., 1954). In general, the figures achieved in this manner are quite comparable to those determined by a direct method, except for arginine, histidine, methionine and tryptophan. This procedure was chosen because it appeared to be the most efficient and rapid method of obtaining an estimate of the amino acid requirements of growing mink.

The specific procedure used in the earlier mink trials was a modification of the depletion-repletion technique developed by Cannon et al. (1944) in which the animals are fed diets very low in protein for a period and then placed on a diet which contains adequate levels of amino acids, except for the amino acid being tested, which is fed at graded levels. From this, the amino acid requirements for the particular function can be determined. In the later mink trials, graded levels of lysine were fed to the growing mink in a more conventional feeding test.

1958 Studies

Three experiments were conducted using the depletion-repletion technique in 1958. The amino acid balance used in the rations is shown in table 37 and the composition of the rations is given in table 38. Amino acids in the rations were balanced by using the carcass composition as a base and adding amino acids to the ration so that they were in the same proportions as in the carcass.

Experiment 1 was conducted for 12 days from July 24 to August 5th using 25 dark kit male mink, 5 mink per group. The experiment was divided into 3 periods: 4 days for the mink to become accustomed to the purified ration, during which increasing amounts of the purified depletion diet and decreasing amounts of the ranch ration were fed; 4 days of depletion using the diet containing no protein; and 4 days of repletion using the experimental rations containing graded levels of protein (added at levels of 0.0, 0.33, 0.66, and 0.99 percent lysine as L-lysine monohydrochloride). Lysine represented 4.4 percent of the protein of the basal semi-purified ration. Animals were weighed at 3-day intervals, at the same time of day, in order to reduce the diurnal weight variation. During the repletion period, food was allocated on a dry basis of 75 grams of feed per kilo of body weight. Water was added to the dry ration to make it a palatable consistency. Weight gains or losses of mink during this experiment are shown in table 39. Table 40 shows the food consumption per kilo of body weight per day.

Since all animals gained at nearly a uniform rate, it was decided to reduce food consumption to 50 grams per kilo of body weight during the repletion period. In this way, it was hoped to induce a greater spread between the weights of animals on different experimental treatments. The length of the feed intervals was increased to 6 days or a total of 18 days for the three periods. Thirty animals were used, 10 per group. The diets during the repletion period consisted of: (1) the semi-purified

Table 37. Amino acid composition of mink carcass, mink hair and ration components used -- 1958 study

	Mink hair[1]	Carcass of 12 wk. old kit[1]	Carcass of 30% protein basis	10% casein 10% promine 10% zein	% Amino acids added
Lysine	4.1	6.6	1.98	1.32	0.0 to 0.99
Threonine	5.7	3.9	1.17	0.99	0.18
Valine	4.9	5.0	1.50	1.50	•
Histidine	1.0	2.1	0.63	0.57	0.05
Tryptophan	0.3	0.4	0.12	0.24	•
Arginine	7.6	6.4	1.92	0.29	0.50
Leucine	6.3	7.3	2.19	4.10	•
Isoleucine	2.6	3.5	1.05	1.59	•
Cystine	15.1	?	?	0.18	•
Methionine	1.0	1.8	0.54	0.69	0.25
Phenylalanine	2.9	4.2	1.26	1.68	•
Tyrosine	4.3	2.9	0.87	1.44	•

[1] Moustgaard, J. and P. M. Riis (1957)

Table 38. Rations used in Experiments 1 and 2 -- 1958 study

	Assay ration	Depletion ration
Sucrose	41.0	71.0
Casein	10.0	-
Zein	10.0	-
Soybean protein[1]	10.0	-
Choice white grease	14.0	14.0
Cottonseed oil	5.0	5.0
Cod liver oil	1.0	1.0
Cellulose[2]	5.0	5.0
Minerals[3]	4.0	4.0
Vitamins[4]	++	++
Amino acids[5]	++	-
Totals	100.0	100.0

1 Promine - Glidden Co., Chicago, Ill.
2 Solka-Floc - Brown Company
3 Minerals - Salt mixture, Phillips and Hart (1935) Cobalt 0.005 percent added
4 Vitamins added at the expense of sucrose at the following levels: thiamine HCl 0.5; pyridoxine HCl 0.5; riboflavin 1.0; calcium pantothenate 3.6; nicotinic acid 5.0; I-inositol 50.0; para amino benzoic acid 100.0; folic acid 0.2; biotin 0.05; vitamin B_{12} 0.016; vitamin K 0.15; butylated hydroxytoluene 20.0; alpha tocopherol acetate 4.0, and choline Cl 800.0.
5 Amino acids were added in grams per hundred grams of feed as follows: L-arginine HCl 0.50; DL-methionine 0.25; DL-threonine 0.36; and DL-histidine HCl 0.05. Lysine was added in graded levels as designated in the different experimental treatments.

Table 39. **Average weight gains or losses of mink. Depletion-repletion experiment No. 1** (Aug. 27 - Sept. 4) -- 1958 study

Ration and period	No. mink	July 24	July 26	July 28	July 30	Aug. 1	Aug. 3	Aug. 5	Av. gain or loss
Control ranch	5	1142	1156	1190	1216	1242	1268	1290	+ 148
Accustomization	20	1146	1099	1084	--	--	--	--	- 62
Depletion	20			1084	1033	1000	--	--	- 84
Repletion basal	5					998	1022	1056	+ 58
Repletion + 0.33 lysine	5					1063	1087	1106[1]	+ 43
" + 0.66 lysine	5					1002	1040	1070	+ 68
" + 0.99 lysine	5					998	1018	1052	+ 54

1 Two animals discarded from this group due to non-acceptance of the feed.

Table 40. Feed consumption per kilo of final body weight per day of mink on repletion portion of Experiment No. 1 -- 1958 study

Lot	Consumption per kilo body wt. per day (gms)
Purified basal	67.6
" " + 0.33 lysine	66.8
" " + 0.66 lysine	61.7
" " + 0.99 lysine	56.2

Table 41. Weights of mink on depletion-repletion Experiment No. 2 (Aug. 27 - Sept. 14) -- 1958 study

Ration and period	No. mink	Average weights in grams							Av. gain or loss
		Aug. 27	Aug. 30	Sept. 2	Sept. 5	Sept. 8	Sept. 11	Sept. 14	
Control	10			1311	1336	1325	1339	1363	+ 52
Accustomizing and depletion	20	1357	1268	1267	1238	1158	--	--	- 199
Repletion basal semi-purified	10					1156	1087	1075	- 81
Repletion basal semi-purified + 0.66% lysine	10					1160	1125	1118	- 42

Table 42. Food consumption of mink on repletion portion of experiment No. 2 -- 1958 study

Addition to semi-purified basal ration	Consumption per kilo body wt. per day (gms)
None	51.0
0.66% lysine	48.9

Table 43. Amino acid content of rations used in experiment No. 3 -- 1958 study

	Carcass calculated to 30% protein[1] (%)	5% Casein 10% promine 15% zein[1] (%)	Added (%)
Lysine	1.98	0.90	0.0 to 0.66
Threonine	1.17	0.92	0.25
Valine	1.50	1.22	0.28
Histidine	0.63	0.50	0.13
Tryptophan	0.12	0.18	.
Arginine	1.92	1.17	0.75
Leucine	2.19	4.79	.
Isoleucine	1.05	1.49	.
Cystine	?	0.22	.
Methionine	0.54	0.63	0.30
Phenylalanine	1.26	1.74	.
Tyrosine	0.87	1.37	.

1 For the ration containing 20% protein the amount of the protein mix of casein, promine and zein and the percent of amino acids added are two-thirds of the above figures.

Table 44. Rations used in experiment No. 3 -- 1958 study

	Assay ration 30% protein (%)	Assay ration 20% protein (%)	Depletion ration (%)
Sucrose	41.0	51.0	71.0
Casein	5.0	3.33	.
Zein	15.0	10.0	.
Soybean protein[1]	10.0	6.67	.
Choice white grease	14.0	14.0	14.0
Cottonseed oil	5.0	5.0	5.0
Cod liver oil	1.0	1.0	1.0
Cellulose[2]	5.0	5.0	5.0
Minerals[3]	4.0	4.0	4.0
Vitamins[4]	++	++	++
Amino acids	++[5]	++[6]	.

1 Promine - Glidden Co.
2 Solka-Floc - Brown Co
3 Salt mixture -- Phillips and Hart (1935) cobalt chloride 0.005 percent added
4 Vitamins were added at the following levels in milligrams per 100 grams of feed at the expense of sucrose: thiamine HCl 0.5; pyridoxine HCl 0.5; riboflavin 1.0; calcium pantothenate 3.6; nicotinic acid 5.0; I-inositol 50.0; para amino benzoic acid 100.0; folic acid 0.2; biotin 0.05; vitamin B_{12} 0.016; vitamin K 0.15; butylated hydroxytoluene 20.0; alpha tocopherol acetate 4.0 and choline cl 800.0
5 Amino acids were added in grams per hundred grams of feed as follows: L-argining HCl 0.74; DL-methionine 0.31; DL-threonine 0.25; DL-histidine HCl 0.13 and DL-valine 0.56
6 Amino acids were added in grams per hundred grams of feed as follows: L-arginine HCl 0.49; DL-methionine 0.20; DL-threonine 0.17; DL-histidine HCl 0.09 and DL-valine 0.37

Table 45. Weight losses or gains and food consumption per day in experiment No. 3 -- 1958 study

Lot	% Protein in ration	Lysine added	No. mink	Food allowed/kg. body wt. (gms)	Average cons./kilo body wt. (gms)	Init. wt. (gms)	Final wt. (gms)	Gain (gms)	Av. cons. /day (gms)
1	30	--	2	60	62.6	1005	950	-55	59.5
2	30	--	1	65	65.2	1180	1150	-30	75.0
3	30	+	2	60	59.8	1020	970	-50	58.0
4	30	+	2	65	61.9	1030	1035	+ 5	64.1
5	20	--	2	60	61.2	1030	925	-125	56.6
6	20	--	1	65	64.7	890	810	-80	52.4
7	20	+	1	60	55.6	1140	990	-150	55.1
8	20	+	1	65	54.7	1150	1020	-130	62.9

Weighed averageds of above treatments:

		Init. wt.	Final wt.	Gain
20% protein vs. 30% protein	- 20% protein	1052	936	-116
	30% protein	1058	1026	- 32
60 Gms/kilo/day vs. 65 gms/kilo/day	- 60 gms/kilo/day	1049	959	- 90
	- 65 gms/kilo/day	1062	1004	- 58
Control vs. added lysine -	Control	1026	959	- 67
	Added lysine	1085	1038	- 47

basal with no added lysine; and (2) the semi-purified basal plus lysine added at a level of 0.66 percent. The experiment was initiated on August 27th and completed on September 14th. Animals were weighed at 3-day intervals. Weights of mink are shown in table 41 and food consumption during the repletion period is given in table 42.

Since the mink had gained rather uniformly on 75 grams per kilogram of body weight and lost rather uniformly on 50 grams per kilogram of body weight, it was decided to use levels of 60 and 65 grams per kilogram of body weight for the next test.

A total of 24 kits were used for experiment 3 which was initiated on October 1 and conducted during two periods for a total of 18 days (9 depletion and accustomization and 9 repletion). In addition, the proportions of casein, zein and promine were altered to produce protein of which only three percent was lysine. Half the mink were tested at 20 percent, and half at 30 percent protein.

Amino acid balance of the ration is shown in table 43 and the composition of the rations given in table 44. Table 45 shows the feed consumptions and weight gains or losses by groups.

Although 24 kits were used in this experiment, only those kits whose food consumption was adequate are considered in table 45. It was necessary to remove one animal (lot 4) to avoid starvation and several animals consumed only from one-half to two-thirds of the food allowed them.

From table 45 it can be seen that there was less loss by mink receiving 30 percent, than 20 percent protein; by mink given 65 grams per kilogram body weight compared to 60 grams and by those receiving added lysine as compared to those not receiving this amino acid.

1959 Studies

Several changes in the approach to the problem were made in 1959. Three experiments were conducted - two growth studies and one depletion-repletion study. Analyses were obtained from Armour and Company on two mink carcasses and two mink pelts that were supplied by the Michigan State University Fur Animal Project. This information was used in planning the 1959 diets. Also in an attempt to improve availability, the protein ingredients were changed to ten percent casein and 15 percent zein; promine was removed.

Experiment I

The first experiment was conducted from July 13th to August 2nd using 40 male mink kits in 5 lots of 8 mink each. The protein level was 25 percent. Lysine content of the basal ration was 3.16 percent of the protein. Lysine was added in increments of 0.2 percent so that the diets contained 0.79, 0.99, 1.19, 1.39 and 1.59 percent lysine, respectively. Other amino acids were added so that the balance of the amino acids was similar to that of the mink carcass. Ingredients for the basal ration are listed in table 46 and the amino acid balance and additions are listed in table 47. Table 48 shows the average weight gains of the mink during the period.

Mink on this trial showed a fairly good gain for this type of ration, averaging 35 grams per animal per week which was approximately the same for all groups.

Experiment II

Because the gains in experiment I seemed to be comparable, it was considered possible that the protein level was so high that all

Table 46. Basal ration for experiment No. 1 — 1959 study

	%
Vitamin-free casein	11.363
Zein	15.
Choice white grease	10.
Cottonseed oil	4.
Cod liver oil	1.
Sucrose	49.637
Cellulose[1]	5.
Minerals[2]	4.
Vitamins[3]	++
Amino acids[4]	++
Total	100.0

1 Solka-Floc

2 Phillips and Hart (1935) 0.005 percent cobalt chloride added

3 Vitamins were added in milligrams per 100 grams of feed at the expense of sucrose as follows: Alpha-tocopherol acetate 8.0; thiamine HCl 0.50; pyridoxine HCl 0.50; riboflavin 1.0; calcium pantothenate 3.6; nicotinic acid 5.0; I-inositol 50; PABA 100; folic acid 0.20; biotin 0.05; vitamin B_{12} 0.015; menadione sodium bisulfite 0.150; BHT 20 and choline Cl 800.

4 Amino acids were added in grams per hundred grams of feed as follows: DL-threonine 1.26; DL-valine 0.84; L-histidine HCl 1.32; DL-tryptophan 0.66; L-arginine HCl 0.76; L-cysteine HCl 0.54; and DL-methionine 0.22. Lysine was added in graded levels as designated in the different experimental treatments

Table 47. Amino acid composition of mink carcasses, rations and additions Experiment No. 1 -- 1959 study

	Carcass - 25% prot. basis		Casein prot. 15% Zein prot. 10%	Added amino acids
	M.R[1] (%)	Armour[2] (%)	(%)	(%)
Lysine	1.65	1.75	0.79	0.0 to 0.80
Threonine	0.97	1.35	0.72	0.63
Valine	1.25	1.48	1.06	0.42
Histidine	0.52	1.35	0.26	1.08
Tryptophan	0.10	0.80	0.14	0.66
Arginine	1.60	1.28	0.65	0.63
Leucine	1.82	1.05	3.51	.
Isoleucine	0.88	1.00	1.29	.
Cystine	.	0.63	0.16	0.47
Methionine	0.45	0.90	0.68	0.22
Phenylalanine	1.05	1.30	1.48	.
Tyrosine	0.73	0.58	1.39	.

1 Moustgaard, J. and P. M. Riis (1957).
2 Analysis supplied by Mr. George Josh, Armour and Company. Values are highest of values from analysis of two mink.

Table 48. Weights and weight gains of mink on Experiment No. 1 (July 13 - Aug. 2) -- 1959 study

Lot	No. mink	Lysine (%)	Weight July 13 (gm)	Weight Aug. 2 (gm)	Av. gain (gm)
1	8	0.79	719	835	116
2	8	0.99	733	842	109
3	8	1.19	709	816	107
4	8	1.39	734	820	86
5	8	1.59	722	835	113

Table 49. Weights and weight gains of mink in Experiment No. 2 (Aug. 3 - Aug. 15) -- 1959 study

Lot	No. mink	Lysine (%)	Weight Aug. 3 (gm)	Weight Aug. 15 (gm)	Av. gain (gm)
6	6	0.48	839	862	23
7	6	0.68	847	882	35
8	6	0.88	821	871	50
9	6	1.08	819	880	61
10	6	1.28	849	906	57

Table 50. Rations for experiment No. 3 -- 1959 study

Ingredient	Basal ration	Depletion ration
Vitamin-free casein	6.36	-
Zein	8.40	-
Choice white grease	10.0	10.0
Cottonseed oil	4.0	4.0
Cod liver oil	1.0	1.0
Sucrose	61.24	76.0
Cellulose[1]	5.0	5.0
Minerals[2]	4.0	4.0
Vitamins[3]	++	++
Amino acids[4]	++	-
Total	100.0	100.0

1 Solka-Floc

2 Phillips and Hart mixture (1935) 0.005 percent cobalt chloride added

3 Vitamins were added in milligrams per hundred grams of feed at the expense of sucrose as follows: alpha-tocopherol acetate 8.0; thiamine HCl 0.50; riboflavin 1.0; pyridoxine 0.50; calcium pantothenate 3.6; nicotinic acid 5.0; I-inositol 50.0; PABA 100.0; folic acid 0.20; biotin 0.05; B_{12} 0.015; menadione sodium bisulfite 0.150; BHT 20. and choline cl 800.

4 Amino acids were added in grams per hundred grams as follows: DL-threonine 0.70; DL-valine 0.47; L-histidine HCl 0.74; DL-tryptophan 0.37; L-arginine HCl 0.43; L-cystine HCl 0.30 and DL-methionine 0.12

Table 51. Weights and weight losses of mink on Experiment No. 3 (Aug. 27 to Sept. 16) -- 1959 study

Lot	Lysine	Av. wt. at end of depletion (gms)	Av. wt. at end of repletion (gms)	Gain or loss (gms)
11	0.45	888	880	- 8
12	1.05	959	950	- 9

groups received a sufficient amount of lysine. Consequently, the animals were switched on August 3rd to a diet containing 15 percent protein (6 percent casein and 9 percent zein protein). The added amino acids were at the same level as in the previous test. Six mink were allocated to each group. The mink were maintained on this ration for 12 days. Two mink that had not eaten well in the previous experiment were eliminated from each group. Weights and weight gains are given in table 49.

In this case, the gain was lower, averaging from 13 grams per week per mink for the lowest level to 33 grams for the highest level. Differences in response were not statistically significant.

Experiment III

From August 27th to September 16th, a depletion-repletion experiment was conducted with 24 mink divided into two lots. The animals were gradually accustomed to a purified diet for six days, fed a depletion diet for 8 days and then placed on a repletion diet with graded levels of lysine.

The repletion diets contained 14 percent protein with the amino acid level adjusted to carcass composition at a similar level. The lysine contents of the basal and experimental lots were 0.45 percent and 1.05 percent, respectively. Composition of the rations is given in table 50 and gains and losses are given in table 51. In this case, there was a slight average loss during the repletion period in both groups.

Discussion

Several problems became apparent during the course of this investigation. So little is known about the growth of mink that it is very difficult to arrive at a level of protein at which to initiate studies of protein needs. This is further complicated by the problem of fat levels. Typical ranch rations contain from 15 to 25 percent fat and it was felt that if the work was to be a basis for practical feed formulation, it must have a fat level in the range of practical usage. This was not the case in the two studies reported earlier which were the only guideposts in the matter of protein levels.

It is not possible to compound a diet from readily available natural ingredients that would be suitable for adding graded levels of a deficient amino acid in order to determine amino acid requirements. Because of this, it was necessary to use foods unnatural to the mink. This led to the problem of possible unavailability to the mink of the amino acids in these foods. It also led to palatability problems which were partially solved by eliminating from consideration animals that did not eat adequately.

Other questions, as yet unresolved, are the discrepancies of the content of the different amino acids as shown by the analyses from the two different sources and the differential requirements for amino acids for different periods of growth. For instance, it is possible that the rather uniform gains and losses of the mink on the different treatments might have been due to the uniform need for some nutrient(s) (possibly cystine and methionine) that was(were) uniformly deficient in all diets. Cystine makes up about 15 percent of the composition of hair and is known to be rapidly absorbed by the mink during periods of hair growth (Wolterink, et al., 1958). Therefore, it is very likely that rations used in this study to determine amino acids needed for body growth would need a substantial amount of amino acids related to fur growth or the test would have to be conducted when the mink coat was in a dormant state. It is interesting to note that the highest responses in both years were achieved in early August, with diminishing responses as the season (furring) progressed.

This suggests two possibilities. One, to conduct the studies before August 15th (on mink from 7 to 14 weeks of age), and the other is to carry out depletion-repletion studies on adult mink. Both of these solutions are limited in their application - the former by time, and the latter by the fact that growth would not be occurring at the normal rate. Although not statistically significant, there did seem to be a relationship between the amount of lysine in the diet and the feed efficiency as measured in consumption per kilo body weight per day.

Summary and Conclusions

Six experiments were conducted on 80 male kit mink over a period of two growing seasons to determine the protein and amino acid requirements for growing mink. Depletion-repletion and growth study techniques were applied with partial success.

Growing mink maintained their weights for short periods of time on semi-purified diets containing 20 percent fat and 15 percent protein when supplemented with amino acids to match the amino acid pattern of the mink carcass.

Although gains in weight were not always affected, feed efficiency was improved by increasing the levels of lysine in the basal rations.

Other factors, probably cystine and methionine, appeared to be limiting the growth of the kit mink in the experimental rations used.

Some of the problems involved in this type of study are discussed in relation to possible future investigations of this important problem.

The Effects of Intermittent Doses of Diethylstilbestrol During Gestation on the Reproduction of Mink

Introduction

During the past several years there has been an increasing number of field reports of unexplained kit losses during parturition and lactation. In many cases, the mothers seemed to have insufficient milk for their young. There have been many postulations as to the possible cause of these whelping difficulties. One possibility which has been given consideration is that diethylstilbestrol may be inadvertently present in mink food and ingested intermittently after the embryos have been implanted. Warner et al. (1957) have shown that diethylstilbestrol is detrimental to mink production if female breeders continuously ingest amounts as small as ten micrograms per mink per day during pregnancy.

Procedure

Ranchers feed chicken by-products which could contain residues of diethylstilbestrol pellets or they might feed cereal (steer) supplements which contain stilbestrol. Thus, it is entirely possible that mink might receive intermittent doses of stilbestrol; consequently, an experiment was initiated during the spring of 1958 to determine the effects of intermittent doses of this compound. Six bred female mink were fed 150 micrograms of diethylstilbestrol, and five bred female mink were fed 300 micrograms every third day from April 23rd until May 17th. The intermittent dosages of diethylstilbestrol were thus given after the ova had become implanted but before the mothers had whelped. The ranch ration was 26 2/3 percent each of horse meat, tripe and ocean fish, 5 percent of liver and 15 percent of supplemented cereal. Six females from the same age and genetic background receiving the same ration, except for the diethylstilbestrol, were used as the control.

Reproductive performance is given in the following tables.

Results and Discussion

Tables 52 and 53 clearly show the devastating effects of the administration of diethylstilbestrol at the doses indicated after implantation has occurred. In June, necropsies were performed upon the three females that did not whelp and four females that whelped but lost their litters. Mummified foeti were found in two of the non-producing females (D230, D352). The third female indicated normal involution of the uterus and developing follicles but had not been pregnant.

The mammary glands showed varying stages of development. Female D280 who carried two kits to weaning had well developed mammary glands and showed marked secretory activity. In female D830, whose kits died May 18th, mammary glands showed some evidence of secretion, but the acini of the glands were not well developed. Female D340 showed well developed acini but no evidence of secretion. Female D352 showed poorly developed acini with a few showing secretion.

There are several ways in which mink might receive intermittent doses of diethylstilbestrol in doses high enough to be harmful. For example, the ear of one injected steer containing the residue of one-third of its 35 mg pellet could give a 150-microgram dose of diethylstilbestrol to 80 mink for one day or a 10-microgram dose to 40 mink for a month.

One chicken head containing a residue of one-third of its 15 mg pellet or 1-pound of steer feed containing five mg of diethylstilbestrol could supply a 150-microgram dose to 33 mink for one day or a 10-microgram dose to 17 mink for a month. Thus, it can be seen that diethylstilbestrol contamination is readily possible at doses very harmful to mink and that mink food manufacturers and ranchers must exercise caution in the selection of mink food ingredients. Since the effect of the intermittent dosages at 150 micrograms were so devastating, it is entirely possible that much lower levels would also be harmful.

Summary and Conclusions

Doses of diethylstilbestrol of 150 and 300 micrograms, respectively, were fed every third day to each of two groups of six and five bred female mink, respectively, from April 23rd to May 17th, 1958. This period included the latter part of pregnancy, parturition, lactation and early kit growth.

Almost complete failure of the normal reproductive processes, including reabsorption of litters, lowered kit production, lowered kit weights and greater kit mortality occurred in the mink receiving the diethylstilbestrol.

Table 52. Reproductive performance, kit size and mortality -- 1958 diethylstilbestrol reproductive experiment

Diethylstilbestrol fed every third day	No. females	No. that whelped	Kits born	Kits at 1 day		Kits at 14 days		
				Born dead or died	Av. wt. (gms)	Number alive	Loss since first count	Av. wt. (gms)
None	6	6	34	3	10.2	31	0	68.6
150 mcgs.	6[1]	4	22	6	7.1	9	7	48.0
300 mcgs.	5[2]	4	12	4	9.7	6	2	64.6

1 One female with 7 kits apparently refractory to effects of diethylstilbestrol
2 One female with 6 kits apparently refractory to effects of diethylstilbestrol

Table 53. Individual performances of mink receiving intermittent doses of diethylstilbestrol after they had implanted but before they had whelped -- 1958 diethylstilbestrol reproduction experiment

Female	Date whelp	Total kits born	Kits born alive	Kits alive 14 days
Control:				
D24	4/30	8	6	6
D160	5/9	7	7	7
D620	5/6	5	4	4
D752	5/3	5	5	5
D800	5/6	5	5	5
D836	5/2	4	4	4
150 mcgs. per dose:				
D280	5/3	6	5	2
D32	5/2	7	7	7
D230	-	*		
D340	5/12	3	0	0
D812	-			
D802	5/2	6	4	0
300 mcgs. per dose:				
D224	5/7	1	0	0
D352	-	*		
D372	5/7	1	0	0
D830	5/6	3	2	0
Co150	5/3	7	6	6

* Mummified kits found on necropsy 6/5

Effect of Feeding Thyroprotein on Lactation And Early Kit Growth Performance of Mink

Introduction

The period of parturition and lactation is recognized as the time of greatest nutritional importance for female mink breeders. For kits, greatest stress and kit mortality occurs during early growth when they are nursing their mothers. Thus, any practice that would improve performance during these periods would be very valuable to the mink industry.

Recently, it has been reported that thyroprotein improves lactation performance in cattle and swine under certain conditions. Consequently, it was decided to study the effects of thyroprotein in the diet of female breeders prior to and after whelping. By this addition, it was hoped to improve the milk output of the mothers and thus improve the growth rate of the kits.

Procedure

In the spring of 1958, the experiment was initiated using 30 dark adult female mink, 15 per group. The experiment was designed so that there were five control animals and five treated mink on each of three different diets containing 20 percent, 30 percent and 40 percent fat, respectively. The 20 percent fat diet contained 26 2/3 percent each of horse meat, tripe and ocean perch, 15 percent Kellogg 1001 cereal and 5 percent liver. Animal grease was added at the expense of the ration to produce the diets high in fat.

Previous studies by Reineke, et al. (1960) evaluated thyroxine secretion rate and the thyroactive iodinated casein utilization in mink and thus made it possible to use a level of iodinated casein that was within the physiological range of the mink.

Starting on April 28th, 2.5 ml. of a suspension containing 24 milligrams of thyroprotein mixed into 125 grams of food was fed daily to each treated group of five mink. This was given and consumed in the morning before the mink were allowed further food. This gave a dosage of 0.53 mg. of thyroactive iodinated casein (1.0 percent thyroxine) per 100 grams of body weight per day which is twice the amount needed to be equivalent to the thyroxine secretion rate of adult male mink in April. Performance of the females and their young is shown in tables 54 through 57.

Results and Discussion

Whelping results and weights at one and 14 days are given in tables 54 and 55. Analysis of variance of the one-day weights showed no significant differences between treatments. Likewise, there was no difference that could be attributed to the differences in dietary fat levels. Table 57 shows the analysis of variance of 14-day weights which indicates that the treated group weighed less than the control; this was apparent at the one percent level of significance. The thyroprotein treated group was also lower in the one-day weights. However, because the kits were not identified at 1 day of age, it was impossible to run an analysis of co-variance to determine if the 14-day weights were related to the 1-day weights.

In considering kit weights, it is necessary to remember that the mother supplies the environment and nutrition of from one to 8 or more kits. This exerts a confounding influence upon the analyses of the kit weights, particularly when there is as small a number as 15 mothers per group. Further, the experiment was run with only one level of thyroprotein, which might not have been the dose to produce optimum results at this period.

Summary and Conclusions

Thyroprotein was given to 15 mink mothers at a level of 0.53 mg. per hundred grams of body weight per day of thyroactive iodinated casein (1.0 percent thyroxine) starting about five days before the first litter was expected to be born and was continued until the young were two weeks old. Fifteen breeder females and their young were used as controls.

There appeared to be no effect upon number of kits born or incidence of mortality of the young.

Kits from the treated mothers were non-significantly smaller at the 1-day weighings but significantly smaller at the 14-day weighing. However, due to the relatively small numbers of mothers involved and the variable number of kits per litter, the experiment should be repeated before definite conclusions can be made as to the beneficial or harmful effects of adding thyroprotein at this level during this period.

Table 54. Production of mothers and mortality of kits -- Thyroprotein, lactation and early kit growth experiment

Lot	Number females	Number that whelped	Total no. kits born	No. kits born alive	No. kits alive at 14 days
Control	15	14	99	90	71
Treated	15	15	104	96	72

Table 55. Average weights of kits in grams -- Thyroprotein, lactation and early kit growth experiment

Lot	At 1 day			At 14 days		
	Male	Female	Av.	Male	Female	Av.
Control	9.3	8.6	9.0	61.2	56.5	58.9
Treated	8.6	8.2	8.4	55.8	54.0	54.9

Table 56. Weights and gains in weight in grams of mink on different dietary treatments — Thyroprotein, lactation and early kit growth experiment

Treatment	No. mink	At 1 day			No. mink	At 14 days		
		Male	Female	Av.		Male	Female	Av.
Control:								
% Fat								
20	32	7.8	8.2	8.0	27	60.5	56.2	58.4
30	24	10.7	9.0	9.8	22	64.5	55.0	59.8
40	34	9.4	8.8	9.1	22	58.9	59.1	59.1
Treated:								
% Fat								
20	28	9.4	8.4	8.9	23	51.0	53.6	52.3
30	38	8.4	7.7	8.1	26	56.7	57.3	57.0
40	30	8.4	8.1	8.3	23	58.8	51.5	55.2

Table 57. Analysis of variance of 14-day weights -- Thyroprotein, lactation and early kit growth experiment

Source	Degrees of freedom	Mean Square	F values		
			Calculated	P = 0.05	P = 0.01
Total	144	28.79			
Sex	1	9.77	6.78**	3.84	6.63
Treatment	1	16.61	11.53**	3.84	6.63
S X T	1	2.41	1.67	3.84	6.63
Error	141	1.44			

** ($P < 0.01$)

The Effect of High Levels of Antibiotic Upon Mortality and Early Kit Growth of Mink

Introduction

In most mammals that produce litters, a substantial mortality occurs in the young during the first few days of life. Mink are no exception as they may have a mortality of from 5 to 30 percent or more, most of which occurs during the first three days of life. Thus, any practice that will increase the viability of young will greatly increase the efficiency and reduce the cost of production per animal. Broad spectrum antibiotics have been shown to improve the growth responses of weanling mink (Warner *et al*. 1956) and to improve the environment of other species (Libby and Schaible, 1955). Thus, it was desired to see if an antibiotic might improve the growth and livability of newborn mink.

Procedure

In the springs of 1956 and 1957 there were placed respectively 20 and 40 mothers on the control ration and 25 and 39 mothers on the same ration plus terramycin. In 1956, the control ration (table 2) was the regular ranch diet. In 1957, half of the females in each group received the control ration and half received this ration with three percent fat added as choice white grease. Chlortetracycline was fed to the mothers at a level of 400 grams per ton of food starting a few days before whelping and continuing until the mink kits were three weeks old.

The results on reproduction, kit mortality and 1- and 21-day kit weights are shown in the accompanying tables.

Results and Discussion

Analyses of variance were conducted on the 1-day and 21-day weights for both years. There were no significant differences in either of the 1956 weights or for the 1-day weights in 1957. However, the 21-day weights in 1957 showed a significant difference in treatments at the five percent level of probability in favor of the controls.

Summary and Conclusions

During 1956 and 1957 terramycin was used at high levels in an attempt to reduce kit mortality and to improve growth of young mink during their first three weeks of life. Forty-five adult female dark mink were used the first year and 79 the second year. These mothers produced 217 and 442 kits, respectively. There was no difference in kit production or mortality that could be attributed to the antibiotic treatment.

The birth weights of the kits whose mothers received terramycin were comparable during 1956; in 1957, kits from the control animals were significantly greater in weight than those from the treated group at the five percent level of probability.

These results demonstrate that there was no beneficial effect and a possibility of harmful effects from the addition of terramycin to the ration at levels of 400 grams per ton during this period.

Table 58. Production of mothers and mortality of kits -- Antibiotic, lactation and early kit growth study

	No. females	No. that whelped	At 1 day: No. alive	At 1 day: No. born dead or died	At 1 day: % Loss	At 14 days: No. alive	At 14 days: Loss alive 1 day	At 14 days: % Loss
1956:								
Control	20	17	97	4	4.1	89	4	4.5
Terramycin	25	21	113	3	2.6	103	7	6.8
1957:								
Control	40	36	197	6	4.6	179	12	6.7
Terramycin	39	36	219	20	9.1	173	26	15.03

Table 59. Weights of kits at one day and 21 days -- Antibiotic, lactation and early kit growth study

	1-day weights			21-day weights		
	Male	Female	Av.	Male	Female	Av.
1956:						
Control	10.1	9.3	9.7	110.6	95.5	103.0
Terramycin	9.9	9.3	9.6	109.0	98.3	103.6
1957:						
Control	9.7	9.2	9.4	112.4	101.4	106.9
Terramycin	9.5	8.8	9.2	107.4	99.9	103.6

Table 60. Analysis of variance of the 21-day weights of kits in 1957 -- Antibiotic, lactation and early kit growth study

Source	Degrees of freedom	Mean square	F values Calculated	P = 0.05	P = 0.01
Total	350	99.19			
Sex	1	85.56	41.13	3.84	6.63
Treatment	1	10.56	5.05**	3.84	6.63
S X T	1	3.07	1.47	3.84	6.63
Error	347	2.09			

** ($P < 0.01$)

General Discussion and Summary

The experiments previously discussed represent a three-fold approach to the solution of some important problems of mink nutrition, namely the use of ranch-type rations, semi-purified diets and dry diets. The least complex studies are those involving the use of ranch-type rations containing fresh animal products. Research of this type is necessary to obtain information of more immediate and practical value to the feeder.

A. Studies using ranch-type rations were conducted during the reproductive cycle to determine the possible beneficial effects of high level antibiotics and thyroid-active compounds during lactation and early kit growth, and to determine the possible harmful effects of intermittent dosages of stilbestrol during this period.

1. Oxytetracycline (terramycin) was fed at levels of 400 grams per ton of feed during two lactation and early kit growth seasons. There was no beneficial effect in kit production, growth or mortality that could be attributed to the antibiotic treatment. At 21 days of age the body weights of kits from mothers which received the antibiotics were significantly lower than the body weight of the control kits.
2. Thyroprotein was fed to fifteen mother mink at levels of 0.53 milligrams per 100 grams of body weight (one percent thyroactive iodinated casein) starting about five days before the first litter was to be expected and continued until the young were two weeks of age. This treatment had no effect on the

number of kits born or the incidence of mortality of the young. Kits from treated mothers were significantly smaller at 14 days of age.

3. In another experiment, diethylstilbestrol was fed intermittently beginning after implantation and continuing through late gestation, whelping and early kit growth. Results indicated an almost complete failure of reproductive processes - embryo reabsorption, lowered kit production, lowered kit weights and greater kit mortality were observed.

B. The development of dry diets for mink presented a more complex problem to the nutritionist due to the use of feeds in a form unnatural to the mink.

1. Studies on dry diets containing no fresh animal products, or dry diets supplemented with fresh liver or fresh tripe were carried through two growth and two reproduction periods. The dry diets resulted in a somewhat inferior growth rate compared with the ranch ration during the period from 11 weeks to 30 weeks of age, and growth was much poorer, especially during the period from 11 to 16 weeks. However, from 16 weeks to 30 weeks, the gains of mink on dry diets was as great or greater than those on ranch rations. The growth response of mink fed dry diets which were supplemented with 25 percent fresh liver were intermediate between those on the ranch ration and those on dry diets. There were no significant differences in animal length gains among mink on the different dietary treatments.

2. Increasing the fat level from 12 to 20 percent in the dry rations improved the growth of kits. No beneficial effect was

apparent from increasing the fat to 28 percent. The response of the males to changes in diets was greater than that of the females.

3. Adult mink fed dry diets during winter maintenance and dry diets with 25 percent of fresh liver during breeding, gestation and lactation, were comparable in adult weight, breeding performance and number of kits whelped, to mink that received a typical commercial ranch ration. However, 21-day-old kit weight of the controls was greater. The response from adding fresh liver or fresh tripe during lactation and early kit growth was similar which indicated that the value of the fresh animal products may be due to palatability rather than nutrient value.

Dry diets would have many obvious advantages, but successful adaptation awaits greater nutritional knowledge of the requirements of mink. Some progress has been achieved in this direction. However, much work still remains to be done. It is almost certain that successful dry rations for all phases of the life cycle in mink will ultimately be achieved. It is possible that a solution to dry rations will be attained by an entirely different approach than those currently used. Likely possibilities include: (a) an intensive investigation of digestibility and palatability; (b) studies on the use of enzymes to increase utilization of dry feeds; (c) studies on nutrients or nutritional factors which may be destroyed by the drying processes and which need to be replaced; and (d) studies on the possibility of strain differences, all of which should be taken into account.

C. The third approach used in these investigations was the use of semi-purified diets. This is the only possible approach to certain types of nutritional studies as it is the only means by which known and controllable amounts of certain ingredients can be fed.

1. Experiments were conducted using semi-purified diets to ascertain: (a) if adult mink require dietary vitamin K; (b) whether dark mink differ in this respect from sapphire mink; and (c) if sulfaquinoxaline or certain antibiotics affect blood clotting time. The dietary requirement of normal adult mink was established as being less than 13 milligrams of menadione sodium bisulfite per ton of feed. Sulfaquinoxaline fed for six to eight days at the 0.5 percent level or higher significantly increased whole blood prothrombin clotting times, while the addition of aureomycin or terramycin at levels of 400 grams per ton did not significantly increase clotting times.
2. During two growing seasons, experiments were conducted to determine the protein and amino acid requirements for growing mink. Depletion-repletion and growth study techniques were applied with partial success. Growing mink maintained their weight for short periods on semi-purified diets containing 15 percent protein and 20 percent fat when supplemented with appropriate amino acids. Other factors, probably cystine and methionine, appeared to be limiting the growth of the mink on the experimental rations used.

In conclusion, it may be stated that by using the above techniques, advances in the knowledge of mink nutrition were made in specific areas. The limitations of knowledge and procedures were also defined and by these means, the groundwork has been laid for further advances in the relatively undeveloped field of mink nutrition.

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