A NUTRITIONAL STUDY OF RANCH RAISED MINK

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This is to certify that the

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A NUTRITIONAL STUDY OF RANCH RAISED MINK

By

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ABSTRACT

The primary purpose of the problem was the development of a practical mink feed, devoid of fresh meat, which would support an adequate nutritional plane through all stages of the life cycle of the animal.

A comparative group feeding trial method, in which mink were kept under conditions closely simulating commercial practice, was used to allow dietary evaluation. Body weight, determined at weekly intervals, was the major criterion of response to dietary modification. Collateral observations were made on morbidity, mortality, reproduction, and fur quality.

An average of 45 mink were continuously subjected to three successive dry-mash rations during a period of 18 months. Supplements were introduced into the basal rations and responses evaluated.

The final and most successful experimental ration allowed sub-normal growth and reproduction, and fairly adequate adult maintenance. Complete elimination of deficiencies inherent in the basal ration was achieved only with the addition of a high level of fresh meat. This level, however, was considerably lower than that normally included in a commercial ration.

Experimental results indicated that the critical deficiencies in the final experimental ration were not protein or vitamin in nature, but were more directly concerned with palatability and digestibility.

W. R. Hunt.

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I. INTRODUCTION

Expansion and Importance of Mink Ranching

The ranch mink industry has probably surpassed all other forms of animal husbandry in recent rate of expansion. Its mushrooming growth, virtually replacing the comparable fox industry of a decade ago, is attributable to the intrinsic value of its popular pelt and the successful adaption of the animal to confinement.

Commercial mink farming was conceived in the United States in 1866 (Kellogg, Bassett, and Enders, 1948), when trapped wild mink were caged and allowed to breed. The nascent industry spread but little, as the volume of better quality wild mink pelts furnished by trappers was adequate for the fur trade. It was not until 1920 (Coombes, et al., 1950), that the ranch raised mink assumed any economic importance, and then it was overshadowed by the more popular and established silver fox. The popularity of the long furred fox began to wane in favor of the superior durability and short furred beauty of the mink, and in the last decade, the latter has been the most sought after fur in the industry.

Today, according to Sheldon, (1951), the United States raises 65.14 per cent of the total ranch mink in the world, and uses 90 per cent of the world's production. Statistics compiled by the National Board of Fur Farm Organizations (Sheldon, 1950), reported that 110,426 pelts, valued at $1,241,000, were produced in the United States in 1939. Production was reported from 2,836 ranches located in thirty-two states. In 1948, there were 1,490,360 pelts produced and marketed for $34,364,000; Michigan had moved from its 1940 rank of tenth in number of pelts produced, to third place with a

production of approximately 7 per cent of the domestic total. It was exceeded only by Wisconsin and Minnesota, which contributed 37 and 12 per cent respectively. Despite increased production at home, imports have jumped from 178,986 pelts in 1939 to 1,200,286 in 1949. Recent and pending legislation, however, will curtail future imports.

Current Problems in Mink Production

The rapid growth of mink farming has not been without attendant difficulties. An adequate store of practical knowledge has not accumulated and formal research in the field has been practically non-existent. Currently there is an increasing awareness and appreciation of the many problems of the industry and research work at institutional and governmental levels has been initiated. Feed and pharmaceutical firms have also strengthened and intensified work in this field. The several journals of the industry have done much to inform, advise, and distribute available information.

Progress in the field in the past is primarily attributable to efforts within the industry. Their success is attested by the relatively satisfactory solution of critical problems in marketing, disease, reproduction, and feeding. The latter factor has been of major importance since the beginning of the industry when captive mink, fed solely on meat, failed to thrive as they did in the wild. Even today, many of the problems of disease, fur quality and reproduction can be traced to dietary difficulties, despite the variety of nutritionally excellent feeds achieved by the long years of trial and error. The variety in todays feeds is restricted to supplementary components. Most feeds at the present time are similar in

that they contain high levels of fresh meat, usually from the horse. The fur farming industry is unique in the field of animal husbandry in that it has so long been penalized and restricted by lack of a stable, low cost feed which is readily available in uniform quality. The current problem in mink feeding is not one of formulation; it is one of preparation, ingredient availability, and cost.

It is significant that the narrow margin of profit on which the fur rancher currently operates is due, in the main, to excessive feed, labor, and equipment costs. These stem directly from the large quantities of expensive fresh meat which must be incorporated into the successful ration. Elaborate refrigeration, hoists, grinders, hoggers, saws, and mixers, along with the necessary buildings, combine to form an exceedingly heavy investment. The many disadvantages and inefficiencies inherent in small-batch formulation and mixing can be illustrated in the field of poultry production. Only after a commercially formulated and mixed poultry feed of satisfactory quality became widely available, did the poultry industry flourish.

A factor more critical than the complexity, variability and high cost of todays ration is the rapidly diminishing supply of the basic ingredient of mink feed - horse meat. The reason is readily seen when the statistics of horse population are examined. In 1946, the Crop Reporting Board of the United States Department of Agriculture reported the decline in the number of horses to be, relatively and actually, the greatest for any year on record. The national horse population for that year totalled only 7,251,000, ten per cent less than in 1945 and the smallest since 1868. The

accelerated downward trend, which had been in evidence for many years, was attributed to exports, slaughter, and a small colt crop. An indication of a further decrease in horses is the relatively small number of colts under one year of age. Only three per cent of the national horse population fall into this category.

Some estimate of the increased demand for slaughter horses is supplied by Henning (1947) who reports only three horse slaughtering establishments under Federal inspection in 1939. Their combined volume was less than 20,000 for the year. In 1947, there were twenty-three such establishments and they accounted for 156,872 animals in the first eight months of the year.

Exports have jumped from an annual average of three million pounds during the period 1930 to 1940, to 41.5 million in 1946, according to Henning (1947).

It might be interesting to speculate on the number of horses required in a year by the mink industry. Figures are not available for the total breeding mink stocked, but if a number equal to one-half the production is accepted as a fair estimate, one million mink would have been retained in 1948. Daily consumption of three ounces of meat per animal would estimate the annual consumption to be ninety million pounds for the breeding stock and a like amount for these animals pelted. Assuming an average horse to yield 700 pounds of meat, the number of horses slaughtered in the United States for mink feed would approximate 257,142. At six cents per pound, this 180 million pounds of horse meat would represent an expenditure of eleven million dollars.

A realization of the demands placed by the fur industry and other

animal feed suppliers on the depleted horse supply has resulted in an increased use of substitute products. Among these, rough fish and by-products from processing plants have been most important. Results obtained from their incorporation into the ration have been variable and many times disasterous. In general, no major substitution in the horse meat component of the ration has been completely successful. It has become apparent that fresh animal by-product utilization can only partially alleviate existing feed shortcomings, for problems of supply, uniformity, contamination, and spoilage are intensified.

Validation and Statement of the Problem

It would seem certain that the fast dwindling horse population will be unable to support a rapidly expanding fur industry and supply the ever increasing demands for export and pet food manufacturers. The time is rapidly approaching when the mink ration, as fed today, will be non-existent or economically impossible. This stresses the critical need for the early development of a mink feed consisting of readily available ingredients adequate to allow proper nutrition of the animal through all phases of the life cycle. If such a ration could be formulated from dessicated meat and vegetable constituents, it could be fed moistened or right from the bag. Problems of supply, storage, formulation, and mixing would be eliminated and the fur industry would be on a plane similar to older, more familiar forms of animal husbandry.

The feasibility of such a ration is strongly corroborated. The facility with which dogs and foxes have adapted to a non-fresh meat ration indicates the non-essentiality of fresh meat if a substitute ration,

balanced to the needs of the animal, is available. The ability of the mink, itself, to use such 'foreign' foods is demonstrated in some of the successful, commercial rations of today. Levels of non-fresh meat ingredients are higher than heretofore thought advisable. Even more significantly, recent work has been reported by Wisconsin workers in which the ability of the mink to subsist entirely on a synthetic experimental feed was demonstrated. The whole field of nutrition is progressing at such a rate that the unknowns, impossibilities, and miracles of today are tomorrows' matter-of-fact commonplaces. It would be blindness and ill-informed complacency to ignore the possibility of radical ration reform for any species.

Accordingly, this work was directed toward the formulation of a successful mash-type mink ration. It was hoped that the collateral and incidental information obtained would contribute to the inadequate fund of general knowledge concerning the practical feeding of this animal.

II. LITERATURE REVIEW

In reviewing the literature pertinent to mink nutrition and feeding, it is apparent that little factual information of a fundamental nature is in existence. The several excellent journals of the fur trade contain voluminous material on practical mink feeding, but much of it is contradictory, opinionated, unsubstantiated, and controversial in nature. This is as would be expected in so new an industry. Despite these shortcomings, this material contains most of the information available on the mink today and therefore cannot be ignored. When evaluated in terms of established principles of nutrition and feeding, these popular articles are valid sources of invaluable information.

In view of the relatively meager nutritional information specific for the mink, it was deemed advisable to extend the literature reviewed to include related fields. The natural food of the mink, commercial mink feeding practices, both current and past, nutritional and feeding work with dogs, cats and foxes, as well as sources in the general field of animal nutrition, have been carefully reviewed. It is felt that this should give an appreciation of the overall basic concepts, so necessary in a problem of this nature, as well as information which could be integrated to allow a satisfactory solution of the problem.

The Food of the Wild Mink

The first ration offered captive wild mink was predicated on the general observation that mink and the closely related weasel were strictly carnivorous, eating nothing but freshly killed prey. Work since that time

has modified this early concept but little.

Sealander (1943) studied the winter food habits of wild mink in Michigan. He found the diet to vary with availability, but with mammals, ranging in size from small insectivora to the snow shoe hare, invariably comprising over one-half the volumetric dietary intake. The remainder consisted of birds, frogs, fish, snakes and crustaceans. Negligible amounts of vegetable matter were found in stomach contents and were attributed to accidental belting along with small prey. The particle size of stomach contents never exceeded one-half inch in diameter and was normally much smaller. He noted that the smaller mammals, together with fish and crustaceans, were more thoroughly chewed than larger prey. Dixon (1925) also reports the mink to be a thorough chewer, surpassed among the carnivores, only by the otter. He states that the largest single meal he had observed taken by a mink consisted of forty-seven grams of fish.

Dearborn (1932) also studied the food habits of Michigan wild mink and his findings during the winter are similar to Sealander's. However, his studies on fecal residues carried through the summer showed a marked decrease in the mammalian dietary component with a compensatory increase in crayfish. He found no evidence that vegetable matter was ever consumed.

Yeager (1943), in a rather comprehensive study of the habits of wild mink, stressed the relative large size of the prey and the extensive storing in the nest. He found ten muskrats in a winter den in Illinois. In the spring he found five coot, four ducks, and nine muskrats in a North Dakota den.

All work on this subject emphasizes meat consumption to the complete

exclusion of vegetable matter. It should be pointed out, however, that the smaller animals are consumed in their entirety - bones, viscera, and stomach contents. Even with larger animals, tasty portions of the viscera are selected and consumed along with the muscle and fat. This would do much to correct any dietary imbalance, for the liver alone is a veritable storehouse of nutritional essentials.

The Commercial Mink Ration

A digest of the practical feeds fed on commercial mink ranches should give much valid information on the dietary requirement of the animal, for today's rations are a distillate of the feeding practices of the past twenty-five years. Specific conclusions cannot be drawn from a study of these rations, however, for the rancher, in an effort to formulate the ultimate in a feed, has incorporated many auxillary components in the absence of real evidence of need. If observable harm does not result, or circumstantial evidence indicates a favorable effect, the additive is incorporated into the basic ration. Subsequent modifications are introduced in a like manner. A satisfactory but overly complex ration is the result. This practice is not to the rancher's discredit, for the complete lack of factual information has made trial and error experimentation a necessity. Furthermore, the value of the animals, coupled with the production of only one annual crop, would certainly indicate use of the best feed possible, regardless of cost.

The variety of recommended mink rations recorded in the literature implies that a standard commercial mink ration does not exist. Coombes et al., (1950) in an excellent summary of fur animal feeding, notes that mink rations

are becoming less complex. A comparatively small number of basic formulae are being used, with ranchers introducing simple modifications to fit their particular conditions. These changes are most commonly introduced, in practice, to allow for the assumed changes in dietary requirements during periods of growth, maintenance and reproduction. It is also suggested that with an increasing fund of information, newcomers are less tempted to experiment, preferring to profit from the experience of others.

The apparent extreme variety of ration is many times due to the type of fresh meat used. Kellogg, Bassett, and Enders (1948) list a few of the forms in which fresh meat enters the ration. Among them are lungs, tripe, spleen, udders, liver, gullets, kidney, chicken heads, feet, viscera, rabbits, fish and fish by-products, and pelted carcasses of their own species. These are, of course, but substitutions for a part of the horse muscle, made in the interests of economy and availability.

Kellogg, Bassett, and Enders (1948) and Coombes et al., (1950) among many others, report representative rations which are probably as typical as any. The latter reports the results of a study of various rations submitted by ranchers in diverse parts of the nation.

The results are summarized as follows:

Horse meat	32 to 77 per cent
Visceral meats	10 to 25 per cent
Fish	15 to 45 per cent
Liver	3 to 15 per cent
Ground green bone	5 to 8 per cent
or steamed bone meal	2 per cent
Vegetables	3 to 7 per cent
Commercial cereal	15 to 25 per cent
Dried brewers yeast	1.5 to 2 per cent
Cod Liver Oil	0.5 to 1 per cent

The level of meat components tends to remain constant, in that lower levels of muscle meat are balanced by higher levels of viscera or fish.

The role of fresh meat in the ration. Without exception, fresh meat is found to be qualitatively and quantitatively the most important ingredient. Normally it is in the form of horse muscle which, according to Smith and Bassett, (1947), has an average composition of 76.0 per cent moisture, 18.1 per cent crude protein, 4.1 per cent fat, and 0.9 per cent ash.

Roberts (1949) believes the apparent need for high levels of animal products is related more closely to accessory factors than to an unusual protein requirement. Still (1939) attributes their importance to palatability, high biological value, and digestibility. Smith and Loosli (1940) emphasize the importance of fresh meat as an important palatability factor as well as a source of proteins of a desirable amino acid pattern.

Due to its high cost, considerable work has been done to establish minimal levels. Lindow, Brickson, and Hart (1949) state that meat should supply a minimum of 250 calories per pound of feed. Smith and Loosli (1940) allow each adult mink 0.9 ounces of raw meat per day to maintain nitrogen equilibrum. Bassett (1943) has reported that proper supplementation will allow the fresh meat level to be reduced to 30 per cent during the summer, fall, and early winter, with a level of only 36 per cent during the remainder of the year.[1] Wilke and Bassett (1948) found kits required at least 65 per cent horse meat to yield growth equivalent to that obtained with horse meat at the 85 per cent level.

[1]All percentages are converted to the equivalent of the ration as formulated, i.e., before water is added. This practice will be continued throughout this work to allow equivalent levels for comparison.

The role of liver in the ration. Liver is as universally used in the practical mink ration as is horse meat, and is regarded as a near panacea for nutritional ills. There is basis for this, for liver is a recognized source of most major vitamins as well as unidentified dietary essentials.

It is fed at levels varying from 3 to 15 per cent of the ration (Coombes et al., 1950). The commonly recommended level is ten per cent. At this level of feeding, it will prevent and correct hemorrhagic gastro-enteritis, yellow fat, (a non-suppurative inflammation of the panniculus adiposus) and anemia (Whitehair, Schaefer and Elvehjem, 1949).

Kennedy (1947) reports a similar level of approximately one-half ounce per animal per day, to be effective in preventing nutritional anemia and the accompanying acidosis.

Schaefer, Whitehair, and Elvehjem (1946) and others have reported on at least two unidentified factors present in fresh liver that are required by mink.

The role of cereals in the ration. Efforts to establish a minimal level of meat are reversed in the case of cereals. The maximal level at which they can be successfully incorporated into the mink ration is of economic importance. They represent a relatively cheap source of energy and dietary essentials. Lindow, Bricksen and Hart (1949) recommended a cereal level furnishing 1,200 to 1,700 calories per pound of feed for maximum economy. They found levels in excess of 20 to 25 per cent of the ration resulted in an undesirable laxative effect. This was most notable when raw cereals were used. Their findings supported the use of cooked cereals only, as digestibility was increased 20 per cent over the raw grains.

The increase in digestibility resulting from cooking cereals is widely emphasized, but significantly, there is no mention of any great variation in dietary value of the several cereals after they have been properly cooked.

The most common source of the cooked cereals is the breakfast food manufacturers who supply products sub-standard for human consumption, but excellent for animal feed and at a reasonable price. The usual mink cereal feed is a mixture of flaked corn, wheat, and rice. This feed has the advantage of any enrichment or fortification added during manufacture, as well as a history of careful preparation from top quality grain.

Other ingredients of the ration. Vegetables are usually present in the commercial mink ration at levels from 2 to 5 per cent. (Kellogg, Bassett, and Enders, 1948). Although green leafy vegetables are often used, tomatoes, either fresh or canned, are most popular (Smith 1940). Any real need for their presence in a mink ration is somewhat obscure, but the justification most often advanced is their role in the prevention and correction of acidosis, which is revealed by a dribbling of urine usually symptomatic of nutritional anemia. Kennedy (1947) found that tomatoes did indeed alleviate the symptoms, but only temporarily.

Bone meal or ground green bone is added at levels of 1 to 5 per cent to supplement mineral deficiencies inherent in muscle meat (Kellogg, Bassett, and Enders, 1948).

Dried brewers yeast and cod liver oil are normally added at low levels to insure an adequate supply of vitamins of the B series and vitamins A and D. (Hodgson, 1945).

The Digestive Potential of the Mink

The simple digestive system of the mink may well be a limiting factor in supplanting the natural food of the animal. According to Leosli, Smith and Maynard (1940), the ratio between body length and length of the digestive tract is 1:4, or sixty inches for the average mink. This ratio is similar to that found in the cat. In the dog - and presumably the fox - the ratio is 1:6. In the mink, there is complete elimination of food fifteen hours after ingestion (ibid.). Bernard, Smith and Maynard (1942) report that food appears in the feces six hours after ingestion, one half the time given for the fox.

There are a limited number of reports on mink digestion trials. Leosli, Smith and Maynard (1940) found the dry matter digestibility of a good quality mink ration ranged from 70 to 80 per cent. Raw meats were found to have the highest per cent total digestibility. Fresh meat protein digestibility was found to be high, (raw liver - 93 per cent; horse muscle - 86 per cent; and spleen - 84 per cent) and was not significantly depressed by the addition of cereals. They found the protein of beef scraps, fishmeal, and cereals to be about 72 per cent digestible, as was that of cooked or dried horse meat and canned fish.

Smith and Leosli (1940) did considerable work on the digestibility of protein, fat, nitrogen free extract, and fiber in various combinations of common mink ration ingredients. They found the various fats to be well utilized and little influenced by treatment, although there was some evidence of increased digestibility after cooking. The nitrogen free extract was poorly used from every source other than cooked starch, which was 93

per cent digestible. Protein digestibility, high in raw horse meat and liver, was significantly reduced by canning or cooking. Beef tripe was found to be poorly utilized and fiber utilization was found to be extremely low.

Previously, Hodgson and Maynard (1938) had reported the protein digestibility of pure fresh horse muscle to be reduced from 91 to 81 per cent when meatscraps replaced a part of the fresh meat. Utilization of nitrogen free extract and fiber by the mink was found to be low and variable - 36 to 73 per cent and 2 to 40 per cent, respectively. Fat was found to be well utilized, being from 91 to 97 per cent digestible.

Digestion trials reported by Bernard, Smith and Maynard (1942) revealed that in a good quality mink ration with high levels of horse meat, the fat and crude protein were, respectively, 87 and 93 per cent digested by mink. They found cooking increased the digestibility of starch from a highly variable 54 to 75 per cent to a uniform 90 per cent. The starch was combined with raw horse muscle at levels up to 50 per cent. Fiber, when incorporated within limits of palatability, did not influence the overall digestibility of the ration, with the exception of wheat bran. Its depressing effect was attributed to a laxative action. Beet pulp was found to be extremely unpalatable, even at very low levels.

Bernard and Smith (1941) had previously reported cooked starch to be 90 to 95 per cent digested by mink when fed at levels up to 45 per cent of the dry diet. Raw wheat and oats were 85 to 87 per cent digested when fed at a 20 per cent level. Corn was 74 to 76 per cent utilized when fed at a similar level. They noted a reduced overall digestibility in the presence

of indigestible materials.

Fundamental Dietary Requirements

The caloric requirement. The energy requirement of the mink apparently approximates that of similar animals when evaluated in terms of body surface area. Still (1939) made a theoretical estimate of 240 calories per day for an adult mink. Hodgson and Smith (1942) determined that the daily caloric dietary intake should be 124 (95 digestible) calories per pound of body weight which would be equivalent to 2,370 (1,830 digestible) calories per square meter of body surface. Loosli and Smith (1940) report a caloric consumption of 120 to 130 calories per day per pound of body weight by adult mink.

The protein requirement. Smith and Loosli (1940) estimated the crude protein requirement of the adult mink to be twenty-five grams per day, which is equivalent to twenty-two grams of digestible protein. This is derived from their requirement of 0.9 ounces of raw meat for nitrogen equilibrum.

Ten grams of digestible protein per day, in the presence of adequate carbohydrate and fat, will maintain nitrogen equilibrum in adult mink, according to the findings of Loosli and Smith (1940).

Still (1939) estimated the daily digestible dry protein requirement of the adult mink to be ninety-two calories or twenty-two grams.

Bassett (1950) has established the optimum protein level for kit growth to be 28 to 34 per cent dry, or 9.5 to 11 per cent wet. This is considerably higher than the 20 per cent minimal protein level, dry basis, recommended for best growth in puppies (Heiman, 1947).

The fat requirement. There is no record of a deficiency syndrome attributable to an uncomplicated fat deficiency. Small amounts of the so-called essential fatty acids are the only lipid substances considered essential in the presence of an adequate supply of the fat soluble vitamins. It is not probable that a practical mink ration could be formulated without an adequate supply of these acids and sufficient fat to allow vitamin absorption. However, according to Earl (1939), fats are important in a ration marginal in calcium and containing cereal. Formation of the unavailable calcium-phytin complex is prevented in the presence of 11 per cent fat.

The carbohydrate requirement. As in the case of fats, aside from associated vitamins, consideration of carbohydrates in the ration of a mink is limited to maximal use for economic reasons.

The mineral requirement. Calcium and phosphorus are the only minerals for which dietary estimates have been made for the mink. They are apparently the only ones needing consideration in a practical diet. A calcium phosphorus ratio of 1:1 is optimal, according to Smith and Leesli (1949). Calcium is normally added to the practical ration at a level of 0.48 per cent and phosphorus at a 0.24 per cent level (Coombes et al., 1950).

The optimal calcium and phosphorus levels for growing puppies is given at 0.27 per cent and 0.22 per cent, respectively, by Arnold and Elvehjem (1937). An adequate level for adult dogs is approximated by McCay (1949) at 0.5 per cent for each of the two minerals. Harris et al., (1945) found that 0.51 per cent calcium was the minimal level allowing

normal bone development in growing foxes.

The vitamin requirement. Bassett (1950), reporting on work at the United States Fur Animal Experiment Station, states that symptoms of a deficiency due to vitamins A, C, and D are difficult or impossible to produce in mink. Smith and Loosli (1940) found a serious vitamin D deficiency could not be induced from weaning to pelting, although the calcium and phosphorus content of the bones was reduced. No discernible deficiency symptoms were observed in mink maintained for eight and one-half months on an ascorbic acid free diet, according to Loosli and Smith (1940).

Bassett, Loosli, and Wilke (1948) failed to produce symptoms of a vitamin A deficiency in foxes and mink but noted that blood and liver levels of the vitamin varied with dietary intake. They found ascorbic acid exerted a sparing action, or aided retention, of vitamin A. Mayer and Krehl (1948) found that both fox and mink require vitamin A at a level of twenty-five international units per kilogram of body weight. Still (1939) recommended that 250 to 300 international units per pound of feed be provided in practical rations.

Schaefer, Whitehair, and Elvehjem (1946) employed a purified ration, fortified with all known crystalline vitamins, to produce a serious deficiency syndrome in mink which temporarily responded to folic acid. Recurrence of the syndrome responded to fresh liver or raw whole milk.

Continuing this work, Schaefer, Teve, Whitehair, and Elvehjem (1948) found fresh liver contained at least two factors, one methanol soluble and

and the other confined to the residue, essential to the mink. Later Teve, Schaefer, and Elvehjem (1949) found the methanol soluble liver fraction exerted a sparing action on folic acid requirements. This factor was found not to be related to vitamin B_{12}. Additional work by Teve, Lalor and Elvehjem (1950) confirmed the requirement of the mink for the methanol insoluble factor and it was determined further that fish solubles contained the methanol soluble factor.

Substitutes for Fresh Meat

The wide use of a variety of unprocessed, perishable animal by-products as substitutes for the fresh muscle-meat normally included in the mink ration has been previously pointed out. They are not considered here, as attention will be confined to information and ingredients applicable to a dry ration suitable for the mink.

Replacement of the fresh meat component of the ration involves, essentially, the substitution of ingredients of the desired type which will supply similar protein, fat, and vitamin values in a form acceptable to the mink.

Michaud, Hoppert, and Hart (1947) discount the importance of palatability, which they define as "specific tastes essential to appetite stimulation." They believe that an exclusive appetite for a specific taste is entirely an acquired characteristic. They state "that under conditions of domestication, an animal will accept and be satisfied with any substitute that will furnish the nutrients it requires."

Robinson (1946) found the biological value of feeds to be reduced

markedly by high temperatures. He noted an improvement when processing temperatures were lowered from 240 to 180 degrees F. Many of the commercially available animal feed ingredients have been subjected to temperatures as high as 350 degrees fahrenheit.

In the same work, Robinson (1946) reported that, although dogs did well on canned food, submaximal reproduction and minimal growth of pups resulted from a meal type ration composed of processed ingredients. He was unable to formulate a nutritionally optimal product from ingredients processed at high temperatures. He further reported failure to compound a ration from ingredients of this type which would allow the development of kittens. This deficiency could be corrected by the addition of beef or liver and milk. He found that any large quantity of cereal would adversely effect the reproductive ability of the female cat, but not the male.

Morgan (1940) demonstrated that the heating of proteins caused a decrease in biological value with an accompanying loss of heat labile thiamine.

Keahn (1942) reported excellent reproduction in dogs on a dry-type dog ration. McCay (1949) accepts the dry-type dog ration as nutritionally adequate, and Bassett (1943) states that mature foxes are satisfactorily maintained on rations in meal or cube form. He found that, except for a few weeks after weaning, raw meat was non-essential but preferable.

Bassett (1942) reports beef meal to be a well tolerated ingredient in the summer ration of weaned mink kits. In affecting a partial substitution in the fresh meat of the mink ration, soybean oil meal, blood meal, and

liver meal were found to be effective (Bassett, 1943). Fish meal was also found valuable as an extender for fresh fish and horse meat (Bassett, 1945).

Schaefer, Whitehair and Elvehjem (1946) reported no difficulty in obtaining normal feed consumption by mink fed a synthetic ration consisting of casein, sucrose, oil, minerals, and vitamins. Furthermore, response was normal until body stores of folacin and liver factors were depleted. When these deficiencies were corrected by the addition of fresh liver, normal maintenance and growth were allowed.

Travis et al (1949) reported on work - of which this is a continuation - with a dry-mash ration made up of commercially processed ingredients. This ration allowed marginal maintenance but not growth. A response was obtained from addition of a mixture of three amino acids, methionine, lysine, and tryptophane. It was concluded that the principal dietary defect was protein in nature and involved at least one of the three added amino acids. Palatability and digestibility were mentioned as important limiting factors.

III. GENERAL METHODS AND PROCEDURES

Three successive basal rations (Tables 2, 3, and 4) were employed. As work progressed, a new ration was evolved through the incorporation of certain indicated nutritional changes of major consequence. All were of the dry mash type and consisted of commercially available feedstuffs. They were designed as a "complete" ration, theoretically adequate for all of the dietary requirements of the mink. Normally, the dry ration was formulated in 200 pound lots. Minor ration components were blended into the mix by hand and the dry mash was then mixed in a power mixer. Unless otherwise stated, supplements introduced into the basal ration at the time of formulation were at the expense of the cereal. Additions made at the time of feeding were at the expense of the total ration.

Three successive feeding trials were initiated to allow a comparison and study of the responses of the mink to the basal rations and their several modifications. Supplementation was made in an attempt to determine specific deficiencies inherent in the basal ration. Duration of the feeding trials was not fixed in advance, but rather the terminating date was contingent on the gathering of decisive data.

The animals available were dissimilar in age, sex, heredity, and history. They were grouped into similar groups and their individual and collective responses were correlated with dietary variation. In each experiment, one group was maintained on a good quality fresh meat ration typical of those fed on commercial ranches. This group will be referred to as the Control Group and the ration will be termed the Control Ration (Table 1). Another group was kept on the basal ration and will be

identified as the Basal Group.

All rations, as fed, were of similar moisture content. Water was added to each ration at the time of mixing in an amount required to produce the hamburger-like consistency reportedly most appealing to the mink. Rations were mixed by hand each day prior to feeding, at which time water and supplements were added to the dry ration. A premix of the dry ingredients of the Control Ration was combined with the wet ingredients and water was added.

The animals were individually fed each evening except during lactation, when an additional morning feeding was offered the mothers and their kits. Feed was offered in excess of consumption and water was constantly available.

The animals were confined separately in adjacent, commercial-type cages of heavy gauge, one inch mesh netting. Each cage was proved with a watering cup, feed board, and nest box. They were kept in an open enclosure on the Michigan State College campus. Every effort was made to duplicate normal ranch conditions.

Response to the dietary variations was evaluated, primarily, in terms of body weight. This is reported in grams and converted to per cent initial weight to facilitate comparison of animals unlike in size. Differences in body weight variation due to size were found to be insignificant when evaluated in this manner. This method was especially useful in comparing animals of opposite sex, for a marked sex difference in size exists in mink. Weighings were made at weekly intervals at the same hour in order to minimize variation due to ingested food and water.

When appropriate, mortality and reproduction were considered in evaluating the dietary treatments. Pelt quality was generally ignored due to the complex of extra-dietary factors influencing this trait.

All casualty animals were necropsied and the cause of death determined by members of the Animal Pathology Department of Michigan State College.

Each basal ration was fed to growing albino rats for a period of four weeks. The terminal weight and condition of the basal fed rats were compared with that of a similar group fed a laboratory stock ration.

The scope of this problem, involving an infinite number of possible combinations and levels of ration ingredients, necessitated an early delineation of the more productive trends. It was felt that long-term treatments involving large groups of mink would be wasteful of time, facilities, and the limited number of available animals. In general, the maximum number of treatments of brief duration were administered to groups of small size.

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TABLE I

CONTROL RATION

	Per cent
Horse muscle, ground	65.0
Canned fish (Atco)	10.0
Cereal (Kellogg's Nexite)	9.0
Fresh liver	10.0
Conkey's Y-O	1.0
Skim milk powder	2.0
Tomato puree, canned	2.5
Fish oil (400D,2000A)	0.5
	100.0

Analysis (Oven dry basis)

Crude Protein	45.34%	Ether Extract	26.19%
NFE	22.07	Ash	4.44
Crude Fiber	1.96		

Analysis (As formulated)

Crude Protein	15.0 %	Ether Extract	8.6 %
NFE	7.3	Ash	1.45
Crude Fiber	0.65	Water	67.0

Analysis (As fed 30% Water added)

Crude Protein	12.0 %	Ether Extract	6.9 %
NFE	5.8	Ash	1.16
Crude Fiber	0.52	Water	73.62

TABLE 2

EXPERIMENTAL MINK BASAL RATION I

	Per cent
Corn flakes	24.0
Shredded wheat	20.0
Wheat germ meal	5.0
Wheat flour middlings	10.0
Soybean oil meal	20.0
Fish meal	10.0
Dried skim milk	4.0
Dehydrated alfalfa leaf meal	2.0
Brewer's dried yeast	1.0
Distiller's dried solubles	3.2
Salt (iodized)	0.5
Fish oil (400D, 2000A)	0.3
	100.0

Analysis

Protein	24.5%	Fiber	2.57%
NFE	51.85	Fat	3.4
Calcium	.75	Phosphorus	.75

TABLE 3

EXPERIMENTAL MINK BASAL RATION II

	Pounds
Shredded wheat	24.0
Corn flakes	20.0
Soybean oil meal	20.0
Dried skim milk	10.0
Fish meal	10.0
Meat scraps	5.0
Liver meal	4.0
Dehydrated alfalfa leaf meal	2.0
Brewer's yeast	3.0
Wheat germ oil	1.0
Fish oil (400D, 2000A)	0.5
Salt (iodized)	0.5
Manganese sulfate 5 grams	———
	100.0

Analysis

Moisture	6.2 %	Ether extract	4.69%
Ash	8.46	Fiber	2.89
Protein	32.5	NFE	45.26
Calcium	1.42	Phosphorus	.997

TABLE 4

EXPERIMENTAL MINK BASAL RATION III

	Pounds
Rice Crispies	44.1
Soybean oil meal	15.0
Dried skim milk	15.0
Fish meal	10.0
Meat scrap	5.0
Liver meal	4.0
Alfalfa leaf meal	2.0
Brewer's yeast	3.0
Wheat germ oil	1.0
Fish oil (400D, 2000A)	0.5
Methionine	0.2
Fortafeed, Lederle's 2-49C	0.2
Manganese sulfate 10 grams	
Lederle's Parve 5 grams	
	100.0

Analysis

Protein	27.9 %	Fat	2.86%
NFE	54.75	Fiber	2.56

IV. THE MINK FEEDING AND MANAGEMENT QUESTIONNAIRE

Practical information concerning the care of the animals used in this work was an initial necessity. At the same time, validated facts would provide a basis from which to begin, as well as indications of promising areas toward which the work should progress. It was felt that the pooled experience of the commercial mink ranchers would furnish much of what was required. Their observations could be expected to be practical, detailed, and reliable, for they represent a distillate of the long-term findings of many workers, all characterized by complete familiarity with the animal concerned and a real need to accurately discern its needs.

The questionnaire (Fig. 1) was an effort to assemble information from as many ranches as possible. It was general in nature and designed to encourage comment as well as secure somewhat detailed information on feeding practices. Consideration was given factors other than nutritional, not only because of the need for general information per se, but because nutrition is so fundamental it cannot be successfully isolated from the overall picture. Reproduction was necessarily used as the measurement criterion because of its uniformity and the availability of accurate records. It is also the basic means by which the rancher measures the success of his feeding and management program. It was recognized that many other impinging factors would cloud and distort the effect of feed, but it was hoped a general trend could be detected when the results of several ranches were integrated.

From the 314 mailed questionnaires, 76 returns were received. It was necessary to discard 50 of these because of lack of completeness, limited

experience or time in the business by the rancher, or too few animals. The 26 remaining returns were gratifying in their completeness, sincerity and grasp of the purpose of the questionnaire.

The results are tabulated in Tables 5, 6 and 7. Table 5 gives the percentage of each ration ingredient fed by each of the 26 ranches reporting. The size of the breeding herd is given to allow some weighting of the results. The efficiency of the herd is expressed as kit average, ie., the average number of young for the total number of breeding females stocked. The overall average is shown to be 3.6 kits per female. This is in good agreement with the average of 4.0 which is normally associated with satisfactory production. This agreement would tend to indicate that despite the small number of returns used, a relatively representative sample was obtained.

Table 5 shows horse meat and cereal to be common to all rations. The cereal component is relatively constant in all rations, averaging about 11 per cent. The level of horse meat is not so uniform, varying from 20 to 80 per cent. This variation is accompanied by compensatory changes in the amounts of the other fresh feedstuffs of animal origin. When the total fresh animal products are considered, the percentages are less variable with extremes of 72 and 85 per cent of the total ration.

Vegetables, fish and liver appear in nearly all of the rations. Vegetables vary in amounts from 1 to 10 per cent, with an average of 4 per cent. This variation is attributed to the type of vegetables used and difference of opinion as to their value. The liver variation is due to cost and availability, ten per cent being indicated as the desired level. An

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average of 7 per cent was reported. The use of fish is common and levels again are dependent on the levels of other meats.

Commercial vitamin supplements and natural vitamin concentrates are generally added. Brewer's yeast and wheat germ meal were used most commonly. Bone meal was the only reported mineral source added to the ration.

Information on Table 5 has been divided as shown on Table 6 in an effort to disclose ration differences accompanying reproduction variation. Ranches with a kit average of four and over are combined into one group as are those with a kit average of three to four and those with a kit average of under three. It should be noted that only four ranches fall into the latter group.

No marked ration differences are evident among the three levels of reproduction. Similarity of averages is striking. Levels of horse meat, cereal, and total fresh feedstuffs of animal origin are nearly identical. Some significance might be attributed the reduced level of liver, and vitamin supplements noted in the low production group. However, the limited number of ranches in this group prevent the establishment of a trend.

Table 7 summarizes the expressed opinions of ranchers as to the merit of commonly fed ingredients. For the most part, they were in agreement. Some items, such as tomatoes, reflect disagreement as they are reported to be essential by some and of doubtful value by others who have obtained equally good results without them. It is interesting to note that while fresh meat is listed as of prime importance, rancid meat is a first priority offender.

Eight diseases, in order of frequency reported, are also listed on

Table 7. Significantly, four of these diseases are of nutritional origin, two are related to feed contamination, and of the remaining two, pneumonia is well known as a secondary invader most prevalent among animals on a marginal nutritional plane. The other disease, boils and abscesses, is many times attributable to bone slivers in the ration. The importance of feeding and nutrition in mink morbidity is clearly indicated.

The objections given to the present ration are listed on Table 7 in the order of frequency of appearance. These objections are identical with those which have been previously discussed and serve to point up the importance of work on the development of a modified mink ration.

The questionnaire was unsuccessful in denoting an ingredient or ingredient complex which would elicit a typical response in terms of reproduction. The similarity between rations yielding poor and superior reproduction is surprising. The existence of factors sufficiently strong to completely overshadow the nutritional aspects are indicated.

The importance of fresh meat and the complexity of the current practical rations are emphasized. The level of horse meat is apparently not as important as the level of fresh animal products. The role of fresh liver in the ration was not clarified, for although most rations contained it at variable levels, rations without it were apparently fully as successful.

Significantly, no mention was made of the use of dessicated animal protein feeds other than the two instances in which liver meal was used to supplement the fresh liver.

FIGURE I

MINK FEEDING AND MANAGEMENT QUESTIONNAIRE

Name_____ Average No. of kits per litter_____

Address_____ Age at weaning_____Variety of mink_____

_____ Average No. of mink stocked_____

Ration Ingredient	Maintenance From_____ To_____ (date)	Mating & Gestation From_____ To_____ (date)	Growth From_____ To_____ (date)	Pelting From_____ To_____ (date)
1. Horsemeat	_____%	_____%	_____%	_____%
2._____	_____	_____	_____	_____
3._____	_____	_____	_____	_____
4._____	_____	_____	_____	_____
5._____	_____	_____	_____	_____
6._____	_____	_____	_____	_____
7._____	_____	_____	_____	_____
8._____	_____	_____	_____	_____
9._____	_____	_____	_____	_____
10._____	_____	_____	_____	_____
Total	100 %	100 %	100 %	100 %
No. feedings per day	_____	_____	_____	_____
Oz fed each per feeding (before adding water)				
Male.	_____	_____	_____	_____
Female.	_____	_____	_____	_____

Remarks on ingredients you feel particularly essential for a well balanced mink ration:_____

_____

Remarks on ingredients you feel are harmful or of doubtful value in a mink ration:_____

_____

FIGURE I continued

Remarks on disease incidence and methods of prevention:_____

_____

_____

_____

_____

_____

What are your objections to your present ration, i.e., labor in preparation, expense, scarcity of feedstuffs, etc.?_____

_____

_____

_____

_____

_____

Give a brief resume of any outstanding management and feeding practices you feel may have contributed to past successes and failures in mink ranching:_____

_____

_____

_____

_____

_____

Any further comments:

TABLE 5

A COMPARISON OF RATIONS FED ON COMMERCIAL MICHIGAN MINK RANCHES
(Amounts in Percent of Total Ration)

Ranch No.	Horse Meat	Liver	Fish	Chicken by-Products	Other Fresh Meat by-Products	Commercial Cereal Mix	Commercial Vitamin Supplement	Wheat Germ Meal	Brewer's Yeast	Bone Meal	Powdered Skim Milk	Liver Meal	Tomatoes & Leafy Vegetables	Alfalfa Leaf Meal	Cod Liver Oil	# Breeding Mink	Kit Average
1	60	10				15	2			2	2		3			200	3.9
2	65	8			10	10			0.5		1		5	0.5		300	4.0
3	55	5			20	11	3	2					2	1.0		70	4.5
4	37	10	28		10	7	3						5			150	3.7
5	55	10	15			10	1	3	1.0	1	1		3			250	3.7
6	25	6	25		20	10	1			2			5			175	3.6
7	15	5	10	30	18	10	1.5	1	1.0		2	3	5		x	450	4.0
8	60		20			12	1			2			5		x	200	4.0
9	20	10	17		25	8		3	1.5				5	0.5		600	3.0
10	25	5	25		25	10		2.5	1.5	1			5			430	1.5
11	44	10	10		20	12			0.5				1		x	680	4.2
12	25	4	25		24	12						2	5	2.0		150	5.0
13	40	5	15	15		15			2.	1	2		5		x	200	3.0
14	56		10	10		10	2	2					5			280	3.9
15	29	5			39	8	2	2					5			150	4.0
16	50	15			17	11	1		1	2			3			75	4.0
17	40		15		30	13	2								x	50	1.2
18	80	5				8							5			20	2.0
19	55	12	5			15				2			5		x	51	3.0
20	32	3	30		10	10		2	2		1		10			150	4.1
21	72	10				15		2					3		x	50	4.6
22	40	2	20		15	15	2			2	4		2			100	4.3
23	60	5	10		10	15										250	3.7
24	45	5	8		25	14			1	1						440	2.9
25	40	20			25	8		1		2	3		3		x	100	4.3
26	25	3	25	25		10	3	2		2			5			96	4.8
													Total Mink			5667	
													Kit Average				3.6

Note: The percentage composition of the rations given is an average approximation, as rations are changed with the seasons and with ingredient availability and cost. Generally, the rations given are those in effect during mating and gestation as particular care is given feed composition at this time. Not all percentages will total exactly 100 per cent due to the incorporation of ingredients fed periodically, i.e., weekly or on alternate days.

TABLE 6

A COMPARISON OF AVERAGE RATIONS FED ON MINK RANCHES GROUPED ACCORDING TO REPRODUCTION LEVELS

Ingredient	Overall Average	Kit Average: 4 and over (13 ranches)	3 to 4 (9 ranches)	under 3 (4 ranches)
Horse meat	45	42.5	45.3	47.5
Liver	7	6.9	7.5	3.7
Fish	12	10.8	13.9	12.0
Chicken by-products	3	4.2	2.8	0.0
Other animal by-products	14	15.2	7.2	20.0
Commercial cereal mix	11	11.1	11.7	11.2
Vitamin & mineral supplement	1	2.7	1.0	0.5
Wheat germ meal	1	0.92	0.88	0.0
Brewer's yeast	0.5	0.38	0.50	0.62
Dried skim milk	1.0	0.85	0.55	0.0
Bone meal	0.5	0.92	0.33	0.50
Tomato or leafy vegetable	4	4.2	4.0	2.5
Fish oil				
Total fresh feedstuffs of animal origin	81	79.6	76.8	83.2

TABLE 7

RESULTS FROM MINK MANAGEMENT QUESTIONNAIRE (1950)
(Listed in Order of Frequency Reported)

An Evaluation of Common Ration Ingredients

Beneficial	Harmful or of Doubtful Value
Fresh muscle meat	Rancid meat
Tomatoes	Fresh animal by-products
Brewer's Yeast	Chicken by-products
Milk (fresh or dry)	Uncooked rough fish
Fish oil	Ground green bone
Green vegetables	Raw egg white
Bone meal	Potatoes
Cereal	Green vegetables
Fresh animal by-products	Tomatoes
	Commercial vitamin mixtures

Objections to Present Ration

Cost
Scarcity (increasing)
Handling, storing, processing
Complexity

Common Diseases

Boils and abscesses
Salmonella
Botulism
Yellow fat
Acidosis
Renal calculi
Pneumonia
Gastro-enteritis

V. FEEDING TRIAL I

Methods and Procedures

The Michigan State College experimental mink ration reported by Travis et al. (1949) was modified to form Basal Ration I. Carbohydrate availability was increased by the use of cooked cereals. Protein quality was improved by increasing the soybean oil meal and fishmeal and adding powdered skim milk. Increased vitamin content was achieved by the addition of powdered skim milk, wheat germ meal, dried brewer's yeast, and distillers solubles. The calcium-phosphorus ratio was altered.

The seventeen mink available for experiment were those reported on by Travis et al. (1949) and were currently on the dietary treatments reported by him.

One group consisting of three animals, and another group of four animals, were changed from the Control Ration (Table I) to Basal Ration I (Table 2), with one week allowed for transition. At the end of the eighth week of the feeding trial, the first group received a supplement of homogenized fish at a 37 per cent level. The addition was made at the expense of the ration. This group was compared with the second group which remained on the unsupplemented basal ration.

Four animals currently on Travis's ration were changed abruptly to Basal Ration I. This allowed a direct comparison of the two rations.

A group of five mink, previously used as a control group in the aforementioned work, were continued on the Control Ration as a control group.

It was thought necessary to terminate the weekly weighings at the end of the tenth week of the feeding trial because of mating and subsequent

gestation and lactation. Dietary treatments were continued unchanged. Supplementation with the homogenized fish was discontinued on the 138th day of Feeding Trial I because of the mortality among the animals of the two groups on this treatment. Duration of the homogenized fish supplementation had been eighty-two days.

To allow some observations during the period when weighing was restricted, four male mink were selected at random from the basal groups and separated from the herd. Two of the males received the basal ration supplemented with 0.2 per cent dl-methionine. The remaining two animals received the basal ration supplemented with a mixture supplying 0.2 per cent dl-methionine; 0.25 per cent dl-lysine, and 0.3 per cent dl-tryptophane. Duration of this treatment was six weeks, during which time the animals were weighed weekly as usual.

Results and Discussion

The responses of two dissimilar groups of adult mink to a change from the control ration to the Basal Ration I are given in the first period of Tables 8 and 9 and on Figure II. The similarity of response among unlike animals to identical treatment is found to be apparent when evaluated in terms of per cent of the initial weight. Figure II and Tables 8 and 9 reflect the uniformity of response between and within groups.

The inadequacy of Basal Ration I is indicated by an average weight loss of 31 and 24 per cent for Group 1 and Group 2, respectively. The major portion of the weight loss occured during the first three weeks following the ration change, (19 per cent in the case of both groups), after which body weight tended to plateau.

The changes in body weight incident to a change from the experimental mink ration reported by Travis et al. (1949) to Basal Ration I are reflected in Table 10 and Figure II. The first mentioned ration had been in effect for 145 days when Basal Ration I was initiated. No significant response was noted in the four females comprising the group. Initial weight was maintained with little variation throughout the eight weeks of the first period.

The response to supplementation of the basal ration with homogenized fish is indicated during period 2 of Tables 8 and 10, and in Figure II. The two weekly weighings reflect a depressing effect in both groups, but more severe in Group 3. This depression is not noted in the unsupplemented Group 2, Table 9.

The weekly weighings were discontinued at the end of the tenth week of the feeding trial due to the inadvisability of disturbing the animals during mating, gestation, and lactation. The treatments were continued. The homogenized fish supplement was discontinued after eight weeks, due to the moribund condition of the animals receiving it.

A high and constant body weight was maintained by the animals in Group 4, the Control Group (Table II). A slight but uniform weight gain was demonstrated. This would indicate that the variations noted in the other groups were primarily attributable to dietary factors.

The results of amino acid supplementation are shown in Table 12. A moderately favorable response was exhibited by three of the animals. Response from the fourth was mildly depressed. None of the animals indicated an ability to regain the weight lost on the basal ration.

Reproduction among animals on the experimental rations was markedly depressed. Mating was difficult or impossible. The males lacked the weight and virility necessary to subdue the females from the Control Group. The females on the basal ration generally refused the males, exhibiting no signs of estrus. Only one basal fed female whelped. She had been on a ration devoid of fresh meat for a total of 300 days at the time of whelping. Matings from a male fed the basal ration for 120 days at the time of mating, resulted in two litters from females of the Control Group.

Mink numbers 5 and 6 in Group one, and number 16 in Group three, died during the course of Feeding Trial I. All were on the basal ration supplemented with homogenized fish. The disproportionate mortality in these groups resulted in discontinuance of the homogenized fish supplement. Necropsy revealed a similar pathological syndrome in each of the animals. Death was due to severe, chronic gastro-enteritis with accompanying hepatic and renal degenerative changes. These symptoms were attributed to general inanition. Lesions pointing to a specific dietary deficiency were absent.

Inanition, often to a moribund degree, was evident among the animals subjected to the basal ration. Abnormal stools, excessive water consumption, and a constant nervous running were generally observed. An obvious distaste for the basal ration was displayed by all animals. Feed consumption was sub-normal and many times amounted to complete refusal of feed for extended periods.

The performance of rats fed the basal ration was fully equivalent to that obtained on the stock ration. No deficiency signs were seen and growth was normal.

In general, sub-normal body weight was maintained and mortality was moderate on Basal Ration I. Ovulation, spermatogenesis, and gestation were possible in at least one instance. Basal Ration I, however, was clearly shown to be inadequate for maintenance and reproduction in mink. There was no indication of improvement on the experimental mink ration reported by Travis et al. (1949).

Supplementation with a high level of homogenized fish failed to correct any deficiencies, exerting a depressing effect instead.

Limited work with crystalline amino acids indicated the principal dietary deficiency of the basal diet not to be concerned with protein.

TABLE 8

WEEKLY WEIGHTS OF MINK IN GROUP ONE*
(Given in Grams and Percent Initial Weight)
(12/3/48 to 2/11/49)

Time in Weeks		1	2	3	4	5	6	7	8	Average % Initial Wt. for Period	1	2
	Initial Weight	Period 1									Period 2	
Mink #4 (Female)	782	745	670	605	615	585	610	620	625		575	560
% I. W.		95	86	77	79	75	78	80	80		73	72
Mink #5 (Female)	675	645	575	545	550	560	565	575	520		485	500
% I. W.		95	85	81	81	83	84	85	77		72	74
Mink #6 (Male)	1050	1025	950	895	870	885	870	880	830		740	750
% I. W.		98	90	85	83	84	83	84	79		70	71
Group Average % Initial Wt.		96	87	81	81	81	82	83	79		72	72

*Group One - Transferred from Control Ration to Basal I Ration at start of Period 1
Period 1;
Basal Ration I
Period 2:
Basal Ration 1 plus 37% homogenized fish.

TABLE 9

WEEKLY WEIGHTS OF MINK IN GROUP TWO*
(Given in Grams and Percent Initial Weight)
(12/3/48 to 2/11/49)

Time in Weeks	Initial Weight	1	2	3	4	5	6	7	8	Average % Initial Wt. for Period	1	2
		Period 1									Period 2	
Mink #10 (Male)	1005	970	855	790	790	770	775	775	760		710	690
% I. W.		96	85	79	79	76	76	76	75	80	71	69
Mink #11 (Male)	1035	995	895	825	830	810	780	770	765		750	820
% I. W.		96	86	80	80	78	75	74	74	80	72	79
Mink #12 (Male)	1070	1025	910	840	860	820	770	780	755		720	745
% I. W.		96	85	78	80	77	72	73	71	79	67	70
Mink #14 (Male)	1130	1110	1005	925	935	910	880	910	850		850	930
% I. W.		98	93	82	83	80	78	80	75	84	75	82
Mink #15 (Female)	685	665	615	575	575	570	565	575	570		555	530
% I. W.		97	90	84	84	83	82	84	83	86	81	77
Group Average % Initial Weight	100	97	88	81	81	79	77	77	76	82	73	75

*Group Two - Transferred from Control Ration to Basal Ration I at start of Period 1
Period 1:
Basal Ration I
Period 2:
Basal Ration I

TABLE 10

WEEKLY WEIGHTS OF MINK IN GROUP THREE*
(Given in Grams and Percent Initial Weight)
(12/3/48 to 2/11/49)

Time in Weeks		1	2	3	4	5	6	7	8	Average % Initial Wt. for Period	1	2
	Initial Weight										Period 2	
Mink #2 (Female)	537	530	500	500	510	510	520	510	515		480	465
% I. W.		99	93	93	95	95	97	95	96	95	90	87
Mink #16 (Female)	645	650	620	615	630	660	655	660	650		620	580
% I. W.		100	96	95	98	102	101	102	100	99	96	90
Mink #17 (Female)	725	755	745	750	775	800	820	820	825		770	740
% I. W.		104	103	103	107	110	113	113	114	108	106	102
Mink #18 (Female)	635	630	550	510	560	570	580	580	630		520	490
% I. W.		99	87	80	88	90	91	91	99	91	82	87
Group Average % Initial Wt.	100	101	95	93	97	99	101	100	102	98	93	89

*Group Three - Transferred from MSC Experimental Ration to Basal Ration I at start of Period 1
Period 1:
Basal Ration I
Period 2:
Basal Ration I plus 37% homogenized fish

TABLE 11

WEEKLY WEIGHTS OF MINK IN GROUP FOUR*
(Given in Grams and Percent Initial Weight)
(12/3/48 to 2/11/49)

Time in Weeks		1	2	3	4	5	6	7	8	Average %	1	2
	Initial Weight	Period 1								Initial Wt. for Period	Period 2	
Mink #7 (Female)	725	730	710	700	720	740	750	770	775		780	770
% I. W.		101	98	97	99	102	104	106	107	102	108	106
Mink #8 (Female)	700		640	640	670	715	740	760	755		750	765
% I. W.			91	91	96	102	106	109	108	100	107	109
Mink #9 (Male)	1040	1032	1012	1030	1035	1060	1100	1130	1100		1110	1095
% I. W.		99	97	99	100	102	106	109	106	102	107	105
Mink #19 (Female)	707	830	810	690	740	790	770	750	775		725	745
% I. W.		117	114	97	104	111	108	105	109	108	102	105
Mink #31 (Female)	900	890	880	870	895	920	940	930	910		920	920
% I. W.		99	98	97	100	102	105	103	101	101	102	102
Group Average % Initial Wt.	100	110	99	96	100	103	105	106	106	103	105	105

*Group Four - Continued on Ranch Control Ration
Period 1:
Ranch control ration
Period 2:
Ranch control ration

TABLE 12

EFFECT OF AMINO ACID SUPPLEMENTATION ON BODY WEIGHT
OF ADULT MALE MINK ON BASAL RATION I
(Given in Grams and Percent Initial Weight)
(5/2/49 to 6/20/49)

Time in Weeks		1	2	3	4	5	6	Average %
	Initial Weight							Initial Wt. for Period
Methionine*								
Mink #10	660	700	750	770	765	760	610	
% I. W.		106	114	117	116	115	92	110
Mink #11	825	780	795	770	760	760	725	
% I. W.		95	96	93	92	92	88	93
Amino Acid Mix**								
Mink #12	840	905	910	880	890	870	830	
% I. W.		108	108	105	106	104	99	105
Mink #14	760	825	860	830	840	830	800	
% I. W.		109	113	109	110	109	105	109

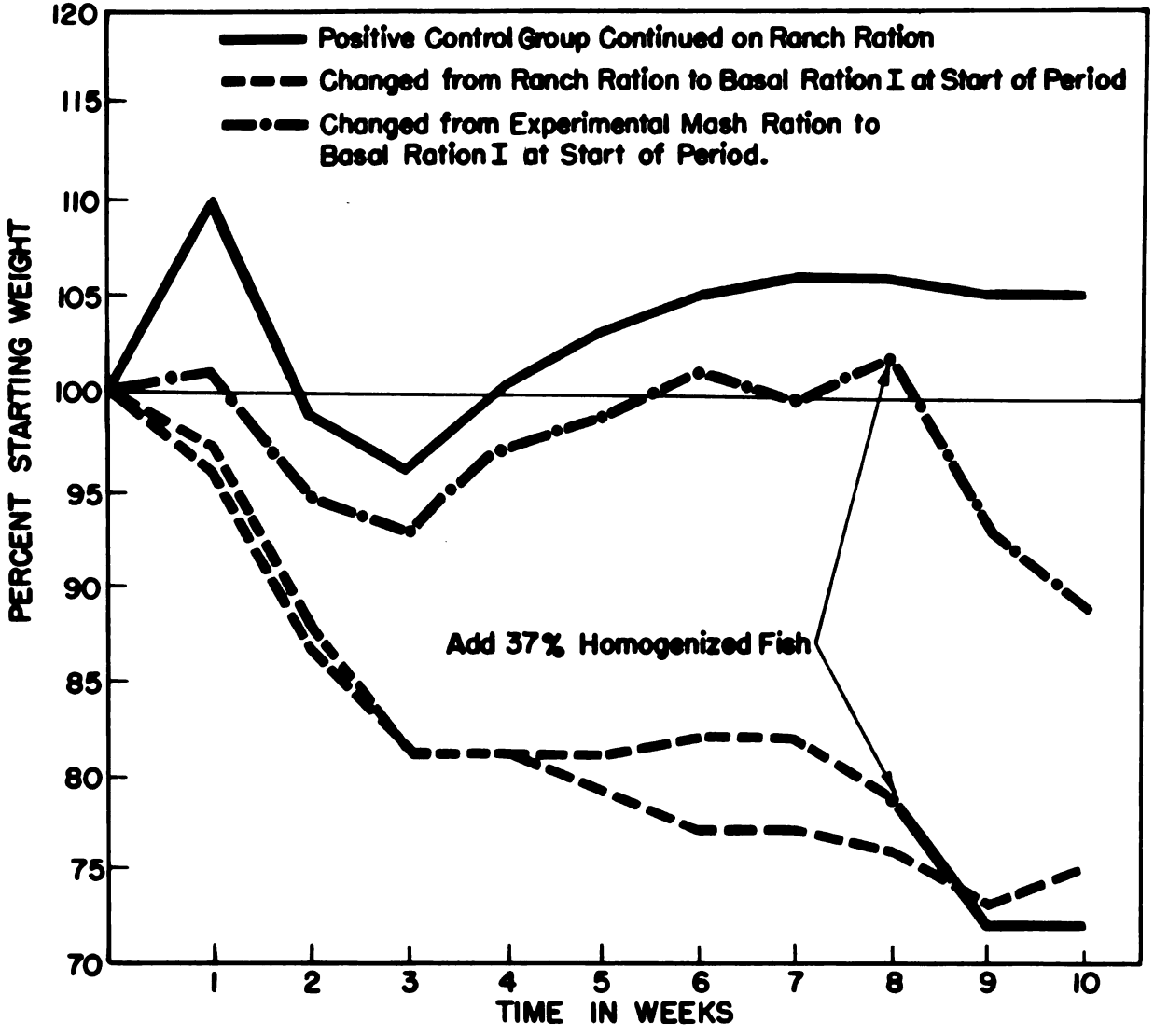
*0.2% dl-methionine added to dry Basal Ration I

**An amino acid mixture was added to the dry Basal Ration I supplying the following amounts of three amino acids:

dl-methionine	0.2%
dl-lysine	0.25%
dl-tryptophane	0.30%

FIGURE II

AVERAGE GROUP RESPONSE OF MINK TO RATION VARIATION
12/3/48 to 2/11/49



VI. FEEDING TRIAL II

Methods and Procedure

Basal Ration II (Table 3) was formulated in an effort to improve on the inadequate Basal Ration I. Uncooked cereal products were completely eliminated in favor of corn flakes and shredded wheat. Meatscraps, liver meal, and powdered skim milk were added to increase and improve the protein content. Forty-nine per cent of the protein of the resulting ration was of animal origin.

Thirty-six dissimilar mink with a nutritional plane standardized on the Control Ration were carefully divided according to age, sex, heredity, and size into six similar groups. These were placed on differing experimental ration treatments after one week of gradual transition as follows:

The basal group received Basal Ration II.

Group one received the basal ration supplemented with 0.2 per cent dl-methionine.

Group two received the basal ration and methionine with 2.5 per cent canned tomato puree.

Group three received the Group two treatment, with 0.5 per cent beef extract added.

Group four received the basal ration supplemented with 0.5 per cent beef extract.

After ten weeks on the above treatments, changes were introduced. The beef extract supplementation (Group Four) was discontinued, and Merck's

Animal Protein Factor Supplement was added at a level to provide 125 micrograms of vitamin B_{12} per pound of the dry feed of all groups except the basal and control.

These treatments were continued for a period of five weeks, at which time all existing supplementation was discontinued, leaving only the basal and control groups unchanged. Group four was abruptly changed to the Control Ration. The remaining three groups received the basal ration supplemented with casein at a 10 per cent level. Two weeks were allowed for a response to these changes, at which time Feeding Trial II was terminated to allow changes in the basal ration.

Throughout this feeding trial, independent exploratory efforts and observations were made on the effect of feed consistency and the value of fresh liver. The consistency of the basal ration was varied from moist granularity to soupiness by increasing or decreasing the amount of water added. Gelatin added to the basal ration resulted in a congealed form, similar in consistency to meat, which could be fed in chunks.

Short term supplementation with various levels of fresh minced liver was tried with animals exhibiting signs of depletion on Basal Ration II. It was anticipated that, if ration insufficiency was due to factors present in liver, the depleted body stores would be replenished and a favorable growth response should follow.

Results and Discussion

The individual and collective responses of the animals to the varied dietary treatments of period 1 are given in Tables 13 through 18. Weekly weights are reported in grams and in per cent of the initial weight. The

means for the weeks and for the period are reported in per cent initial weight only. The average per cent of initial weight maintained during the period, shown in the last column, allows comparison of animals and groups on the basis of performance during the entire period, without complete emphasis on the terminal weight.

An analysis of the variance among terminal weights of the five groups being fed the basal ration, with and without supplementation, is as follows:

Source of Variation	Degrees of Freedom	Mean Square
Total	26	
Treatments	4	89.25
Animals	22	113.72
$F = 89.25/113.72 - 0.5484$	$F_{.95}$ (4,22)	$= 2.82$

The F ratio points out the complete absence of variation among the groups. It is quite apparent that the supplementation did not influence the value of Basal Ration II. Any, or all, of the groups can therefore be compared with the Control Group. Table 19 facilitates the comparison of the weekly means of the six groups. The inadequacy of the basal ration, as compared with the control, is apparent. The control group shows a gain during the period of 17 per cent of the initial weight with an average of 115 per cent of the initial weight maintained during the period. These groups receiving the experimental treatments show weight losses of from 12 to 22 per cent at the end of the period.

TABLE 13

WEEKLY WEIGHTS OF MINK IN BASAL GROUPS*
(Given in Grams and Percent Initial Weight)
(10/14/49 to 1/1/50)

Time in Weeks		1	2	3	4	5	6	7	8	9	10	Average Percent Initial Weight for Period
	Initial Weight	Period 1										
Mink #9	660	760	700	640	620	580	620	600	480	Death		
% I. W.		115	106	97	94	88	94	91	73			
Mink #103	1160	1200	1100	1080	1030	960	900	920	880	880	840	
% I. W.		103	95	93	89	83	78	79	76	76	72	84
Mink #27	860	880	800	820	830	760	760	780	760	760	720	
% I. W.		102	93	95	97	88	88	91	88	88	84	91
Mink #108	1260	1300	1190	1140	1140	1060	1100	1060	1100	1100	1090	
% I. W.		103	94	90	90	84	87	84	87	87	87	89
Mink #22	850	920	810	760	720	640	680	640	700	660	580	
% I. W.		108	95	89	85	75	80	75	82	78	68	83
Mink #16	650	760	680	660	650	560	560	620	580	600	520	Death
% I. W.		117	105	101	100	86	86	95	89	92	80	95
Group Average % Initial Wt.												

*Diet: Basal Ration II

TABLE 14

WEEKLY WEIGHTS OF MINK IN GROUP ONE*
(Given in Grams and Percent Initial Weight)
(10/14/49 to 1/1/50)

Time in Weeks		1	2	3	4	5	6	7	8	9	10	Average Percent Initial Weight for Period
	Initial Weight	Period 1										
Mink #8	625	700	560	600	580	480	540	600	620	560	590	
% I. W.		112	90	96	93	77	86	96	99	90	94	93
Mink #104	1120	1160	1040	820	880	800	Death					
% I. W.		103	93	73	78	71						
Mink #25	820	840	740	800	800	680	760	800	760	700	640	
% I. W.		102	90	98	98	83	93	98	93	85	78	91
Mink #109	1220	1340	1240	1080	1030	880	900	920	800	800	800	
% I. W.		110	102	89	84	72	74	75	65	65	65	80
Mink #23	740	740	620	620	600	560	580	620	680	660	620	
% I. W.		100	84	84	81	76	88	84	92	89	84	86
Mink #17	680	720	700	680	620	580	560	600	580	580	540	
% I. W.		106	103	100	91	85	82	88	85	85	80	90
Group Average % Initial Wt.		105	94	90	88	77	85	88	84	83	80	87

*Diet: - Basal Ration II supplemented with:
0.2% dl-Methionine

TABLE 15

WEEKLY WEIGHTS OF MINK IN GROUP TWO*
(Given in Grams and Percent Initial Weight)
(10/14/49 to 1/1/50)

Time in Weeks		1	2	3	4	5	6	7	8	9	10	Average Percent Initial Weight for Period
	Initial Weight	Period 1										
Mink #7	650	660	580	580	580	520	540	600	620	580	590	
% I. W.		101	89	89	89	80	83	92	95	89	91	90
Mink #105	1080	1140	1040	980	940	820	880	900	880	800	900	
% I. W.		106	96	91	87	76	81	83	81	74	83	86
Mink #26	820	900	820	780	760	640	660	700	700	640	640	
% I. W.		110	100	95	93	78	80	85	85	78	78	88
Mink #113	1060	1140	1010	960	940	820	900	900	860	840	800	
% I. W.		108	95	90	89	77	85	85	81	79	75	86
Mink #24	740	820	800	760	760	540	680	720	700	640	640	
% I. W.		111	108	103	103	73	92	97	95	86	86	95
Mink #19	620	720	600	640	580	460	540	580	620	580	560	
% I. W.		116	97	103	94	74	87	94	100	94	90	95
Group Average % Initial Wt.		109	98	95	93	76	86	89	89	83	84	90

* Diet: Basal Ration II supplemented with:
0.2% dl-Methionine
2.5% Tomato Puree

TABLE 16

WEEKLY WEIGHTS OF MINK IN GROUP THREE*
(Given in Grams and Percent Initial Weight)
(10/14/49 to 1/1/50)

Time in Weeks		1	2	3	4	5	6	7	8	9	10	Average Percent Initial Weight for Period
	Initial Weight	Period 1										
Mink #5	620	660	650	640	610	510	580	600	660	600	640	
% I. W.		106	105	103	98	87	94	97	106	97	103	100
Mink #106	1100	1100	940	1020	960	820	880	840	840	840	860	
% I. W.		100	85	93	87	74	80	76	76	76	78	82
Mink #28	825	900	810	820	790	680	780	720	760	720	720	
% I. W.		109	98	100	96	82	95	87	92	87	87	93
Mink #115	1125	1160	1080	1040	1030	860	960	980	940	880	860	
% I. W.		103	96	93	92	76	85	87	84	77	76	87
Mink #18	720	800	720	760	730	680	680	720	700	720	680	
% I. W.		111	100	105	101	94	94	100	97	100	94	100
Mink #21	640	700	620	620	560	480	560	620	600	600	580	
% I. W.		109	97	97	87	75	87	97	94	94	90	93
Group Average % Initial Wt.		106	97	99	93	81	89	89	92	88	88	92

* Diet: - Basal Ration II supplemented with:
0.2% dl-Methionine
2.5% Tomato Puree

TABLE 17

WEEKLY WEIGHTS OF MINK IN GROUP FOUR*
(Given in Grams and Percent Initial Weight)
(10/14/49 to 1/1/50)

Time in Weeks		1	2	3	4	5	6	7	8	9	10	Average Percent Initial Weight for Period
	Initial Weight	Period 1										
Mink #5	630	680	610	680	660	600	620	660	640	600	640	
% I. W.		108	97	108	105	95	98	105	101	95	101	101
Mink #107	1200	1220	1130	1040	990	900	900	920	840	820	740	
% I. W.		102	94	87	82	75	75	77	70	68	62	79
Mink #15	840	880	820	840	860	740	760	780	740	720	740	
% I. W.		105	98	100	102	88	90	93	88	86	88	94
Mink #116	1400	1380	1270	1240	1220	1060	1140	1140	1080	980	900	
% I. W.		99	91	88	87	76	81	81	77	70	64	81
Mink #20	680	760	680	620	560	540	600	620	600	600	560	
% I. W.		112	100	91	82	79	88	91	88	88	82	90
Mink #11	680	720	625	660	690	580	620	660	Death			
% I. W.		106	92	97	101	85	91	97				
Group Average % Initial Wt.		105	95	95	93	83	87	91	85	81	79	89

*Diet: - Basal Ration II supplemented with:
0.5% Beef extract

TABLE 18

WEEKLY WEIGHTS OF MINK IN CONTROL GROUP*
(Given in Grams and Percent Initial Weight)
(10/14/49 to 1/1/50)

Time in Weeks		1	2	3	4	5	6	7	8	9	10	Average Percent Initial Weight for Period
	Initial Weight	Period 1										
Mink #3	800	800	800	880	870	800	820	820	880	920	860	
% I. W.		100	100	110	109	100	102	102	110	115	108	106
Mink #102	1180	1220	1220	1460	1480	1420	1480	1560	1580	1620	1560	
% I. W.		103	103	124	125	120	125	132	134	137	132	124
Mink #10	700	740	700	820	840	780	740	800	800	800	800	
% I. W.		106	100	117	120	111	106	114	114	104	114	112
Mink #111	1060	1080	1000	1180	1220	1040	1160	1240	1160	1200	1120	
% I. W.		102	94	111	115	98	109	117	109	113	106	107
Mink #13	660	660	624	720	740	700	720	800	780	780	720	
% I. W.		100	95	109	112	106	109	121	118	118	109	110
Mink #14	600	680	680	860	810	760	760	820	820	820	800	
% I. W.		113	113	143	135	127	127	137	137	137	133	130
Group Average % Initial Wt.		104	101	119	119	110	113	121	120	122	117	115

* Diet: - Control Ration

TABLE 19

A COMPARISON OF THE AVERAGE PERCENT INITIAL WEIGHT MAINTAINED BY GROUPS ON VARIED RATION TREATMENTS (10/14/49 to 1/1/50)

Time in Weeks	1	2	3	4	5	6	7	8	9	10	Average Percent Initial Weight for Period	No. Deaths
	Period 1											
Control Group	104	101	119	119	110	113	121	120	122	117	115	0
Basal Group	108	98	94	93	84	86	86	83	84	78	88	2
Group One	105	94	90	88	77	85	88	84	83	80	87	1
Group Two	109	98	95	93	76	85	89	89	83	84	90	0
Group Three	106	97	99	93	81	89	89	92	88	88	92	0
Group Four	105	95	95	93	83	87	91	85	81	79	89	1

Diets: -

Control Group - Ranch ration
Basal Group - Basal Ration II
Group One - Basal Ration II plus 0.2% dl-Methionine
Group Two - Basal Ration II plus 0.2% dl-Methionine plus 2.5% Tomato Puree
Group Three - Basal Ration II plus 0.2% dl-Methionine plus 2.5% Tomato Puree plus 0.5% Beef Extract
Group Four - Basal Ration II plus 0.5% Beef Extract

Period 2 is concerned with the effect of vitamin B_{12} supplementation. The response of the animals are given in the same manner used for period 1 in Tables 20 through 25. The per cent of initial weight given is based on the weight at the start of the feeding trial, rather than the weight at the beginning of the period.

An analysis of variance among groups of the terminal per cent initial weight is given below. Again, only the groups receiving Basal Ration II and its modifications are included.

Source of variation	Degrees of Freedom	Mean Square
Total	25	-
Treatments	4	334
Animals	21	184.95

$F = 334/184.95 = 1.8$ $\quad F_{.95}(4,21) = 2.84$

The weight variance among groups on different Basal Ration II modifications is insignificant at the 5 per cent level, although more variation exists than in period 1. The addition of vitamin B_{12} has not significantly influenced the ration, nor have the other continued supplementations.

Table 26 allows comparison of the average per cent initial weights of the groups on experimental and control rations. The Control Group again demonstrated its superiority by showing a weight increase while the experimental groups failed to regain any of the weight previously lost.

Two major comparisons are made during the two weeks of period 3. The response to the addition of protein, in the form of casein at the

10 per cent level, is compared with that obtained when the Control Ration replaced the basal ration.

Tables 21, 22, and 23 under period 3, show the absence of a favorable response in body weight within groups given a casein supplement in lieu of the existing ineffectual supplements. This can be compared with the immediate and strong response to the substitution of the Control Ration for the experimental ration. Group averages are compared in Table 26.

Observations on feed consumption as influenced by the consistency of the ration, were conclusive. When the basal ration was offered in a relatively dry form, wastage was great and the animals consistently refused to eat. When offered as a soupy consistency, there was little wastage but feed consumption was reduced, apparently because the feed could not be carried into the nestbox. Addition of gelatin allowed the feed to be fed in chunks and the texture was thought to be similar to meat. This did not appear to influence feed consumption. Neither was any apparent benefit derived from this added easily digestible protein source.

Surplus animals, fed Basal Ration II until signs of inanition appeared, received minced liver mixed in the basal ration, at levels of 10, 20, and 30 per cent of the dry mixture. These treatments were continued for seven days and then the liver was discontinued. The animals receiving liver at the 30 per cent level, exhibited marked weight gains during the week the liver was fed. Animals receiving liver at the 20 per cent level, gained in weight but the weight gains were less. Animals receiving fresh liver at the 10 per cent level demonstrated no significant weight increase. Weights increased during the liver supplementation were

non-persisting. Weight loss had occurred by the end of the following week and by the end of the second week, weights had returned to a point slightly below that shown before liver supplementation.

Apparently the weight increases were not the result of supplying a depleted trace substance. If such had been the case, some response could have been expected from the 10 per cent level of liver. The response could be attributed to increased food consumption due to increased palatability. Unfortunately, feed consumption was not measured.

Six animals died during the course of the feeding trial as noted in the tabulations. All deaths occurred within groups on the dry ration treatments; however, correlation with supplementations is impossible. The deaths are considered only to be symptomatic of the inadequacy of the basal ration. Without exception, the terminal cause of death was a gastro-enteritis of varying severity. In most instances, gastric and intestinal hemorrhage was present. The chronic nature of the condition was indicated by the extent of accompanying renal and hepatic degeneration.

TABLE 20

WEEKLY WEIGHTS OF MINK IN BASAL GROUP*
(Given in Grams and Percent Initial Weight)
(1/1/50 to 2/18/50)

Time in Weeks		1	2	3	4	5	Average Percent	1	2	Average Percent
	Starting Weight	Period 2					Initial Weight for Period	Period 3		Initial Weight for Period
Mink #103	840	860	1000	920	860	840		880	1000	
% I. W.	72	74	86	79	74	72	77	76	86	81
Mink #27	720	780	860	820	740	740		740	780	
% I. W.	84	90	100	95	86	86	91	86	91	88
Mink #22	580	580	700	640	520	540		440	Death	
% I. W.	68	68	82	75	61	63	70	52		
Mink #108	1090	1120	1240	1150	1060	1100		1160	1210	
% I. W.	87	89	98	91	84	87	90	92	96	94
Group Average % Initial Wt.	78	80	91	85	76	77	82	77	92	88

Diet: - Basal Ration II

TABLE 21

WEEKLY WEIGHTS OF MINK IN GROUP ONE*
(Given in Grams and Percent Initial Weight)
(1/1/50 to 2/18/50)

Time in Weeks		1	2	3	4	5	Average Percent Initial Weight for Period	1	2	Average Percent Initial Weight for Period
	Starting Weight	Period 2						Period 3		
Mink #8	590	560	620	620	560	520		500	Death	
% I. W.	94	90	99	99	90	83	92	80		
Mink #25	640	720	740	700	620	600		620	600	
% I. W.	78	88	90	85	76	73	82	76	73	75
Mink #109	800	820	820	920	930	980		980	970	
% I. W.	65	67	67	75	76	80	73	80	79	80
Mink #23	620	680	720	640	660	660		680	630	
% I. W.	84	82	97	87	89	89	91	92	85	89
Mink #17	540	580	600	600	580	580		560	540	
% I. W.	80	85	88	88	85	85	86	82	80	81
Group Average % Initial Wt.	80	84	88	87	83	82	85	82	79	81

* Diet: - Basal Ration II supplemented with:
Period 2:
0.2% dl-Methionine
1.0% Merck's APF Supplement
Period 3:
10.0% Crude casein

TABLE 22

WEEKLY WEIGHTS OF MINK IN GROUP TWO*
(Given in Grams and Percent Initial Weight)
(1/1/50 to 2/18/50)

Time in Weeks		1	2	3	4	5	Average Percent Initial Weight for Period	1	2	Average Percent Initial Weight for Period
	Starting Weight	Period 2						Period 3		
Mink #7	590	580	660	600	620	660		660	590	
% I. W.	91	89	101	92	95	101	96	101	91	96
Mink #105	900	880	1000	960	1020	1080		1040	1050	
% I. W.	86	81	93	89	95	100	92	96	97	96
Mink #26	640	620	720	640	620	660		640	660	
% I. W.	78	76	88	78	76	80	80	78	80	79
Mink #113	800	840	940	920	880	880		980	910	
% I. W.	86	79	89	87	83	83	84	92	86	89
Mink #24	640	680	760	720	720	720		720	670	
% I. W.	86	92	103	97	97	97	97	97	91	94
Mink #19	560	620	720	620	540	560		620	480	
% I. W.	90	100	116	100	87	90	99	84	77	81
Group Average % Initial Wt.	84	86	98	91	89	92	91	91	87	89

* Diet: - Basal Ration II supplemented with:
Period 2:
0.2% dl-Methionine
2.5% Tomato puree
1.0% Merck's APF supplement
Period 3:
10.0% Crude Casein

TABLE 23

WEEKLY WEIGHTS OF MINK IN GROUP THREE*
(Given in Grams and Percent Initial Weight)
(1/1/50 to 2/18/50)

Time in Weeks		1	2	3	4	5	Average Percent	1	2	Average Percent
	Starting Weight	Period 2					Initial Weight for Period	Period 3		Initial Weight for Period
Mink #6	640	620	680	640	620	620		620	600	
% I. W.	103	100	110	103	100	100	103	100	97	98
Mink #106	860	920	1000	950	920	960		830	770	
% I. W.	78	84	91	86	84	87	86	73	70	72
Mink #28	720	770	780	760	740	760		760	700	
% I. W.	87	93	95	92	90	92	92	92	85	88
Mink #115	860	920	1080	1100	1160	1220		1200	1270	
% I. W.	76	82	96	98	103	108	97	107	113	110
Mink #18	680	760	780	750	680	680		700	660	
% I. W.	94	105	108	104	95	95	101	97	92	94
Mink #21	580	660	660	620	580	640		600	630	
% I. W.	90	103	103	97	91	100	99	94	98	96
Group Average % Initial Wt.	88	94	100	97	94	97	96	94	94	94

* Diet: - Basal Ration II supplemented with:
Period 2:
0.2% dl-Methionine
2.5% Tomato puree
0.5% Beef Extract
1.0% Merck's APF supplement
Period 3:
10.0% Crude casein

TABLE 24

WEEKLY WEIGHTS OF MINK IN GROUP FOUR*
(Given in Grams and Percent Initial Weight)
(1/1/50 to 2/18/50)

Time in Weeks		1	2	3	4	5	Average Percent	1	2	Average Percent
	Starting Weight	Period 2					Initial Weight for Period	Period 3		Initial Weight for Period
Mink #5	640	680	760	720	720	740		700	820	
% I. W.	101	108	120	114	114	118	115	111	130	120
Mink #107	740	740	780	740	680	640		560	680	
% I. W.	62	62	65	62	57	53	60	47	57	52
Mink #15	740	800	880	840	780	740		720	850	
% I. W.	94	95	105	100	93	88	96	86	101	94
Mink #116	900	920	1020	940	880	880		660	900	
% I. W.	64	66	73	67	63	63	66	47	64	55
Mink #20	560	540	620	620	640	640		640	760	
% I. W.	82	79	91	91	94	94	90	94	112	103
Group Average % Initial Wt.	79	82	91	87	84	83	85	77	93	85

*Diet: - Period 2:
Basal Ration II plus 1.0% Merck's APF Supplement
Period 3:
Ranch Ration

TABLE 25

WEEKLY WEIGHTS OF MINK IN CONTROL GROUP*
(Given in Grams and Percent Initial Weight)
(1/1/50 to 2/18/50)

Time in Weeks		1	2	3	4	5	Average Percent	1	2	Average Percent
	Starting Weight	Period 2					Initial Weight for Period	Period 3		Initial Weight for Period
Mink #3	860	880	960	920	900	900		920	980	
% I. W.	108	110	120	115	112	112	114	115	122	118
Mink #102	1560	1500	1600	1650	1630	1600		1540	1550	
% I. W.	132	127	135	140	138	135	135	130	131	130
Mink #10	800	800	820	740	750	780		760	870	
% I. W.	114	114	117	106	107	111	111	108	124	116
Mink #111	1120	1160	1260	1380	1360	1400		1360	1440	
% I. W.	106	109	119	130	128	132	124	128	136	132
Mink #13	720	740	820	730	760	780		760	810	
% I. W.	109	112	124	111	115	118	116	115	121	118
Mink #14	800	780	840	820	830	800		830	800	
% I. W.	133	130	140	137	138	133	136	138	133	135
Group Average % Initial Wt.	117	117	126	125	125	126	124	124	129	125

*Diet: - Ranch ration.

TABLE 26

A COMPARISON OF THE AVERAGE PERCENT INITIAL WEIGHT MAINTAINED BY GROUPS ON VARIED RATION TREATMENTS (1/1/50 to 2/18/50)

Time in Weeks		1	2	3	4	5	Average Percent Initial Weight for Period	1	2
	Starting Weight	Period 2						Period 3	
Control Group	117	117	126	125	125	126	125	124	129
Basal Group	78	80	91	85	76	77	82	77	92*
Group One	80	84	88	87	83	82	83	82	79
Group Two	84	86	98	91	89	92	91	91	87
Group Three	88	94	100	97	94	97	96	94	94
Group Four	79	82	91	87	84	83	85	77	93

*Increase due to death of lightest mink.

VII. FEEDING TRIAL III

Methods and Procedures

In an effort to correct deficiencies contributing to the failure of Basal Ration II to support optimum maintenance of adult mink, Basal Ration III was formulated (Table 4). The outstanding changes were in the direction of improved protein quality and increased vitamin content. Powdered skim milk was increased 5 per cent (from 10 to 15 per cent) at the expense of the soybean oil meal. Lederle's "Fortafeed 2-49C" and "Parve" supplied increased levels of riboflavin, pantothenic acid, niacin, choline, and folic acid. To counteract a vegetable protein deficiency, crystalline methionine was added to the basal ration, despite its past failure to induce a detectable response. Rice Crispies replaced the shredded wheat and corn flakes of Basal Ration II. The addition of sodium chloride to the ration was discontinued.

The dietary treatments of Feeding Trial II were terminated and new treatments initiated without a gradual transition. The animal groupings were continued unchanged.

The initial three weeks of Feeding Trial III were designed to disclose any improvement effected in Basal Ration III over Basal Ration II and to continue to test the value of casein and vitamin B_{12} as a supplement. The Control Group and one group on Basal Ration II were continued without change. Three groups were changed to Basal Ration III from Basal Ration II plus 10 per cent casein. Basal Ration III was substituted in the Basal Ration II - APF modification received by Group

Four and Pair B of Group Six. Pair A of Group Six was continued on the basal ration - casein modification with Basal Ration III replacing the previous basal ration.

At the end of the third week, it was felt some measure of the ability of the animals to respond to a favorable dietary situation should be determined in view of prolonged previous severe and differing nutritional stresses. This would allow a comparison of response potential inherent in groups on different dietary treatments. It was also hoped this would tend to standardize the nutritional plane among the groups. Accordingly, at the beginning of the fourth week, all groups excepting the Control Group were given a ration consisting of equal parts horse meat and Basal Ration III.

After one week of the above mentioned recovery and standardization period, the second phase of the feeding trial was introduced. Its purpose was to determine the effect of adding horse meat, two levels of fresh liver, vitamin B_{12}, and casein on the value of Basal Ration III as a mink feed. The animal groupings were continued unchanged. The Control Group continued to receive the control ration. Each of the animal groups received one of the following additions to the basal ration: 50 per cent horse meat; 20 per cent fresh liver; 10 per cent fresh liver; 20 per cent fresh liver plus 1 per cent Merck's APF Supplement; 40 per cent horse meat plus 10 per cent fresh liver; 20 per cent fresh liver plus 10 per cent crude casein; and 20 per cent fresh liver plus 10 per cent crude casein plus 1 per cent Merck's APF Supplement. These treatments were continued for seven weeks at which time whelping rendered it inadvisable to continue the

weighing of the females.

The whelping females were eliminated from further dietary modifications but the groupings were maintained and new treatments initialed with the available mink. Some of the existing supplementations were discontinued to allow a comparison of the effects of addition and deletion. Other supplementations were replaced in an effort to determine the effective principle inherent in the original supplement. A short term trial was made with soybean oil meal replacing 50 per cent of the ration in the hope such an extreme level would give clearcut results on its palatability and digestibility.

During the last two weeks of this final seven week period, all groups except the control were placed on a recovery ration consisting of equal parts Basal Ration III and horse meat.

Phase I

Table 27 shows the four animals of Group One, continued on Basal Ration II, to exhibit a uniform weight loss most severe in the first week but continuing steadily through the third week. During the fourth week, the recovery ration effected a return to the starting weight.

Tables 28, 29 and 31 tabulate the weights of the animals in Groups Two, Three, and Five, changed from Basal Ration II plus 10 per cent crude casein to Basal Ration III. A moderate weight loss similar among individuals and groups, is shown to occur during the first three weeks. The recovery ration, fed during the fourth week, resulted in a recovery of lost body weight.

The weights of the animals comprising Group Four in which Basal Ration III

plus APF replaced Basal Ration II plus APF, are given on Table 30. The mean weight loss here is very slight, but a variation from 79 to 106 per cent of the starting weight is displayed among the individuals of the group at the end of the third week. The recovery ration resulted in a gain by all animals, but again considerable variation is noted in individual response.

Table 32 gives the weights of animals comprising Pair A and B of Group Six, following the substitution of Basal Ration III for Basal II. Both animals of Pair A on the 10 per cent casein supplement, are shown to exhibit a slight weight increase during the first three weeks followed by a moderate increase during the week of the recovery ration. The two animals of Pair B, receiving 1 per cent Merck's APF Supplement in addition to the casein, are unlike in their response. Mink #114 displayed a mild, steady weight loss during the first three weeks and a slight weight increase after the recovery ration - a response typical of the pattern set by the other groups. Mink #1 gained slightly the first week, maintained weight during the second, and lost slightly the third. The recovery ration did not yield a weight increase; instead, a further moderate weight loss resulted.

Table 33 gives the weekly average weights for animals of the Control Group. The consistent weight decline resulted from a purposely restricted food intake to reduce body weight to the level believed to be best for reproduction.

A tabulated comparison of group average weight changes in terms of per cent of the starting weight is given on Table 34 and a graphic representation

is made on Figure III.

It is readily apparent that the introduction of the new basal ration did not result in a marked body weight increase except in the case of Pair A. Levels were, however, markedly above the group continued on Basal Ration II, in which a more marked and consistent weight decline is noted.

An indication of the effect of casein supplementation should be supplied by a comparison of the response of Groups Two, Three, and Five in which casein supplementation was discontinued, and Pair A and B of Group Six in which casein supplementation was continued.

The first mentioned three groups demonstrated a similar response to the diet change. The initial weight loss following the elimination of the casein is felt to be indicative of its past beneficial effect. Although the accompanying change in basal rations makes the response less specific, it would seem likely the depression below the level of comparative groups could be attributed to an additive effect resulting from the deletion of the casein. The weight gain exhibited by Pair A - the most clearcut evidence of ration improvement - would tend to attribute a stimulating effect to the casein combined with an improved basal ration. This is not borne out by the typical response shown by Pair B to a diet identical except for the addition of 1 per cent Merck's APF Supplement. This pair departed from the pattern established by the other groups by maintaining body weight during the first two weeks but failing to respond to the recovery ration. In fact, a mild weight depression followed the addition of meat to the basal ration. This could not be attributed to the presence in the supplemented basal ration of the weight stimulating factor

present in the meat for both animals were losing weight at the time of initiation of the recovery ration. Furthermore, it would seem inconceivable that the APF supplement could suppress an existing favorable response to the casein. Table 32 shows that most of the aberrant response is attributable to one mink of the pair, and in view of the limited number of animals, no conclusions can be made. It would seem that this discrepancy could be well attributable to individual variation.

Group Four, continued on an APF supplemented ration, displayed a weight pattern differing from those receiving the unsupplemented Basal Ration III only in a reduced weight loss in the first week and in the variability of response of the animals comprising the group.

Results from the first phase of Feeding Trial III would seem to indicate a Basal Ration III to be an improvement on the preceeding basal ration. Casein would seem to be the most effective non-fresh meat supplement attempted as evinced by weight loss when removed and improved performance when added. The effect of the addition of vitamin B_{12} and antibiotics in the form of Merck's APF Supplement was not clearly demonstrated. It would seem that any existing effect tended to depress body weight. Basal Ration III, when supplemented with a high level of fresh meat, was more effective in producing weight gain than when fed alone or with the supplementation introduced.

TABLE 27

WEEKLY WEIGHTS OF MINK IN GROUP ONE*
(Given in Grams and Percent Initial Weight)
(2/18/50 to 3/18/50)

Time in Weeks		1	2	3	4	Average Percent Initial Weight for Period
	Initial Weight					
Mink #27	780	720	700	680	770	
% I. W.		92	90	87	99	92
Mink #12	610	570	580	560	580	
% I. W.		93	95	92	95	94
Mink #2	680	600	580	550	640	
% I. W.		88	85	81	94	87
Mink #103	1000	980	980	940	1050	
% I. W.		98	98	94	105	99
Mink #108	1210	1200	1140	1120	1270	
% I. W.		99	94	92	105	97
Group Average % Initial Wt.		94	92	89	100	99

*Diet: - Continued on Basal Ration II
4th week - Basal III plus 50% horse meat

TABLE 28

WEEKLY WEIGHTS OF MINK IN GROUP TWO*
(Given in Grams and Percent Initial Weight)
(2/18/50 to 3/18/50)

Time in Weeks		1	2	3	4	Average Percent Initial Weight for Period
	Initial Weight					
Mink #26	660	520	640	540	580	
% I. W.		79	97	82	88	86
Mink #24	670	600	640	620	700	
% I. W.		89	95	92	104	95
Mink #7	590	520	580	540	640	
% I. W.		88	98	91	108	96
Mink #105	1050	960	920	900	940	
% I. W.		91	88	86	90	89
Mink #113	910	840	900	870	930	
% I. W.		92	99	96	102	97
Group Average % Initial Wt.						

*Diet: - Changed from Basal Ration II plus 10% casein to Basal Ration III at start of period.
4th week - Basal Ration III plus 50% horse meat

TABLE 29

WEEKLY WEIGHTS OF MINK IN GROUP THREE*
(Given in Grams and Percent Initial Weight)
(2/18/50 to 3/18/50)

Time in Weeks		1	2	3	4	Average Percent Initial Weight for Period
	Initial Weight					
Mink #28	700	620	700	630	760	
% I. W.		88	100	90	108	96
Mink #18	660	670	720	600	660	
% I. W.		101	109	91	100	100
Mink #21	630	580	580	540	600	
% I. W.		92	92	86	95	91
Mink #6	600	520	520	560	620	
% I. W.		87	87	93	103	92
Mink #106	770	730	780	800	920	
% I. W.		95	101	104	119	105
Mink #115	1270	1200	1150	1160	1260	
% I. W.		94	90	91	99	93
Group Average % Initial Wt.		93	96	92	104	96

*Diet: - Changed from Basal Ration II plus 10% crude casein to Basal Ration III at start of period.
4th week - Basal Ration III plus 50% horse meat.

TABLE 30

WEEKLY WEIGHTS OF MINK IN GROUP FOUR*
(Given in Grams and Percent Initial Weight)
(2/18/50 to 3/18/50)

Time in Weeks		1	2	3	4	Average Percent Initial Weight for Period
	Initial Weight					
Mink #15	740	740	740	700	760	
% I. W.		100	100	94	103	99
Mink #20	640	680	740	680	780	
% I. W.		106	116	106	122	112
Mink #30	740	680	700	700	720	
% I. W.		92	94	94	97	94
Mink #6	740	720	780	740	800	
% I. W.		97	105	100	108	102
Mink #116	880	750	800	700	800	
% I. W.		85	91	79	91	86
Group Average % Initial Wt.		96	101	95	104	99

*Diet: - Changed from Basal II plus 1% Merck's APF Supplement to Basal III plus 1% Merck's APF Supplement at start of period.
4th week - Basal Ration III plus 50% horse meat.

TABLE 31

WEEKLY WEIGHTS OF MINK IN GROUP FIVE*
(Given in Grams and Percent Initial Weight)
(2/18/50 to 3/18/50)

Time in Weeks		1	2	3	4	Average Percent Initial Weight for Period
	Initial Weight					
Mink #23	630	550	600	540	620	
% I. W.		87	95	86	98	91
Mink #17	540	480	480	460	560	
% I. W.		89	89	85	104	92
Mink #101	950	900	900	940	940	
% I. W.		95	95	99	99	97
Mink #109	970	880	940	940	1070	
% I. W.		91	97	97	110	99
Group Average % Initial Wt.		90	94	92	103	95

*Diet:- Changed from Basal II plus 10% crude casein to Basal III at start of period.
4th week - Basal III plus 50% horse meat.

TABLE 32

WEEKLY WEIGHTS OF MINK IN GROUP SIX*
(Given in Grams and Percent Initial Weight)
(2/18/50 to 3/18/50)

Time in Weeks		1	2	3	4	Average Percent Initial Weight for Period
	Initial Weight					
Pair A						
Mink #117	1240	1220	1280	1320	1380	
% I. W.		98	103	106	111	104
Mink #110	840	800	849	860	920	
% I. W.		95	100	102	109	101
Pair A Average % Initial Wt.		97	102	104	110	102
Pair B						
Mink #114	1300	1240	1250	1160	1220	
% I. W.		95	96	89	94	93
Mink #1	750	780	780	740	680	
% I. W.		104	104	99	91	99
Pair B Average % Initial Wt.		100	100	94	93	96

*Diet: - Pair 'A'
Changed from Basal Ration II plus 10% crude casein to Basal Ration III plus 10% crude casein at start of period.

Pair 'B'
Identical with Pair 'A' with an added 1% Merck's APF Supplement.

TABLE 33

WEEKLY WEIGHTS OF MINK IN CONTROL GROUP*
(Given in Grams and Percent Initial Weight)
(2/18/50 to 3/18/50)

Time in Weeks		1	2	3	4	Average Percent Initial Weight for Period.
	Initial Weight					
Mink #10	870	800	760	750	780	
% I. W.		92	87	86	90	89
Mink #13	810	800	760	720	700	
% I. W.		99	94	89	86	92
Mink #14	800	800	760	730	720	
% I. W.		100	95	91	90	94
Mink #3	980	870	880	840	840	
% I. W.		89	90	86	86	88
Mink #102	1550	1500	1540	1460	1460	
% I. W.		97	99	94	94	96
Mink #111	1440	1400	1460	1350	1360	
% I. W.		97	101	94	94	96
Group Average % Initial Wt.		96	94	90	90	93

*Diet: - Control Ration

TABLE 34

FEEDING TRIAL III

A COMPARISON OF THE AVERAGE PERCENT INITIAL WEIGHT MAINTAINED BY GROUPS ON VARIED RATION TREATMENTS*
(2/18/50 to 3/18/50)

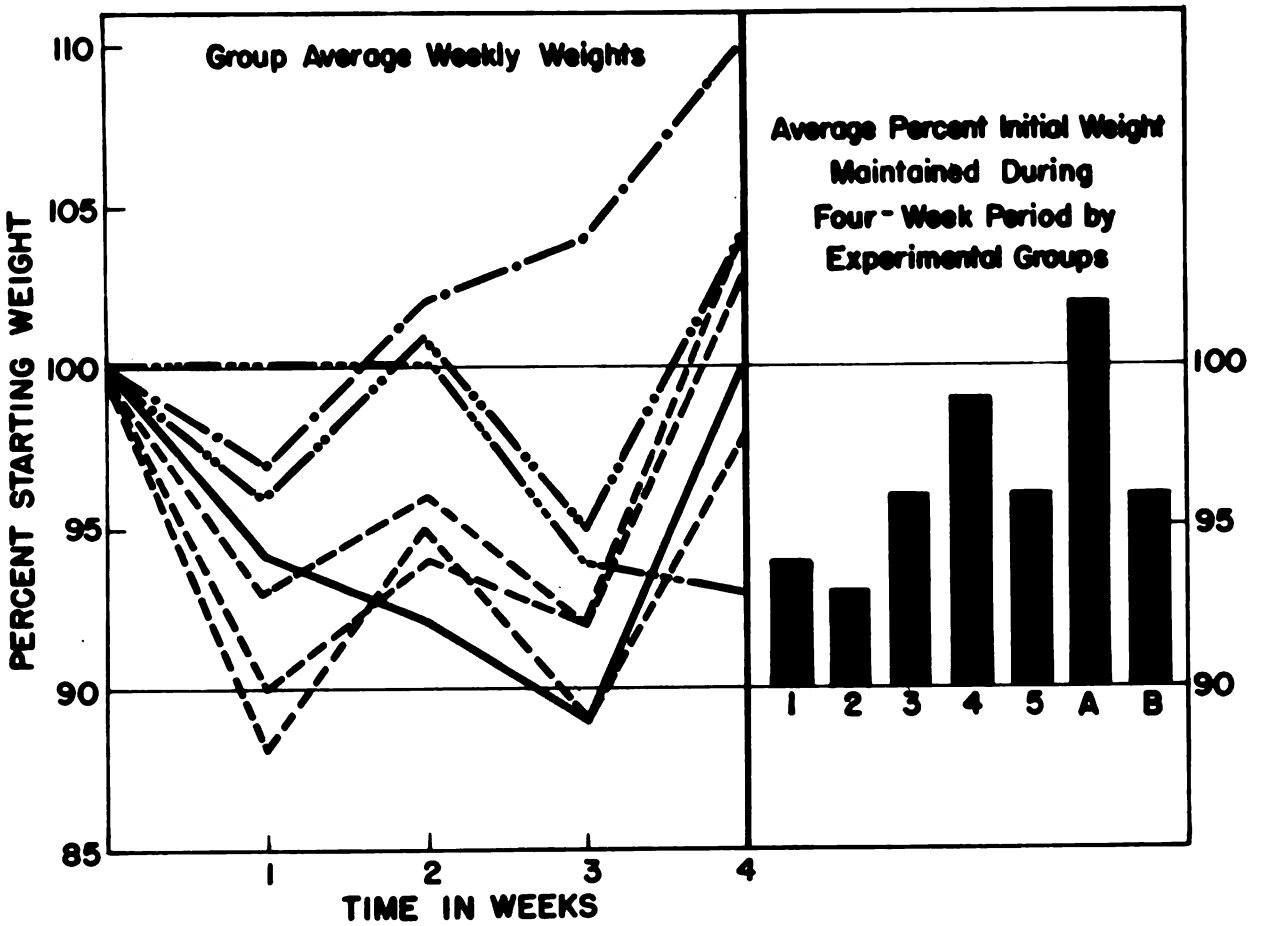
Time in Weeks	1	2	3	4	Average Percent Initial Weight for Period
Control Group	96	94	90	90	93
Group One	94	92	89	100	94
Group Two	88	95	89	98	93
Group Three	93	96	92	104	96
Group Four	96	101	96	104	99
Group Five	90	94	92	103	95
Group Six					
Pair A	97	102	104	110	102
Pair B	100	100	94	93	96

*Diets: - Control Group - Control Ration continued from previous period.
Group One - Basal Ration II continued from previous period.
Group Two - Changed from Basal Ration II plus 10% crude casein to Basal Ration III at start of period.
Group Three - Identical with Group Two.
Group Four - Changed from Basal Ration II plus 1% Merck's APF Supplement to Basal Ration III plus 1% Merck's APF Supplement at start of period.
Group Five - Identical with Group Two.
Group Six:
Pair 'A' - Changed from Basal Ration II plus 10% crude casein to Basal Ration III plus 10% crude casein at start of period.
Pair 'B' - Identical with Pair 'A' with an added 1% Merck's APF Supplement.

All groups changed to Basal Ration III plus 50% horse meat at end of 3rd week, except the Control Group.

FIGURE III

INFLUENCE OF RATION MODIFICATION ON BODY WEIGHT
2/18/50 to 3/18/50



———	Group One	Continued on Basal Ration II
- - - -	Gps 2,3 & 5	Basal Ration II ≠ casein to Basal Ration III
—·—	Pair A	Basal II ≠ casein to Basal III ≠ casein
—··—	Pair B	Basal II ≠ casein-APF to Basal III ≠ casein-APF
—··	Group Four	Basal II ≠ APF to Basal III ≠ APF

Phase II

Responses to the indicated dietary changes introduced during the second phase of the feeding trial are tabulated on Tables 35 through 42 inclusive, and graphically depicted on Figure IV. The responses are, in some instances at least, confused by variations attributable to reproduction. Especially is this noted in gravid females in the latter stages of gestation. Animals whelping shortly after the final weighing are indicated.

The equality of weight response in the Control Group and Group One would indicate the basal ration to be equal to the control ration when supplemented with an equal amount of horse meat.

The weight response of Group Five shows no ration improvement when 10 per cent of the 50 per cent meat supplement is replaced with fresh liver. Weight patterns observed in this group are similar and slightly lower than those of Group One.

Groups Two, Three, and Four are similar in their response. This would indicate little or no difference between a 10 or 20 per cent level of liver. Neither level resulted in a normal weight increase. The addition of 1 per cent Merck's APF Supplement again seemed to result in a mild depression of body weight.

The response to casein and liver as evaluated by Pair A of Group Six would certainly again indicate failure of the liver to replace the horse meat of the preceeding ration. However, even after the weight loss subsequent to the replacement of the horse meat with 10 per cent liver, the weights are within the limits of normalcy.

Any effect of APF on the casein and liver supplementation is not

demonstrated by Pair B. The two animals gave differing responses, the male in a manner similar to Pair A. The weight increase exhibited by the female would well be attributed to gestation for she whelped within seven days after the final weight.

Again Basal Ration III was shown to be fully equal to the Control Ration when supplemented with 50 per cent horse meat. Liver gave no indication of being superior to horse meat as a supplement. The moderate response resulting from liver supplementation would appear directly related to its ability to furnish the nutrient factors and palatability of fresh meat. Animal Protein Factor supplementation again tended to demonstrate a slight weight depressing action. Casein again gave some evidence of value as a supplement, although it was ineffective to prevent loss when 20 per cent liver was substituted for 50 per cent horse meat supplement.

TABLE 35

WEEKLY WEIGHTS OF MINK IN GROUP ONE*
(Given in Grams and Percent Initial Weight)
(3/18/50 to 5/6/50)

Time in Weeks		1	2	3	4	5	6	7	Average Percent Initial Weight for Period
	Initial Weight								
Mink #27	770	880	840	840	720	740	840	840	
% I. W.		114	109	109	93	96	109	109	106
Mink #12	580	600	600	640	620	600	740	780	
% I. W.		103	103	110	107	103	127	134	113**
Mink #2	640	700	760	820	760	820	900	880	
% I. W.		109	119	128	119	128	141	137	126
Mink #103	1050	980	1050	1080	980	930	1050	1020	
% I. W.		93	100	103	93	88	100	97	96
Mink #108	1270	1300	1340	1340	1280	1140	1200	1200	
% I. W.		102	105	105	101	90	94	94	99
Group Average % Initial Wt.		104	106	109	101	98	110	109	105

*Diet: - Basal Ration III plus 50% horse meat

** -Whelped within 7 days after weighing

TABLE 36

WEEKLY WEIGHTS OF MINK IN GROUP TWO*
(Given in Grams and Percent Initial Weight)
(3/18/50 to 5/6/50)

Time in Weeks		1	2	3	4	5	6	7	Average Percent Initial Weight for Period
	Initial Weight								
Mink #26	580	580	700	680	620	600	720	760	
% I. W.		100	121	117	107	103	124	131	115
Mink #24	700	700	740	720	640	600	740	820	
% I. W.		100	106	103	91	86	106	117	101
Mink #7	640	630	620	580	540	550	720	760	
% I. W.		98	97	91	84	86	112	119	98
Mink #105	940	950	980	980	920	880	960	980	
% I. W.		101	104	104	98	94	102	104	101
Mink #113	930	900	900	840	720	650	720	740	
% I. W.		97	97	90	77	70	77	79	84
Group Average % Initial Wt.		99	104	100	91	86	102	107	98

*Diet: - Basal Ration III plus 20% fresh liver

TABLE 37

WEEKLY WEIGHTS OF MINK IN GROUP THREE*
(Given in Grams and Percent Initial Weight)
3/18/50 to 5/6/50)

Time in Weeks		1	2	3	4	5	6	7	Average Percent Initial Weight for Period
	Initial Weight								
Mink #28	760	740	720	740	640	630	720	700	
% I. W.		97	95	97	84	83	95	92	92
Mink #18	660	680	720	620	540	530	700	740	
% I. W.		103	109	94	82	80	106	112	98
Mink #21	600	600	620	640	540	500	660	700	
% I. W.		100	102	107	90	83	110	117	101
Mink #6	620	630	640	760	550	580	700	700	
% I. W.		102	103	122	89	93	113	113	105
Mink #106	920	880	900	920	820	800	840	900	
% I. W.		96	98	100	89	87	91	98	94
Mink #115	1260	1200	1300	1220	1060	1020	1150	1160	
% I. W.		95	103	97	84	81	91	92	92
Group Average % Initial Wt.		98	102	102	86	84	99	102	96

*Diet: - Basal Ration III plus 10% fresh liver.

TABLE 38

WEEKLY WEIGHTS OF MINK IN GROUP FOUR*
(Given in Grams and Percent Initial Weight)
(3/18/50 to 5/6/50)

Time in Weeks		1	2	3	4	5	6	7	Average Percent Initial Weight for Period
	Initial Weight								
Mink #15	760	740	720	700	620	600	740	760	
% I. W.		97	95	92	82	79	97	100	92
Mink #20	780	740	740	700	500	600	680	660	
% I. W.		95	95	90	64	77	87	85	85
Mink #30	720	740	720	720	620	560	600	620	
% I. W.		103	100	100	86	78	83	86	91
Mink #5	800	740	760	760	660	700	800	800	
% I. W.		92	95	95	82	87	100	100	93
Mink #116	800	740	740	800	720	700	900	900	
% I. W.		92	92	100	90	87	112	112	98
Group Average % Initial Wt.		96	95	95	81	82	96	97	92

*Diet: - Basal III plus 20% fresh liver plus 1% Merck's APF Supplement

TABLE 39

WEEKLY WEIGHTS OF MINK IN GROUP FIVE*
(Given in Grams and Percent Initial Weight)
(3/18/50 to 5/6/50)

Time in Weeks		1	2	3	4	5	6	7	Average Percent Initial Weight for Period
	Initial Weight								
Mink #23	620	660	700	640	640	660	740	760	
% I. W.		106	113	103	103	106	119	122**	110
Mink #17	560	560	620	620	640	660	660	640	
% I. W.		100	111	111	114	118	118	114	112
Mink #101	940	1000	940	980	880	900	1000	1020	
% I. W.		106	100	104	94	96	106	108	102
Mink #109	1070	1120	1220	1140	1040	990	1100	1080	
% I. W.		105	112	106	97	92	103	101	102
Group Average % Initial Wt.		105	109	106	100	101	110	110	106

*Diet: - Basal Ration III plus 40% horse meat plus 10% fresh liver.

** Whelped within 7 days of last weighting.

TABLE 40

WEEKLY WEIGHTS OF MINK IN GROUP SIX*
(3/18/50 to 5/6/50)

Time in Weeks	Initial Weight	1	2	3	4	5	6	7	Average Percent Initial Weight for Period
Pair 'A'									
Mink #117	1380	1440	1420	1380	1200	1140	1220	1100	
% I. W.		104	103	100	87	83	88	80	92
Mink #110	920	940	880	780	680	800	740	800	
% I. W.		102	96	85	74	87	80	87	87
Pair 'A' Average % Initial Wt.		103	100	94	82	84	85	83	90
Pair 'B'									
Mink #114	1220	1200	1230	1100	960	1020	1040	1040	
% I. W.		98	101	90	79	84	85	85	89
Mink #1	680	800	790	820	780	900	960	1020	
% I. W.		118	116	120	115	132	141	150	127**
Pair 'B' Average % Initial Wt.		105	106	101	91	101	105	108	102

*Diet: - Pair 'A' - Basal III plus 20% fresh liver plus 10% crude casein.
Pair 'B' - Basal III plus 20% fresh liver plus 10% crude casein plus 1% Merck's APF Supplement.

TABLE 41

WEEKLY WEIGHTS OF MINK IN CONTROL GROUP*
(Given in Grams and Percent Initial Weight)
(3/18/50 to 5/6/50)

Time in Weeks		1	2	3	4	5	6	7	Average Percent Initial Weight for Period
	Initial Weight								
Mink #10	780	740	800	800	720	800	920	940	
% I. W.		95	102	102	92	102	118	120	105
Mink #13	700	740	720	780	680	700	700	740	
% I. W.		106	103	111	97	100	100	106	103
Mink #14	720	740	800	960	700	800	820	820	
% I. W.		103	111	133	97	111	114	114	112
Mink #3	840	860	900	900	840	960	1000	1100	
% I. W.		102	107	107	100	114	119	131	114**
Mink #102	1460	1400	1360	1320	1220	1300	1300	1200	
% I. W.		96	93	90	83	89	89	82	89
Mink #111	1360	1400	1360	1400	1240	1320	1320	1340	
% I. W.		103	100	103	91	97	97	98	98
Group Average % Initial Wt.		100	101	105	92	100	103	105	101

*Diet: - Continued on Control Ration from previous period.

** - Whelped within 7 days after weighing.

TABLE 42

A COMPARISON OF THE AVERAGE PERCENT INITIAL WEIGHT MAINTAINED BY GROUPS ON VARIED RATION TREATMENTS (3/18/50 to 5/6/50)

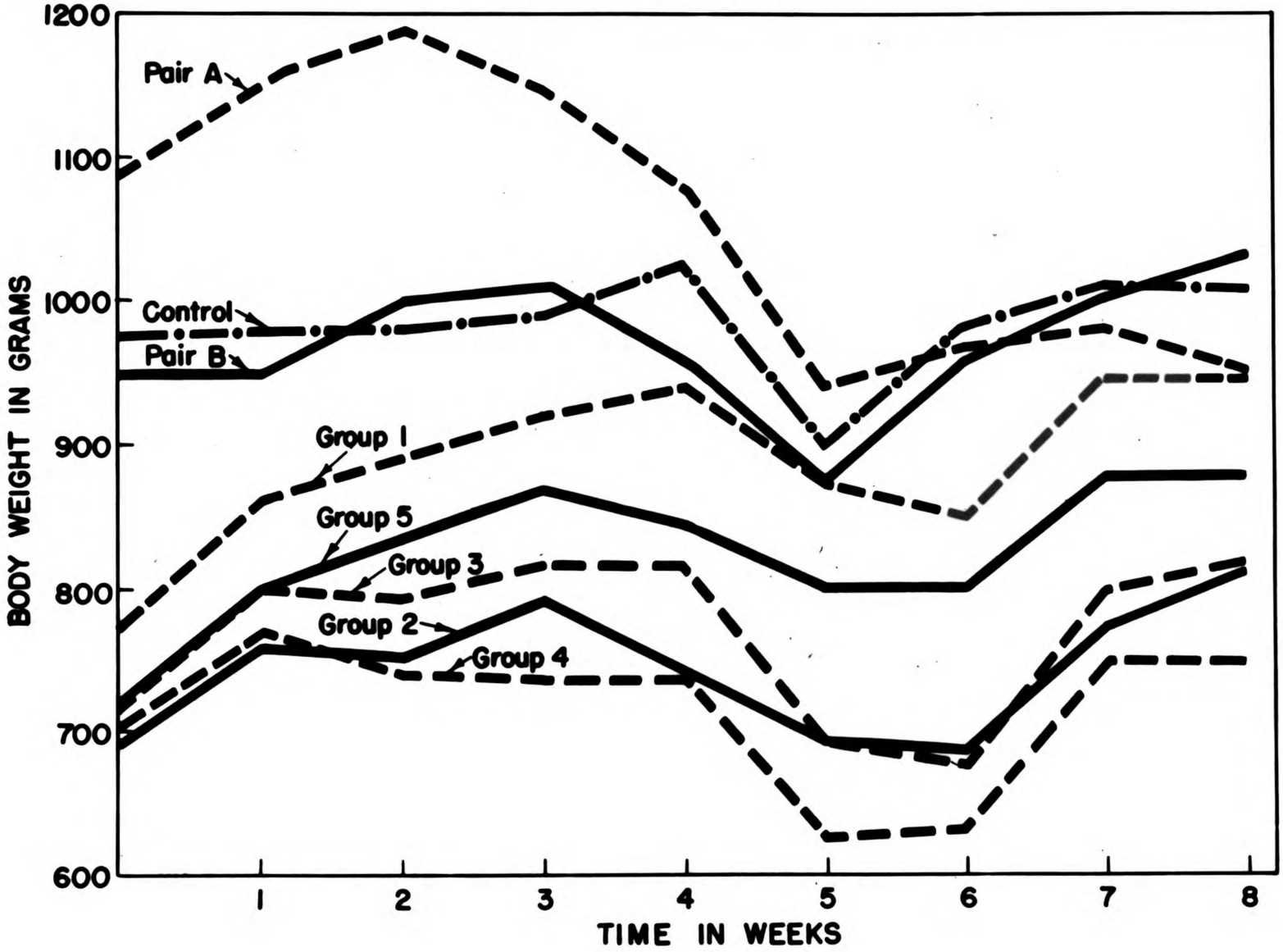
Time in Weeks	1	2	3	4	5	6	7	Average Percent Initial Weight for Period
Control Group	100	101	105	92	100	103	105	101*
Group One	104	106	109	101	98	110	109	105*
Group Two	99	104	100	91	86	102	107	98
Group Three	98	102	102	86	84	99	102	96
Group Four	96	95	95	81	82	96	97	92
Group Five	105	109	106	100	101	110	110	106*
Group Six								
Pair 'A'	103	100	94	82	84	85	83	90
Pair 'B'	105	106	101	91	101	105	108	102*

Diets: Control Group - Control Ration
Group One - Basal III plus 50% horse meat
Group Two - Basal III plus 20% fresh liver
Group Three - Basal III plus 10% fresh liver
Group Four - Basal III plus 20% fresh liver plus 1% Merck's APF Supplement
Group Five - Basal III plus 40% horse meat plus 10% fresh liver
Group Six
Pair 'A' - Basal III plus 20% fresh liver plus 10% crude casein
Pair 'B' - Basal III plus 20% fresh liver plus 10% crude casein plus 1% Merck's APF Supplement

*One female whelped within 7 days of last weighing

FIGURE IV

A COMPARISON OF ANIMAL WEIGHT VARIANCE IN RATION GROUPINGS
3/11/50 to 5/6/50



Phase III

At the end of the eleventh week of Feeding Trial III, dietary treatments were again readjusted. Groupings were no longer intact, due to the elimination of whelping and lactating females. The animals continued on experiment were left in the previous groupings to prevent the confusing influence of differing dietary history. The males and females are treated separately because of possible variation in response during reproduction.

The first three weeks shown on Table 43 indicate the weight response following an abrupt withdrawal of the supplementation of the previous period. The animals of Group Four, receiving Basal Ration III supplemented with 20 per cent liver and 1 per cent Merck's APF Supplement at the start of the period, are shown to display a weight loss. The three males of Group Six, receiving the 20 per cent liver and 10 per cent casein, demonstrate a similar weight decline.

The effect of the addition of an equal amount of soybean oil meal to the basal ration is shown in the second period of Table 43. Surprisingly, a markedly favorable response resulted in all animals. The response did not persist through the second week in the females of Group Four; however, the effect was generally more persisting in the males. Mink #6 died the day following the termination of the soybean oil meal supplement. The cause of death was determined to be pneumonia so could not be directly attributed to a dietary inadequacy. No degenerative changes in the organs was noted and adequate body fat was present.

Increased feed consumption observed during the time the soybean oil meal supplementation was in effect, is believed to be responsible for a part of the favorable response. This would indicate soybean oil meal to

be relatively acceptable to the mink.

The soybean oil meal supplementation was discontinued after two weeks and replaced with horse meat. The uniformly favorable response is indicated in the last two week period on Table 43. Again, increased food consumption was noted.

Table 44 compares the responses of non-whelping females to the indicated dietary treatments. Only initial and terminal weights are given for it was felt to be inadvisable to continue weekly weighings during the time when pregnancy was in doubt. Table 45 gives the same information for the males and weekly weights are reported. Corresponding groups of the two tables received identical dietary treatments. Separation was made only to segregate any sex variation.

The Control Group demonstrates the general weight decline, most evident in the females, normally observed during the first warm months. This is also apparent in Group One which was continued on the 50 per cent horse meat supplementation. Similarity of responses in the two groups would indicate a similar nutritional plane.

The weight loss incurred by both sexes in Group Two following the substitution of 1 per cent amino acid mixture for the 10 per cent liver, would indicate the failure of these amino acids to replace the liver. The male and female constituting Group Five show even greater weight loss following the substitution of the amino acid mixture for 40 per cent horse meat and 10 per cent liver.

The weight response of the males of Group Three (Table 45) indicate a 10 per cent casein supplement to be as effective as a 10 per cent liver supplement. A similar response is noted in one of the females (Table 44)

but the other is shown to lose markedly. This mink, however, is shown to be in a refractory state as evinced by her failure to respond favorably to the subsequent recovery ration.

The response to the recovery ration, Basal Ration III plus 50 per cent horse meat, is shown on Tables 44 and 45. The Control Group and Group One were continued unchanged, and little weight change is indicated. All other averages show a favorable response. There is little indication that any of the supplementations had either altered the ability of the animal to respond or seriously modified the nutritional plane.

The final phase of the feeding trial was handicapped by the small size and dissimilarity of groups. Interpretation of results was made difficult by the masking effect of weight variation normal in mink at this season. It was intended only to make the best possible use of the time and animals available to disclose the more obvious tendencies. For these reasons, no fine distinctions are attempted.

Liver at the 20 per cent level again demonstrated an ability to exert a favorable influence on the basal ration. Not, however, in the dramatic manner of a critical deficiency correction. Its role seemed to be that of any fresh meat ration ingredient. Casein at the 10 per cent level appeared to have an effect similar to liver at a like level.

A high-level supplementation with soybean oil meal resulted in the only markedly favorable response in the brief time alletted. It was noted that the meal seemed relatively palatable to the mink, increasing feed consumption.

Other supplementations failed to demonstrate a discernible effect. This does not negate their ability to influence the ration, but an influence less than critical is indicated.

TABLE 43

A WEIGHT COMPARISON OF ANIMALS ON VARIED RATION TREATMENTS
(Given in Grams and Percent Initial Weight)
(5/6/50 to 6/10/50)

Time in Weeks		1	2	3	Average Percent Initial Weight for Period	1	2	Average Percent Initial Weight for Period	1	2	Average Per-Cent Initial Weight for Period
	Initial Weight										
Group Four											
(Females)		Basal Ration III				Basal Ration III plus 50% Soybean Oilmeal			Basal Ration III plus 50% Horse Meat		
Mink #15	760	740	640	640		760	640		720	720	
% I. W.		97	84	84	88	100	84	92	95	95	95
Mink #30	620	480	480	540		540	500		600	620	
% I. W.		77	77	87	80	87	81	84	97	100	98
Mink #5	800	800	740	620		640	660**				
% I. W.		100	93	78	90	80	82	81**			
Average % Initial Wt.		91	85	83	86	89	82	86	96	97	97
(Males)											
Mink #116	900	860	900	800		820	900		1120	1140	
% I. W.		96	100	89	95	91	100	95	124	127	125
Group Six											
(Males)											
Mink #117	1100	1020	900	900		900	960		1020	1180	
% I. W.		93	82	82	86	82	87	85	93	107	100

TABLE 43 (Continued)

Time in Weeks	Initial Weight	1	2	3	Average Percent Initial Weight for Period	1	2	Average Percent Initial Weight for Period	1	2	Average Per-Cent Initial Weight for Period
		Basal Ration III				Basal Ration III plus 50% Soybean Oilmeal			Basal Ration III plus 50% Horse Meat		
Mink #110	800	820	800	780		800	900		900	960	
% I. W.		103	100	98	100	100	113	106	113	120	116
Mink #114	1040	1040	980	840		960	960		970	1100	
% I. W.		100	94	81	92	92	92	92	93	106	99
Average % Initial Wt.		99	92	87	93	91	97	94	100	111	105

**Death due to pneumonia. No degenerative changes. Well nourished with adequate body fat.

TABLE 44

A WEIGHT COMPARISON OF FEMALE MINK ON VARIED RATION TREATMENTS
(Given in Grams and Percent Initial Weight)
(5/6/50 to 6/24/50)

	Initial Weight	End of 5-Week Expmtl. Period	End of 2-Week Recovery Period
Control Group			
Mink #13	740	620	600
% I. W.		84	81
Mink #14	820	740	800
% I. W.		90	98
Average % Initial Wt.		87	89
Group One			
Mink #27	840	700	660
% I. W.		83	79
Mink #2	880	660	740
% I. W.		75	84
Average % Initial Wt.		79	81
Group Two			
Mink #26	760	580	660
% I. W.		76	87
Mink #24	820	660	640
% I. W.		80	78
Mink #7	760	540	600
% I. W.		71	79
Average % Initial Wt.		76	81
Group Three			
Mink #28	700	720	800
% I. W.		103	114
Mink #6	700	540	540
% I. W.		77	77
Average % Initial Wt.		90	95
Group Five			
Mink #17	640	500	460
% I. W.		78	72

TABLE 45

WEEKLY WEIGHTS OF MALE MINK ON EXPERIMENTAL RATION TREATMENTS
(Given in Grams and Percent Initial Weight)
(5/6/50 to 6/24/50)

Time in Weeks	Initial Weight	1	2	3	4	5	Average Percent Initial Weight for Period	1	2	Average Percent Initial Weight for Period
CONTROL GROUP			Ranch Ration					Ranch Ration		
Mink #102	1200	1220	1300	1200	1220	1040		1140	1040	
% I. W.		102	108	100	102	87	98	95	87	91
Mink #111	1340	1340	1300	1280	1360	1280		1240	1280	
% I. W.		100	97	96	101	96	98	93	96	95
Average % Initial Wt.		101	102	98	101	91	98	94	91	93
GROUP ONE			Basal III plus 50% horse meat					Basal III plus 50% horse meat		
Mink #103	1020	1080	1060	1000	1100	1080		1090	1120	
% I. W.		106	104	98	108	106	104	107	110	109
Mink #108	1200	1200	1180	1120	1180	1180		1190	1160	
% I. W.		100	98	93	98	98	97	99	97	98
Average % Initial Wt.		103	101	95	103	102	101	103	103	103

TABLE 45 (continued)

Time in Weeks	Initial Weight	1	2	3	4	5	Average Percent Initial Weight for Period	1	2	Average Percent Initial Weight for Period
GROUP TWO		Basal III plus Amino Acid Mix						Basal III plus 50% horse meat		
Mink #105	980	960	900	840	900	900		980	1000	
% I. W.		98	92	86	92	92	92	100	102	101
Mink #113	740	700	660	600	600	700		740	800	
% I. W.		95	89	81	81	94	88	100	108	104
Average % Initial Wt.		96	90	83	87	93	90	100	105	102
GROUP THREE		Basal III plus 10% casein						Basal III plus 50% horse meat		
Mink #106	900	940	800	840	760	840		800	920	
% I. W.		104	89	93	84	93	93	89	102	95
Mink #115	1160	1240	1180	1040	1000	1040		1060	1120	
% I. W.		107	102	90	86	90	95	91	97	94
Average % Initial Wt.		105	95	91	85	91	94	90	99	94
GROUP FIVE		Basal III plus Amino Acid Mix						Basal plus 50% horse meat		
Mink #101	1020	960	900	840	860	840		880	920	
% I. W.		94	88	82	84	82	86	87	90	88

VIII. OBSERVATIONS ON RESPONSES OTHER THAN BODY WEIGHT

Mention of morbidity and mortality has been intentionally omitted heretofore. Neither established a trend which could be attributed to any dietary treatment, with the exception of the increased mortality apparently resulting from the homogenized fish supplement in Feeding Trial I. Furthermore, it was believed impossible to attribute death to a particular dietary treatment when the same animals were subjected to a continuous series of varied, short term ration modifications. These factors were thought to be illustrative of the overall experimental period.

The total casualties during the three feeding trials numbered 16. Four animals died during Feeding Trial I; eight during the second feeding trial and four in the last. The pathology exhibited a similar pattern throughout. The terminal cause of death was typically inanition accompanied by, and probably resulting from, a severe gastro-enteritis, usually hemorrhagic. Typical parenchymal changes found at post mortem included severe fatty degeneration of the liver and renal damage. In some instances, signs of inanition were completely absent. Diseases and infections commonly occurring in mink were generally absent.

Reproduction was not reported in the foregoing. It occurs but once each year and, as previously pointed out, is dependent on many non-nutritional factors as well as past dietary treatment of undetermined duration.

Two mating seasons were encompassed in the period covered by this

work. In both, reproduction was sub-normal in both the control and experimental groupings - markedly so in the latter. Animals on the experimental treatments were found loath to mate and often barren and sterile. Normal reproductive ability, however, was demonstrated by both sexes on the mash type rations. Lactation was successful, although depressed.

All experimentally fed animals displayed a nervous restlessness and irritability. Feed consumption was erratic and subnormal when compared with the control group. The general lack of palatability of the basal rations was apparent.

A persistent diarrhea and excessive water consumption were the principal observable physiologic responses to the mash type rations.

Fur quality, although important, was not considered due to difficulties inherent in classification and the dependence of this characteristic on heredity.

IX. SUMMARY AND CONCLUSIONS

Considerable progress was made in approximating a fresh meat mink ration with a dry feed comprised of cereals, dessicated animal products, vegetable proteins, vitamin concentrates, and minerals. Successive improvements in protein quality, digestibility, and vitamin content resulted in a steadily improved animal response. The last and most successful basal ration was found to support subnormal growth and reproduction when fed alone. The rapid recovery and reproduction performance obtained from the addition of 50 per cent horse meat in Feeding Trial III would indicate normal growth and reproduction to be possible when the basal ration was supplemented with a level of meat considerably lower than in the control ration.

Efforts, through supplementation, to identify the critical fresh meat factors lacking in the dry mash rations, were generally ineffective. Results would indicate the shortcomings not to be vitamin in nature, for high levels of all known major vitamins, from natural and concentrated sources, failed to effect correction. Furthermore, liver, a rich source of vitamin and essential micro-nutrients, failed to yield a markedly favorable effect when fed at levels intended to minimize the fresh animal protein values. Fresh meat must be incorporated at levels far above those commonly associated with trace factor sources before corrective action is noted. Additional evidence against a vitamin deficiency is offered by the absence of any syndrome typical of an avitaminosis.

The favorable response to the excellent protein quality of casein would

indicate a minor part of the deficiency to be protein in nature. Amino acid supplementation disclosed the deficiency not to be in the three most likely amino acids, methionine, lysine, and tryptophane. Failure to effect complete correction indicated the critical deficiency to be elsewhere.

Absence of evidence for a specific nutrient deficiency, combined with the apparent adequacy of the experimental rations, would strongly indicate the principal fault to lie in the direction of palatability and digestibility. This is borne out by observations on feed consumption and fecal volume.

A successful continuance of work in this field would appear to be predicated on an improvement in the palatability of the dry ration. When satisfactory food consumption is achieved, the problem of improved digestibility will become of cardinal importance.

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