DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
DOMINION EXPERIMENTAL FARMS

EXPERIMENTAL FOX RANCH

SUMMERSIDE, P.E.I.

PROGRESS REPORT
OF THE SUPERINTENDENT

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FOR THE YEARS 1931, 1932, 1933 and 1934

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PROGRESS REPORT OF THE SUPERINTENDENT OF THE EXPERIMENTAL FOX RANCH, SUMMERSIDE, P.E.I.

INTRODUCTION

It has been deemed advisable to publish an account of the progress made up to the present on the main projects investigated at the Experimental Fox Ranch, so that fox breeders may have the benefit of the information secured and the recommendations deduced. It is not considered that a final conclusion has been reached with regard to any one project, and further investigation will be undertaken, as circumstances will permit, upon all the projects.

The research work has been divided into five main groups:—

Nutritional requirements of foxes.
Internal and external parasitic infestation.
Inheritance of the inherent traits of foxes.
Sundry physiological processes.
General ranching methods.

The nutritional problems have been attacked from five different angles:—

The influence of the different contents of the diet: protein, fat, vitamin, caloric value, etc.

Determination of the normal annual fur cycle, and the dietary factors that induce the most favourable results during the entire annual cycle.

Determination of the normal annual cycle of breeding foxes, and the dietary factors that induce the changes in a most natural manner.

The fitness of the seasonal nutritional and other environments of foxes in the wild state to meet the seasonal functions and the changes of foxes in captivity.

Disturbances due to the deficiencies in the diet, the so-called deficiency diseases.

As would be expected, the same results in the great majority of cases have been obtained from whichever angle the nutritional problems have been attacked. In the research work, it is absolutely necessary that each project should be considered individually, and there are many advantages in presenting them in that manner. It would be cumbersome to repeat the results obtained and the recommendations deduced in one project over and over again in all the other projects, where the same conclusions have been arrived at from studying the problems from other angles.

In discussing the different projects, in order to present the various points in a clear-cut and well defined manner, it has been necessary to make many repetitions, but as far as possible these have been reduced to a minimum. Hence, it becomes necessary to read the report as a whole, in order to fully grasp the work that has been done on each project. It would not only be very cumbersome, but would unduly increase the printing cost to present in this publication each project as a complete entity. Hence, when the press, journals, or other news agencies, are taking advantage of the opportunity of copying the contents of this report and reprinting different projects individually, where necessary, the attention of the readers should be referred to the results and recommendations in the other projects.

ACKNOWLEDGMENTS

The department wishes to express its thanks and appreciation to Mr. George A. Callbeck, President, Canadian National Silver Fox Breeders' Association, 1932-3-4, for his criticism and suggestions regarding the experimental work; also to Mr. George H. MacCallum, Secretary of that association, for his courteous co-operation and for the ready manner in which he placed many of the office facilities of the association at the disposal of the Experimental Fox Ranch.

PROJECT No. 1—MAINTENANCE OF SILVER FOXES IN CAPTIVITY

(a) Total Food Caloric Requirements and the Variation, if any, during the Different Seasons of the Year

The latest results of the work of the Experimental Fox Ranch indicate that, for worm-free foxes, the total caloric maintenance requirement is between ninety-five and one hundred calories per kilogram live weight, based on the minimum summer weight, and there is a very slight variation in that requirement during the entire year. The fact that the foxes lose weight during the summer months and gain during the fall months appears to be dependent upon the class of food. Also, the degree to which foxes gain weight in the fall months and lose weight during the summer months is dependent on the condition of the animal rather than on the amount of food.

The experimental work has demonstrated that the total caloric requirements are dependent on the body area of the foxes rather than on their live weight, and classifying the foxes according to their body length has proven to be more satisfactory than taking the live weight as the basis. The classification of the foxes according to body area can, for practical purposes, be obtained by measuring the foxes from the tip of the nose to the base of the tail, and, in the experimental work, only these measurements have been used for classifying the foxes according to their total food or caloric requirements. The measurements have been made in the following manner: The tip of the nose of the fox is placed against an upright board; the measurement from the board to the tip of the tail is taken, which gives the total length of the fox; the measuring stick is placed underneath the tail and the length of the tail is measured. The body length is obtained by subtracting the length of the tail from the total length.

The live weight of foxes may vary to the extent of fifty per cent or more during the different seasons of the year, but according to the results of the experimental work, the variation in the caloric requirements, if there is any, during the different seasons, is only very slight.

TABLE 1—TOTAL DAILY CALORIC REQUIREMENTS

Classification of fox	Body length of fox	Caloric value of daily ration
Small	Under 24 inches	360 calories
Medium	24 to 25 "	400 "
Large	25 to 26 "	460 "
Extra large	26 to 27 "	500 "
Super large	Over 27 "	550 "

RECOMMENDATIONS

Overfeeding is the great bugbear of silver fox ranching. The average fox breeder is losing money both ways; unnecessary amounts are fed, increasing the ranching cost; and the results become poorer, both from a fur and breeding standpoint, in proportion to the excessive amounts that are fed. The experimental work clearly demonstrates that the more the overfeeding, the worse will be the results. For fur production, for breeding results, or for gaining weight in the fall months, condition is the all-important factor. Continued overfeeding will invariably throw the foxes out of condition, and if, during the fall months or any other period of the year, the condition of the foxes would warrant the fox breeders increasing the amount above normal requirements, the overfeeding should not extend more than one week. The foxes should then

be returned to their normal rations, and if necessary, after a period of two weeks, they can be subjected to overfeeding for a period of one week, but fox breeders are warned against overfeeding for an extended period.

(b) Protein Requirements and the Variation, if any, During Different Seasons of the Year

The results indicate that the total protein requirements for foxes in captivity are approximately 1·25 grams of protein nitrogen per kilogram live weight (1·25 gm/N/KW) during the summer months, based on the minimum summer weight, 1·5 grams during September and the first part of October, and 1·75 grams during the latter part of October and during the months of November and December. The amount of protein in the daily rations during the respective seasons of the year should not exceed the amount given in the following table, 2.

TABLE 2—TOTAL PROTEIN REQUIREMENTS DURING THE DIFFERENT SEASONS OF THE YEAR FOR DIFFERENT SIZED FOXES

Foxes' size	Summer June 1 to Aug. 31	Early fall Sept 1 to Oct. 15	Late fall Oct. 16 to Dec. 31
	oz.	oz.	oz.
Small	1	1¼	1⅜
Medium	1¼	1⅜	1½
Large	1½	1⅝	1¾
Extra large	1⅝	1¾	1⅞
Super large	1¾	1⅞	2¼

Where large quantities of protein have been fed during the early fall months, there has been a premature and an overdevelopment of the underfur, the guard hairs being weak, and the fur open and streaky, going off colour with a tendency to rub long before the hide was prime. When relatively small quantities of protein have been fed during the early fall months, there has been very little growth of the underfur with a very favourable development of the guard hairs. After the guard hairs had developed and the cold weather had set in, and the protein content of the diet was increased about the middle of October, there was a most favourable development of the underfur, giving depth and volume to the fur.

The fur has a very high protein content and it would be expected for its development that large quantities of protein would be required, but the underfur comprises nearly ninety per cent of the fur by weight and the guard hairs a relatively small percentage. Large quantities of protein fed, therefore, during the initial stages of the development of the fur, will induce a premature development of the underfur at the expense of the guard hairs. On the other hand, when relatively small quantities of protein are fed during the initial stages of the development of the fur, there will be a favourable development of the guard hairs with a limited development of the underfur. The underfur should develop only when the real cold weather sets in during the late fall months. But the experimental work has demonstrated very clearly that proteins are required for the natural increase in weight and for the growth of the guard hairs during the early fall months. When the foxes made an average weekly gain of six ounces and more during the month of September, while they looked as if they were furring out in a favourable manner, the results later in the fall were most disappointing. Also, when the foxes were not gaining in weight or were losing

weight during the month of September, they did not become fully furred until late in the following year and it was not conducive to good breeding results When foxes make an average weekly gain of six ounces and more during the summer, an excessive amount of protein is being fed. On the other hand, when the foxes are not gaining in weight or losing weight during September, it is an indication that the rations do not contain sufficient protein for the normal development of the guard hairs. Foxes should gain weight during September, but the average weekly gain should not exceed three to four ounces.

It was also clearly demonstrated that large amounts of protein should not be fed to pregnant females. On the thirty-eighth day of the gestation period the foetus of a fox pup weighs about one-sixth of an ounce, so that with females carrying six pups, the total weight of the pups on the thirty-eighth day would be less than one ounce, which would contain less than one-quarter of an ounce of protein. Experiments indicate that the small amount of protein required for the development of the foetus should come from the maternal tissue rather than from the food the females are receiving. The most favourable results from a breeding standpoint have been obtained when pregnant females have been fed a sub-maintenance ration during the gestation period. On the other hand, most unfavourable results have been obtained when the pregnant females have been fed heavily. Where high protein rations have been fed, while there has been an average production of pups during the first year, in the subsequent years, when the high protein rations have been continued, the females have become sterile and the pups produced from females fed high protein diets failed to be continued breeders.

High meat rations, fed to the foxes after the 15th of October to the end of the year, have produced very good results. During this season of the year, high protein diets should be fed to foxes to induce a good development of the underfur and a proper growth of the guard hairs with regard to length. There appears to be a high protein requirement during the last stages of the development of the fur, much more so than during the initial stages.

RECOMMENDATIONS

Fox breeders are recommended to avoid feeding excessive amounts of protein during the summer months. A normal ration containing three to four ounces of meat will supply all the protein requirements. If at any time dried meat, fishmeal, or meatmeal be fed in place of meat, breeders are warned not to feed more than one ounce at the very most to individual foxes or pups during any one day. The meat content of the ration should be increased on the 1st of September to induce a proper growth of the fur during the initial stages and to promote a proper gain in weight during the fall months, but avoid feeding excessive amounts; over six or seven ounces will be liable to produce unfavourable results.

It appears imperative that the meat content of the ration should be increased at least by the 1st of September, and if the change is delayed until the end of the month, both the fur and the breeding qualities of the foxes will be jeopardized. A further increase is advised in the amount of meat that is fed daily, after the 15th of October, so as to induce a good depth and volume of the underfur and a continued growth in length of the guard hairs. After the females have mated, and throughout the entire gestation period, high protein rations should be avoided and the meat content of the daily rations should not exceed five to six ounces.

During the summer months, when it is desirable to feed low protein rations, the cereal portion of the ration should consist mostly of rice, which has a low protein content of approximately 7·5 per cent. During the fall months, wheat, oats, and other products having a higher protein content, from 12 to 15 per cent, should form the chief portion of the cereal content of the ration.

(c) Total Nitrogen Output During Starvation

(J. C. Jack, *Animal Physiologist*)

Determinations of the daily nitrogen output in the urine and feces of a male fox were made during two separate periods, each of seven days duration, and in those of a vixen for a period of nine days. During each period, each fox was kept in a metabolism cage without food, but distilled water was before the animal at all times. The results for the last five days of each starvation period were found to be consistent, and they indicated a total daily nitrogen output of 0·4 gram per kilogram live weight, approximately 90 per cent being excreted in the urine and 10 per cent in the feces.

During starvation, the fox depends solely upon his tissues for his supply of protein. Scientific research in other animals has shown that, in order to maintain the nitrogen balance, an animal requires somewhat more protein in its daily food than is indicated by the nitrogen output during starvation. Furthermore, scientific research has shown that the nearness with which the total protein of the diet, during nitrogen balance, approximates the total protein used during starvation depends upon the quality of the proteins included in the diet. The quality of a protein is in turn dependent upon its amino-acid content and is also relative to the animal consuming the protein. Therefore, in order to produce a diet for the fox, the total protein of which would maintain nitrogen balance and yet very closely approximate in quantity that used during starvation, only proteins containing amino-acids strictly essential for the fox could be included, and inessential amino-acids would necessarily be excluded. The difficulties attending such a procedure are solved in practice by using mixed diets containing a wide variety of proteins. Consequently this requires the use of much more protein than is indicated by the nitrogen output during starvation, but nevertheless the inclusion of a wide variety of proteins in a practical diet ensures the fox against depletion of essential protein and amino-acid reserves.

PROJECT No. 2—VITAMIN REQUIREMENTS OF SILVER FOXES IN CAPTIVITY

(a) Vitamin Requirements During the Summer Months

Vitamins A and D.—When substances rich in vitamins A and D were fed during the summer months, the fur became very dry and had a tendency to mat, which interfered to a very marked extent with the proper shedding of the fur; while the fur appeared dead, it still adhered tightly to the body. The most unfavourable influence was the production of a pronounced brown shade which invariably followed the feeding of these substances when the new fur developed in the fall months. There does not appear to be a large requirement for the fat soluble vitamins A and D during the summer months.

Vitamin B.—Foxes are very susceptible to different forms of dermatitis; the skin is very liable to become very dry and scaly and there is evidence that under certain circumstances an irritable condition is set up which causes the foxes to chew their tails and the fur on the other parts of the body. It is a well established fact that vitamin B will counteract dermatitis with a large number of different experimental animals. From our experimental work this appears to hold true with regard to foxes in captivity. Supplementing the rations with vitamin B has led to a more favourable condition in the skin and the foxes have been less inclined to chew their tips and the fur on the other parts of the body.

During the summer months foxes are also very susceptible to fits and convulsions, particularly the growing pups. When the rations of the growing pups were not supplemented with vitamin B, fits and convulsions occurred, but when

yeast was added the foxes were free of fits and convulsions. Some breeders have reported that in previous years their foxes have been very susceptible to fits and convulsions, and at one time or other during the summer practically all the pups in the ranch would suffer from these ailments; but since following the recommendations of the Experimental Fox Ranch and supplementing the rations with yeast and bonemeal, they have had no further trouble whatever in that respect. The experimental work would indicate that it is absolutely necessary that the rations during the summer months should be supplemented with vitamin B.

Vitamin C.—In the experimental work, when grass and other green vegetables, rich in vitamin C, have been fed during the summer months, the foxes have maintained a healthy and vigorous condition and have shed the fur in a most favourable manner; also, the foxes have not been subject to jaundice which occurred with those fed diets deficient in vegetables. The most important rôle in feeding green vegetables during the summer months has been the influence on the new-born pups produced in the subsequent breeding season. Foxes fed rations during the summer and fall months deficient in vitamin C produced pups the subsequent breeding season the majority of which showed very pronounced symptoms of infantile scurvy, and there were numerous deaths among the new-born pups. On the other hand, when the foxes were fed relatively large quantities of green vegetables during the summer and fall months, the pups produced were entirely free of infantile scurvy, and there were very few fatalities at birth.* The results of the experimental work indicate that supplementing the rations during the summer months with vitamin C in the form of vegetables is one of the important factors in ranching foxes in captivity.

RECOMMENDATIONS

Fox breeders are warned to rigidly avoid the feeding of cod liver oil, fat meat, or excessive quantities of milk during the summer months, as they will materially affect the shedding of the fur and cause it to tightly adhere to the body, besides having a very unfavourable effect on the fur as it develops during the late summer months. These substances, when fed during the summer months, will induce a pronounced brown shade in the new fur.

It is advisable that yeast and other substances, rich in vitamin B, should be fed throughout the entire summer months to ward off the occurrence of fits and convulsions, and to promote a healthy condition of the skin. Breeders are recommended to feed daily, throughout the summer months, one-eighth of an ounce of either fresh yeast or dried brewer's yeast.†

It is most important that the rations should be supplemented with green vegetables during the summer months, and in this respect ground green grass, when the grass is making a luxurious growth, is a very good source of vitamin C. It is recommended to feed ground green grass or some other green vegetation daily to all the adult foxes and pups, a quarter of an ounce at each meal when the foxes are fed twice a day, or half an ounce at one meal when the foxes are fed once a day. Not only will this supply the vitamin C requirement, but it is an ideal roughage that will lead to a better digestion of the food as a whole. Experiments indicate that it is imperative to add at least one-quarter of an ounce of ground green grass or some other ground green vegetable to each meal throughout the summer months, not only to lead to a better digestion of the

* 1. Pages 40-43, Report of the Superintendent, Experimental Fox Ranch, Summerside, P.E.I., Dominion Experimental Farms, Department of Agriculture.

† There is now on the market dried brewer's yeast, which is sold at ten cents per pound in twenty-five pound bags, or eight cents per pound in hundred pound bags. This forms a favourable medium for supplementing the rations with vitamin B.

food, but to guard against bloating. In recent years, of the deaths referred to this ranch, those from bloating far outnumbered those from all other causes.

Breeders are warned not to feed cornmeal, wheat germ, or excessive amounts of whole wheat flour during the summer months, as they will not be conducive to good results with regard to the shedding of the fur, and are liable to lead to severe digestive disturbances.

(b) Vitamin Requirements During the Fall Months

Vitamins A and D.—When cod liver oil, cod liver oil meal, fats, excessive quantities of milk and other substances, rich in the vitamins A and D, have been fed during the fall months, they have invariably led to unfavourable results with regard to the development of the fur. These vitamins, when fed during the fall months, not only cause the cuticle of the hairs to become overprime early in the fall, but retard the development of the black pigment so that the fur not only acquires a brown shade through the cuticle becoming overprime and going off colour, but the brown shade becomes more pronounced owing to the lack of the black pigment to mask the colour of the cell walls. The tendency has been the same where the foxes have been kept in either open pens or in covered sheds, but not to the same degree in covered sheds; however, cod liver oil and other substances, rich in the vitamins A and D, have produced an unfavourable influence on the fur when foxes have been kept in covered sheds. As regards the development of the fur, so far the most favourable results have been obtained when rations with a relatively low vitamin A and D content have been fed.

Vitamin B.—While fits and convulsions are not liable to occur during the fall months to the same extent as in the summer months, there are numerous complaints among breeders that their foxes, in the absence of external parasites, are chewing their tips and other parts of the fur during the fall months. During the early fall months the foxes are very susceptible to a dryness of the fur which often develops into a pronounced dermatitis, under which condition an irritation has been set up in the skin which has led to the foxes chewing their fur. Even foxes that are in apparently excellent condition will very often show an abundant amount of dandruff in the fur during September and the first part of October. The results, as a whole, would indicate that vitamin B should be added to the rations during the fall months as it not only leads to a favourable condition of the skin, but also helps to induce a clear black colour of the fur.

Vitamin C.—When rations deficient in this vitamin were fed to a group of foxes, the development of the fur of the whole group was most unfavourable, and from a pelt standpoint had very little value on account of the weakness of the guard hairs. On normal rations, these foxes had been well furred in previous years, and in subsequent years have furred excellently on normal rations. It has been further noted that foxes fed rations deficient in vitamin C would not make a favourable gain in weight during the fall months, and in that respect the experimental work indicates that the gain in weight was not due to the quantity of food, but to the presence of certain constituents in the food. Vitamin C appears to be one of these constituents. There appears to be a great requirement for vitamin C during the early fall months as this vitamin appears to have a very marked influence on the development of the guard hairs with respect to length and strength, and also is conducive to the foxes making a favourable gain in weight.

Vitamin E.—When whole wheat flour, cornmeal, wheat germ and other substances rich in this vitamin have been fed during the fall months, they have a very favourable influence on the development of the fur with regard to life and lustre. Also they have been very conducive to favourable breeding results during the subsequent breeding season. While it does not appear advisable to feed those

substances during the summer months, the results indicate that they are necessary constituents of the rations during the fall months when the foxes are gaining in weight. The vital constituents contained in whole wheat flour, cornmeal, wheat germ and other substances, rich in vitamin E, should be present in the rations in order to induce a favourable gain in weight, and that appears to be the limiting factor with regard to the feeding of these substances. They are necessary when the foxes are gaining weight, but to some extent should be avoided when the foxes are losing weight.

RECOMMENDATIONS

Breeders are advised not to feed cod liver oil, fats, excessive quantities of milk or other substances rich in vitamins A and D during the fall months, as they will invariably produce a pronounced brown shade in the fur, although they will not do as much harm to foxes kept in covered sheds as to those in open pens. Still they should be avoided, even with the foxes in sheds.

In order to induce a clear black colour of the fur and to promote a healthy condition of the skin so that the foxes will not be so liable to chew the tips and other parts of the fur, it is advisable that the rations should be supplemented with vitamin B, and fresh yeast or dried brewer's yeast are recommended during the fall months the same as throughout the summer months.

The presence of vitamin C in the rations influences the length and strength of the guard hairs. Rations should therefore be supplemented with the prevailing vegetables. As long as the grass is making a luxurious growth, it can be fed with favourable results, but it is not advisable to feed it as the source of vitamin C when the growth ceases. Tomatoes, turnips, carrots, beets and cabbage should be fed during the early fall months, but it is necessary that these should be ground to a fine pulp before being fed to the foxes. When the severe frosty weather sets in, they should be eliminated from the rations. There does not appear to be a vegetable requirement for foxes in captivity during the severe winter weather, and there appears to be a possibility that they would do more harm than good.

Whole wheat flour, cornmeal, and other substances rich in vitamin E should form the main bulk of the cereal portion of the ration during the fall months to ensure a favourable life and lustre of the fur. To make certain that there is a sufficient supply of vitamin E, on account of its close relation to reproduction, the rations should be supplemented with wheat germ.

(c) Vitamin Requirements During the Last Stages of the Growth of the Fur

The Fat Soluble Vitamins.—The experimental work has definitely demonstrated that cod liver oil and other substances, rich in the fat soluble vitamins, have produced most unfavourable results with regard to the development of the fur and the general condition of the foxes, when fed during the summer and fall months. Favourable results have been obtained, both from a fur and breeding standpoint, when beef suet has been fed to foxes during the late fall months, and so far this is the only fatty substance that has not tended to produce an unfavourable effect when fed to the foxes during the fall months. All the results would indicate that for a favourable development of the fur, a low-fat ration should be fed during the summer and fall months. The experimental work has been carried out with kidney beef suet, and it appears probable that this fatty substance may contain vital constituents that are required for the development of the fur and for reproduction.

RECOMMENDATIONS

During the late fall months, the fur of many foxes is lacking in proper lustre and life and many foxes fail to put on fat, especially on the medial line

of the abdomen. Fox breeders are recommended to supplement their rations after the first of November with beef suet, feeding on the average approximately one-quarter of an ounce per fox daily, using preferably the kidney beef suet.

(d) Vitamin Requirements During the Breeding Season

Vitamins A and D.—When the rations, during the pre-oestrus period, have been supplemented with cod liver oil and other rich food substances, the majority of the females have been late in coming in heat, and the remainder, while showing typical signs preceding oestrus, have never actually come in heat. In these cases there was a very pronounced swelling of the vulva, more than normal, which continued over a period of several weeks, and although the males were running with them throughout the entire period, the males made no attempt to mate and the females themselves showed none of the typical signs of being in heat. The experimental work as a whole would indicate that rations supplemented with vitamins A and D, when fed during the pre-oestrus period, tend to retard the females from coming in heat.

Examination of our records for several years shows that the most prolific breeders that have been produced in the Experimental Fox Ranch have been from females whose rations were supplemented with cod liver oil during the gestation period. On the other hand, when foxes have been fed rations deficient in this food, in the first year the pups made a fairly favourable growth but they were smaller than usual. Invariably the whole group in the second year produced pups that were undersized and developed a severe form of rickets. On the other hand, where cod liver oil has been fed to the females when they were pregnant, the pups produced made a most favourable growth with a well formed bone structure. More striking still have been the breeding results obtained; the males have been good polygamous breeders and the females have bred consistently.* The results indicate that in order to produce pups that will be prolific breeders, vitamin A, the growth-promoting factor, should be present in the rations during the initial stages of the development of the tissue of the sexual organs during the foetal growth. Also, to produce vigorous and well developed pups with a good bone structure, vitamin D, the anti-rachitic factor, should be present in the rations during the initial development of the bone tissue during the foetal growth. If these vitamins should not be present during the initial stages of the development of the sexual organs and of the bone tissue, the unfavourable effect cannot be counteracted after the birth of the pup.

Vitamin B.—Numerous reports have been received with regard to convulsions and fits in foxes during mating time. Still more numerous reports have been received regarding milk fever at whelping. The experimental work indicates that it is necessary that there should be a good hide condition and a healthy hide circulation during the gestation period, particularly at whelping time, in order to counteract the possibility of milk fever. When the rations during the breeding season have been supplemented with yeast, liver, and other substances rich in vitamin B, there has been no occurrence of fits and convulsions or of milk fever. The evidence as a whole would indicate that there is a great requirement of vitamin B during the gestation period and it is a necessary constituent of the ration during that period.

Vitamin C.—The general deficiency of this vitamin in the rations fed to foxes throughout the whole industry led to a condition, before the Experimental Fox Ranch was established, in which a very great percentage of the

*Factors Controlling Reproduction, Table No. 4, Page 23, Report of the Superintendent, Experimental Fox Ranch, for 1926-7, Dominion Experimental Farms, Department of Agriculture.

pups born lost the tip or entire tail before they were three weeks old. This tail trouble was a source of great worry to practically every fox breeder and was a real menace, as the same condition that led to the loss of the tip, or the tail as a whole, undoubtedly was the direct cause of a number of deaths among new-born pups. Since the Experimental Fox Ranch has demonstrated that this particular condition was due to infantile scurvy and could be counteracted by feeding food substances rich in vitamin C, loss of the tips and other tail trouble with the accompanying deaths has ceased to be a worry to the fox breeders. In previous years bob-tailed foxes were very numerous, and in many ranches practically all the foxes were bob-tailed; at the present time bob-tailed foxes are very rare.

With regard to counteracting scurvy in new-born pups, the results indicate that the most important preventive factor is the feeding of abundant quantities of food substances rich in vitamin C during the summer and fall months. At the same time the experimental work indicates that it is advisable that the rations during the latter part of the gestation period and the entire lactation period should be supplemented with food substances rich in vitamin C.

RECOMMENDATIONS

Breeders are advised not to feed cod liver oil or fat meat or any other rich substances before the females mate, as these substances will have a tendency to retard the females from coming in heat. It should be a practice to feed relatively lean meat, meat that is devoid of fat, during the pre-oestrus period, particularly with foxes that are fat and in good condition. After the females have mated, in order to ensure a good growth of the pups, it is necessary that the rations should be supplemented with cod liver oil, feeding one-eighth to one-quarter of an ounce daily.

Milk fever is liable to occur, particularly where high meat rations have been fed or where the foxes have a pronounced brown colour. In order to promote a healthy condition in the skin that will tend to counteract milk fever, it is advisable that either fresh or dried brewer's yeast should be fed throughout the entire gestation period, the same as during the summer months. As far as possible, beef liver or some other meat substances, rich in vitamin B, should form a portion of the meat rations throughout the gestation period. Fifteen days before the pups whelp, and throughout the time the females are nursing their pups, either lemon juice, or tomato juice should be added to the rations to counteract the possibility of tail trouble, using approximately one-quarter of an ounce of lemon juice or one ounce of tomato juice for each female.

PROJECT No. 3—SEASONAL NUTRITIONAL REQUIREMENTS OF SILVER FOXES IN CAPTIVITY

Since the experimental work first demonstrated that foxes should be fed in step with the season, this viewpoint has been a most valuable guide and has led to clear and well-defined methods for attacking the nutritional requirements of silver foxes in captivity. In this project the problems have been studied along two different and distinct lines:—

(*a*) The fitness of the environment to meet the nutritional requirements of silver foxes.

(*b*) Seasonal changes of silver foxes and the nutritional requirements necessary to induce these changes.

(a) The Fitness of the Environment to Meet the Nutritional Requirements of Silver Foxes

Vegetation.—The results of the experimental work have demonstrated clearly that when green vegetation is prevalent in nature, foxes should be fed green vegetables, and during the early fall months when ripe vegetation is prevalent, foxes should be fed ripe vegetables. In the late fall months, when the frost has destroyed vegetation, foxes do not require fresh vegetables, but require a certain amount of cereal foods. According to the experimental work, during the lactation period in the months of March, April and May, there appears to be a great requirement for vitamin C. While at this time of the year fresh vegetables may not be prevalent in nature, it is very probable that nursing females in the wild state obtain their supply of this vitamin from young buds and shoots that begin to appear.

Meat.—More favourable results have been obtained by feeding freshly killed meat than frozen meat to foxes in captivity. Where the foxes have been fed frozen meat throughout the entire year, the results have been most unfavourable. Freshly killed meat containing the essentials of the prevailing vegetation, would be a favourable means of feeding the foxes in step with the season. In the late fall months, the prey of the fox is in good condition and food is very plentiful. Experimental results have demonstrated very clearly that larger quantities of meat can be fed during November and December than at any other season of the year. On the other hand, during the gestation period, which is at the dead end of winter, when the prey of the fox is in poor condition, favourable results have been obtained when small quantities of meat have been fed to the pregnant females, while most disastrous results have been obtained from feeding high meat rations.

With pregnant females fed high meat rations, there was a fairly good production in the first year, but the pups produced have been very poor breeders. After continued feeding for successive seasons of a high meat ration during the gestation period of foxes, there has been an entire failure to produce pups. The only variety of foxes that have survived in the wild state are foxes that have the gestation period in the late winter, when the prey of the fox is in poor condition and food is scarce. It would appear that fox breeders would destroy the breeding qualities of their foxes entirely by continued feeding of high meat rations to their pregnant females.

Milk.—By feeding milk under certain conditions very favourable results have been obtained, particularly with growing pups and during the season of the year when the grass is making a luxurious growth. Undoubtedly, fresh milk forms an ideal vehicle for feeding silver foxes the essentials of the prevailing vegetation.

(b) Seasonal Changes of Silver Foxes and the Nutritional Requirements Necessary to Produce These Changes

Shedding of the Fur.—Foxes fed green grass and other forms of green vegetation and freshly killed meat shed their fur in a most favourable manner and maintained a healthy and vigorous condition as a whole, while foxes that were fed cornmeal, oatmeal and whole wheat flour, and cold storage meat killed the previous fall months, retained the fur in a most unnatural manner, and were subject to many nutritional disturbances. The study of the dietary factors that control the shedding of the fur has led to a clearer insight of the nutritional requirements of the foxes during the summer months. The results show that the closer the foxes have been fed in step with the season, the more the fur has shed in a favourable manner.

Seasonal Change of the Live Weight of the Foxes.—Since the Experimental Fox Ranch has been established, all the adult foxes have been regularly weighed each week during the summer and fall months until December 31, and after the beginning of the year until whelping time it has been the practice to weigh the foxes every second or third week. Foxes that remained fat during the summer months produced unfavourable results both from a fur and a breeding standpoint, while the foxes that were reduced to a minimum weight during the summer months and then reached a maximum weight by the end of the year, produced the most favourable results both from a fur and breeding standpoint.* Our results indicate that while there may be a reduction in weight during the summer months, there should not be a reduction in weight during September. Further, a rapid increase in weight during the month of September and the first part of October is not conducive to good results to the same extent as a slight gain in weight during that time, but it is imperative that there must be an increase and not a decrease in the weight of the foxes during the early fall months. The most favourable results have been obtained when the great proportion of the increase in weight has been during the latter part of October and during the months of November and December. The study of the dietary factors that control the natural decrease in weight during the summer months and the increase in weight during the fall months has been a very valuable guide in outlining the experimental work.

RECOMMENDATIONS

It is recommended to feed green vegetation during the summer months and as long as that green vegetation is making a luxurious growth. According to the experimental work, when the grass is growing a quarter of an ounce of ground green grass per fox at each meal produces favourable results. During the fall months foxes should be fed ground turnips, beets, carrots, onions, cabbage, etc., but it is not desirable to feed vegetables after the severe frost sets in in December. During the spring months, when the females are nursing their young, the females should be fed lemon juice, or tomato juice, or canned tomatoes to ensure a supply of vitamin C to ward off infantile scurvy in the new-born pups. As far as possible fox breeders should make a practice of feeding freshly-killed meat in preference to cold storage meat, and it would be to their advantage to make a practice of feeding a certain amount of fresh milk, particularly during the time of the year when the grass is making a rapid growth.

PROJECT No. 4—INFLUENCE OF SUNLIGHT

(a) The Influence of Sunlight on the Development and Growth of the Fur

The great handicap in ranching silver foxes in open pens, exposed to direct rays of the sun, is the influence of the rays of light on the underfur, more so than on the guard hairs. In the experimental work, foxes have been kept in open pens throughout the entire year. A number of foxes have acquired a pronounced brown shade at the end of the year, but in the following June, when these foxes shed the underfur, leaving the guard hairs intact, the old guard hairs were a clear black colour and the silver was a bright metallic colour with few signs of a brown shade. In this case, while the underfur had become overprime and off colour long before the end of the year, the guard hairs were still a good colour in the following June. With foxes in open pens, that have had a pronounced development of the underfur during September and

* Factors controlling reproduction of silver foxes, pages 3-10, Report of the Superintendent, Experimental Fox Ranch, for 1928-29-30, Dominion Experimental Farms, Department of Agriculture.

the early part of October, the underfur has had a tendency to acquire a pronounced brown shade early in the season long before the hides have been prime, while foxes whose underfur has been late in developing have maintained a clear black colour of the underfur until the hide has been prime.

(b) Influence of Sunlight Supplemented by Vitamins on the Colour and Development of the Fur

Where the rations have been supplemented during the summer and fall months with varying quantities of cod liver oil, cod liver oil meal, excessive quantities of milk, fat meat and other substances rich in the fat soluble vitamins A and D, the fur has acquired prematurely a pronounced brown shade, has become very dry and brittle, and has shown a restricted growth during the last stages of its development. The microscopic examination of the hairs has shown that there has been a lack of black pigment. On the other hand, most favourable results with regard to the production of a dense black colour of the fur have been obtained when the foxes have been fed a low fat ration during the entire summer and fall months. The black pigment will absorb the rays of light and many observers have wondered why silver foxes, during sub-zero weather, prefer to lie out and sleep in the open pens rather than in the kennels. Undoubtedly the fur containing a dense black pigment with many exposed points would readily absorb the rays of light so that the foxes would be warmer sleeping in the sun than inside the kennels. The fact that there was a lack of production of pigment when foxes were fed rations rich in vitamins A and D (sometimes called bottled sunshine) might indicate that when the vitamins allied to the rays of light are fed internally, the mechanism will not adjust itself to absorb the rays of light externally. On the other hand, if diets low in the vitamins allied to the rays of light are fed to foxes during the summer and fall months, they will enhance the development of a black pigment of the fur, increasing its efficiency for absorbing the rays of light during the season of the year when there is a minimum amount of direct sunlight.

RECOMMENDATIONS

It does not appear feasible, for the production of a high-class pelt, to ranch foxes in open pens, and it would well repay every breeder to have sufficient accommodation in a covered shed for all the foxes that he intends to pelt. Those breeders who find themselves in the position of not having sufficient accommodation in covered sheds for their foxes are advised not to force the development of the fur during September, as it is liable to lead to a premature development of the underfur, which will readily acquire a brown shade in the open pens. The more the growth of the underfur is retarded during September, the greater will be the possibility of retaining a good colour of the pelts in the open pens. Breeders are advised not to feed excessive amounts of substances rich in the fat soluble vitamins A and D, which are allied to the rays of light, during the summer and fall months. On the other hand, according to the experimental work, during the late winter months, when the foxes are subject to a minimum amount of direct sunlight, it appears advisable that the rations should be supplemented with cod liver oil, fat meat, and other substances rich in the fat soluble vitamins. However, breeders are warned against feeding these substances until the growth of the fur is fully completed late in January or the beginning of February.

PROJECT No. 5—FACTORS INFLUENCING THE PRODUCTION OF A CLEAR BLACK COLOUR OF THE FUR OF SILVER FOXES

Each year, during the fall months, the foxes have been examined every week and a record made of the density of the black colour on the one hand or the brown shade on the other. According to observations there are three separate factors that cause a brown shade in the fur of silver foxes.

(*a*) The cuticle becoming overprime and acquiring a brown shade.

(*b*) Lack of black pigment in the medulla of the hairs.

(*c*) The underfur becoming overprime, giving a pronounced brown shade to the fur as a whole. (See project No. 8).

(a) The Cuticle Becoming Overprime and Acquiring a Brown Shade

The overpriming of the cuticle appears to be due partly to improper feeding and partly to exposure to inclement weather. When cod liver oil, cod liver oil meal, or excessive quantities of milk have been fed during the summer and fall months, the fur has developed a pronounced brown shade due to the cuticle of the hairs acquiring a brown shade, which was more pronounced on account of a lack of pigment in the medulla of the hairs. In this case the overdevelopment of the cuticle was associated with a lack of development of the black pigment. When large quantities of fresh fish have been fed to foxes during the summer months, the fur has acquired a dark chocolate shade. In this case there has been a dense amount of pigment in the fur, but the cuticle has become overprime and given a pronounced brown shade to the fur. When the meat portion of the ration, during the summer and fall months, has consisted entirely of cooked meat or dried meat, there appears to have been an unfavourable development with an excessive priming of the cuticle, giving it a horny and harsh texture, which has readily acquired a pronounced brown shade.

The results of the experimental work indicate that the brown shade, so consistently produced with foxes in open pens, is mostly due to the cuticle of the hairs becoming tarnished and acquiring a brown shade, on account of the fact that the fur is exposed to all kinds of inclement weather. During very dry seasons, it has been observed that the foxes kept in open pens throughout the entire year have maintained a better colour than in wet seasons, although exposed to more direct sunlight. One of the most important factors with regard to keeping foxes from going off colour is to take every precaution against getting the fur wet. The extent to which the cuticle will resist the weather and other conditions and maintain a good colour without tarnishing, appears to a certain extent to be an inherent quality. There are certain strains of foxes whose cuticles will maintain a good colour throughout the entire season, while other foxes have a tendency to readily tarnish and go off colour.

(b) Lack of Pigment in the Medulla of the Hairs

The production of the proper amount of black pigment in the fur of silver foxes is one of the most important economic questions in the silver fox industry. It is the black phase that makes a staple commodity of silver fox furs. The black pigment is not only the chief characteristic of the silver fox fur, but it is an important factor with regard to the breeding qualities of the animal; the better the quality of the black pigment, the better the breeding results.

According to observations, foxes that are lacking in the black pigment are lacking also in constitutional vigour. In the Experimental Fox Ranch the foxes that readily acquired a brown shade have invariably been susceptible to parasitic infestation. Such foxes have not been consistent breeders and have not produced consistent breeders. There appears to be a constitutional weakness associated

with the lack of production of the black pigment, and any strain of foxes that readily and consistently acquires a brown shade should be eliminated as quickly as possible from the ranch.

The pigment is produced in the hide, then passes to the follicle and then to the medulla of the hair, so that in the early season the hide will have a pronounced blue colour which gradually disappears as the pigment is absorbed by the hair. When all the pigment has passed from the follicles to the hairs, the hide is white and the fur is generally prime for pelting. This can be observed by parting the hairs, preferably on different parts of the back.

In the experimental work, when foxes have been fed excessive amounts of meat or excessive amounts of milk or have been overfed to a marked extent, the fur has acquired a light brown shade, and there has been a lack of production of the black pigment in the hairs. This is entirely different and distinct from the condition of the chocolate brown shade which results from the overpriming of the cuticle in the presence of a good production of the black pigment. In the presence of overfeeding, or feeding excessive quantities of meats or fats, either the system is poisoned to a certain extent or some other condition is set up that inhibits the production of the black pigment.

When an abundant amount of green vegetation has been fed during the summer months, it has had a very favourable influence upon the production of the black pigment. Very favourable results have been obtained where rice has formed the main bulk of the cereal portion of the ration during the summer months. According to the experimental work, the hide circulation is one of the most important factors with regard to the production of a clear black colour.

RECOMMENDATIONS

To obtain satisfactory production of a clear black colour of the fur, breeders are advised in the first place to avoid exposing their foxes to inclement weather that will cause the cuticle of the hair to tarnish and go off colour, and are advised to feed a low fat ration during the entire summer and fall months so as not to force the development of the cuticle. In order to produce a favourable amount of pigment in the fur during the summer months, breeders are advised to feed rice as the main portion of the cereal content of the ration and to supplement the rations with an abundant supply of green vegetables.

PROJECT No. 6—FACTORS INFLUENCING THE GROWTH AND TEXTURE OF THE GUARD HAIRS

The term guard hairs, as used here, refers to all the hairs and fur in contradistinction to the underfur. The long hairs that protrude through the other hairs, more particularly around the shoulders and the sides, are designated as the overhang. The term guard hairs has been used rather indiscriminately among fox breeders. Some use the term as defined above, while others designate the overhang only as guard hairs.

(a) Factors Influencing Length

There are long-haired silver foxes and short-haired silver foxes. With a given strain of foxes, the length of the guard hairs is dependent to a great extent upon the rate of the development of the underfur. Where the development of the underfur has been forced during August and September, while there appeared to be a favourable development of the guard hairs at the end of September, yet invariably with a premature growth of the underfur the development of the guard hairs has been retarded later in the season, particularly in the centre of the back. Many foxes that on normal rations had developed guard hairs of a favourable length in previous years, when fed rations that

forced the development of the underfur during August and September, never developed a good length of guard hairs that year. All the experimental work indicates that it is necessary to control the development of the underfur during the early part of the furring season in order to obtain the maximum length of the guard hairs later in the season.

The time factor plays an important part with regard to the length of the guard hairs. Where attempts have been made to retard the development of the fur, and the guard hairs and silver hairs did not develop until late in September and the first part of October, while the foxes maintained a good colour, they were shorter furred at the end of the year than in previous years, and the fur did not reach its normal length in the majority of cases until April. The most favourable results have been obtained when a favourable growth of the guard hairs has been initiated by the first of September, with a limited growth of the underfur. Under those conditions it has been observed that there has been a uniform and continued growth of the guard hairs and silver hairs throughout the entire fall months.

The fur of the foxes has continued to grow in length in a very favourable manner until after the end of the year when there has been a uniform growth of the fur throughout the fall months. Such foxes have continued to improve in colour, and many foxes that had shown a slight brown shade early in the fall improved in colour when there was a continued growth of the guard hairs until late in January. On the other hand, those foxes that showed a brown shade and whose fur had ceased to grow after November, acquired a more pronounced brown shade. If a uniform growth is maintained from August to February, the fur will hold its colour in a very favourable manner. On the other hand, if the growth of the fur is forced and is completed by the first of December, which is often the case throughout the silver fox industry, the fur will acquire a brown shade before the hide is prime, which will become more pronounced as the season progresses.

It is necessary that there should be an increase in both the meat and protein content of the rations by the first of September, and this should be further increased at the fifteenth of October, and if the foxes have been fed reasonably during the summer and early fall months, high meat rations will be conducive to favourable results during November and December.

RECOMMENDATIONS

In order to obtain continued growth of the guard hairs throughout the entire furring season and until the hide is prime, the foxes should be fed a maintenance ration with a low meat content, during the summer months, and overfeeeding and large quantities of meat should be avoided; it does not seem advisable to feed more than three to four ounces of meat daily, according to the size of the foxes, during the summer months. At the first of September the meat content of the ration should be increased to five or six ounces daily. It is advisable that the increase of the meat content of the ration should take place on the first of September, and any delay in that respect may retard the manner in which the foxes will fur out. The old fur is very liable to remain on the ears and heads of the foxes until they are fully furred, if the development of the guard hairs is not properly brought about by the first of September. On the other hand, when there is an initial normal development of the guard hairs, a small dark circle will appear around the eyes of the foxes during the late summer months. This circle will gradually increase in size, spreading around the ears and then down the neck and the remainder of the body. There should be a further increase in the meat content of the ration on the fifteenth of October, when the foxes may be fed as high as eight to ten ounces daily without any unfavourable results, if they have not been overfed earlier in the year. In order

to obtain a satisfactory length, it is absolutely necessary that the development of the underfur should be controlled during September and the first part of October. A premature growth of the underfur at that time will inhibit the growth of the guard hairs to a very marked extent.

(b) Factors Influencing Texture and Lustre

The texture and lustre of the fur is dependent on a healthy and vigorous condition of the animal, and more particularly on a favourable circulation of the blood in the hide. In the experimental work, where the fur has been extremely dry and lacking in life and lustre, the condition has been more pronounced in the centre of the back and in the tail, which are the extremities of the hide circulation. If this condition has persisted, the fur has been liable to rub during the later stages of its growth, and the foxes have been very liable to chew their tips and the fur on the other parts of the body. It has been observed that these conditions are more pronounced when high protein rations, high fat rations, or excessive amounts of bone have been fed to the foxes, also with fat foxes, and more particularly with fox pups that are making a rapid gain in weight. In the experimental work, when the rations were supplemented with yeast to counteract the occurrence of dermatitis, and when they were supplemented with potassium iodide to insure a proper function of the thyroid, so that there should be a normal hide circulation, there has been a great improvement in the lustre and texture of the fur. With healthy and normal foxes, there has been an absence of any rubbing of the fur or chewing of the tips. The metabolism of protein, the assimilation of fats and lime, the development of the epidermal appendages and growth in general being closely associated with the thyroid, it appears necessary that the rations should be supplemented with some form of iodine, particularly when high protein rations are being fed or when the rations are being supplemented with bone or other lime compounds, or during the development of the fur, the main epidermal appendage of silver foxes.

When rice and rice products have formed the main portion of the cereal content of the ration during the summer months, as the new fur developed, it had a very favourable life and lustre, but on the same rations there was not a continued improvement during the fall months. On the other hand, when whole wheat flour and wheat products were fed during the summer months, the new fur, as it developed, was extremely dry and lacking in lustre, and as a whole appeared to be in an unhealthy condition, but with the same rations, there was a very marked improvement during the fall months. A whole series of experiments have been carried out with the different kinds of cereals. The results would indicate that in order to have a favourable life and lustre of the fur, rice and rice products should form the main portion of the cereal ration during the summer months, but during the fall months the cereal portion of the ration should consist mostly of wheat products, cornmeal, oatmeal, etc.

Many fox breeders are of the opinion that the dryness of the fur is due to the lack of oils and fats in the rations. When the fur of the foxes has been exceptionally dry and lacking in lustre, the rations have been supplemented with fats and oils under different conditions. Invariably this has had a most unfavourable effect, and not only increased the dryness of the fur, but caused it to become very brittle and harsh. The results of the experimental work as a whole would indicate that lack of life and lustre cannot be corrected by feeding fats and oils. It is a question of condition. If foxes are out of condition, they will neither put on fat nor will the fur have life and lustre. A favourable texture and lustre of the fur is a very important phase of silver fox ranching, as it is evidence of a healthy and vigorous condition, more particularly of a normal blood circulation and thyroid function.

RECOMMENDATIONS

In order to promote a healthy life and lustre to the fur and to ward off the possibility of any rubbing or chewing of the fur, breeders are advised to supplement their rations, throughout the entire summer and fall months, with yeast and with potassium iodide to insure a normal hide circulation. During the summer months, rice or rice products should form the main portion of the cereal content of the ration, and during the fall months whole wheat flour, cornmeal or shredded wheat. When the fur of the foxes is dry and lacking in lustre, fox breeders are warned not to attempt to feed oils or fats to counteract the condition.

(c) Factors Influencing Strength and Inhibition of the Growth of the Guard Hairs

In the experimental work, where high meat rations have been fed, the guard hairs have been very weak and in some cases there has been a partial inhibition of the growth of the guard hairs, and the fur has been very streaky and open. In other cases where high meat rations have been associated with overfeeding as well, there has been a total inhibition of the guard hairs, leading to the so-called samson condition. When rations were fed during the summer and fall months that were deficient in vitamin C, the foxes developed a pronounced hyperemia of the gums, and associated with this the guard hairs were lacking entirely in strength, and instead of being straight, were curly and bent. In order to induce a good development of the guard hairs with regard to strength and life, overfeeding and excessive amounts of proteins in the diet should be rigidly avoided. It is also necessary that the rations should be supplemented with food substances rich in vitamin C.

The Experimental Fox Ranch has a number of different strains of foxes from various ranches. When certain strains of foxes that have had a fairly favourable development of the guard hairs have been interbred, the offspring produced had guard hairs of a very weak character, some of them bordering on the samson condition.

RECOMMENDATIONS

In order to avoid weakness in the guard hairs and the production of a fur that is open and streaky, fox breeders are advised to avoid feeding high meat rations and overfeeding in general during the fall months, and to guard against promiscuous interbreeding of different strains of foxes.

PROJECT No. 7—FACTORS INFLUENCING THE DEVELOPMENT OF THE SILVER HAIRS

(a) Factors Influencing Density and Length

According to the experimental evidence, the amount of the silver has been dependent on the inherent traits of the foxes and also on the way in which foxes were mated. (See project No. 15.) In some cases foxes that were from half to three-quarter silver as pups, have looked entirely black in a subsequent year. In such cases, when there was a fairly favourable growth of the other guard hairs, the silver hairs were present, but they were well inbedded in the underfur and had not grown out. This has occurred with foxes where the development of the underfur had been forced during the month of August. When properly fed in the following years, the majority of those foxes have shown a normal development of the silver hairs.

In the experimental work, when there has been a good development of the silver hairs during September, with very little development of the underfur, there has been a continued growth of the silver hairs until December and January. In order to have an ideal development of the silver hairs, it seems necessary that they should develop well during September. In the experimental work, where the development of the fur has been retarded during September, the silver hairs on the body at the beginning of December were partially developed, failing to give a proper character to the fur. The silver hairs on the hips had developed to a normal length, and, in the majority of the cases, there was a well-defined line between the silver area of the hips and that of the body.

RECOMMENDATIONS

In order to obtain a favourable length of the silver hairs, breeders are advised to change their summer rations to fall rations not later than the 1st of September. (See project No. 6 *re* length of guard hairs.)

(b) Factors Influencing Bright Metallic Colour

In the Experimental Fox Ranch there are certain strains of foxes that have a bright metallic silver, while with other strains the silver is dull and muddy in appearance. While the evidence has shown that the metallic colouring of the silver hairs is, to a great extent, an inherent trait, it also has clearly demonstrated that the development of the silver hairs, without any tarnishing, has been dependent upon the way the foxes have been fed and managed. The same factors that caused a pronounced brown shade in the guard hairs through the cuticle becoming overprime, as discussed in project No. 5, also have led to a discoloration of the silver hairs. When foxes were fed cod liver oil, excessive amounts of milk, or were exposed to the wet weather, their silver hairs invariably became discoloured, due to the weathering and overpriming of the cuticle of the guard hairs. When foxes were subjected to inclement weather and went off colour, the centre area of the individual hairs has been most affected. (See project No. 10.) With certain types of foxes, when kept in open pens, there was a great loss of pelt value due to the discoloration of the silver, while the other fur qualities were very satisfactory. The fur as a whole had lost all its character due to the tarnishing of the silver. Certain strains of foxes with a favourable cuticle resisted tarnishing and the weather to a greater extent than others, yet the best strains of foxes have been susceptible to discoloration of the cuticle with tarnishing of the silver, when kept in open pens. Exposing foxes to wet weather is very liable to discolour the silver to a very marked extent, particularly between the shoulders and in the centre of the back.

RECOMMENDATIONS

In order to develop a bright metallic colour of the silver hairs, breeders are advised to follow the recommendations given in project No. 2 on vitamin requirements during the fall months, project No. 4 on influence of sunlight, and project No. 5 on factors influencing the production of a clear black colour, and section (*a*) on the cuticle becoming overprime and acquiring a brown shade.

PROJECT No. 8—FACTORS INFLUENCING THE GROWTH AND TEXTURE OF THE UNDERFUR OF SILVER FOXES

The results of the experimental work strongly indicate that the proper control of the development of the underfur is one of the keystones in silver fox ranching from both a fur and a breeding standpoint.

(a) Factors Influencing Volume and Texture of the Underfur

When foxes have been fat in August, invariably there has been a premature growth of the underfur. When foxes have been overfed or fed high protein diets during the early fall months, under which conditions there has been a lack of proper development of the guard hairs and the silver hairs in the subsequent stages of the development of the fur, they produced a fur that was streaky and open. It has been further observed that when there was a pronounced growth of the underfur during September, the underfur became very coarse and inclined to mat. With the foxes in open pens, subject to inclement weather, the fur did not shed the water, and remained wet for some time, under which conditions, as pointed out in projects 5, 6, and 7, the cuticle of the guard hairs and silver hairs prematurely overprimed, acquiring a pronounced brown shade. The results were also unfavourable when the foxes were not exposed to the weather and were kept in covered sheds, as there was a great tendency for the fur to rub and for the foxes to chew the fur. On the other hand, in the cases where the development of the underfur has been retarded during the month of September, there has been a very favourable development of the guard hairs and of the silver hairs with a very gradual development of the underfur of a favourable texture, the foxes readily shedding the water. Invariably when the foxes have developed an underfur of a silky lustre and texture, even when subjected to rain and other inclement conditions, there has not been a tendency for them to acquire a brown shade or for the silver to tarnish. The better the texture of the underfur, the easier it is to maintain a clear black colour of the guard hairs and a brighter metallic colour of the silver hairs. In the experimental work, where the foxes have been fed in such a manner that there has been a slight development of the underfur during September and the first part of October, with a favourable development of the guard hairs, when the protein content of the ration has been increased when the cold weather set in during the months of November and December, there has been a rapid growth of the underfur, which has produced a pelt of a greater volume and a better texture than when the growth of the underfur has been forced early in the season. The main growth of the underfur should not take place until after the fifteenth of October.

RECOMMENDATIONS

In order to obtain a pelt with underfur of a good volume and texture, breeders are advised in the first place to bring their foxes down to a minimum weight during the month of August, to avoid overfeeding high protein diets during the early fall months, and to guard against exposing their foxes to inclement conditions. After the fifteenth of October, when the weather comes near the freezing point, the meat content of the ration should be increased, and when the permanent frost sets in, relatively large quantities of meat can be fed with favourable results.

(b) Factors Influencing the Production of Underfur of a Normal Dark Slate Colour

With foxes kept in open pens, while there may be a tendency for the fur to acquire a brown shade, due to being exposed to wet weather and the direct rays of light, the development of a favourable dark slate colour of the underfur appears to be dependent upon the manner in which the foxes are fed. The experimental work has demonstrated that an unfavourable colour of the fur is produced when high meat rations are fed during the summer and early fall months. The production of a favourable dark slate colour of the underfur appears to be dependent upon a favourable vegetable and cereal content of the

rations. Where the foxes have been fed green vegetables, and rice has formed the major portion of the cereal content of the ration during the summer months, and where other vegetables have been fed during the early fall months, and the cereal content of the ration has consisted mainly of raw cereals, the most favourable results have been obtained with regard to the production of a dark slate colour of the underfur.

RECOMMENDATIONS

Breeders are advised, in order to produce a favourable dark slate colour of the underfur, to feed rice for the greater part of the cereal portion of the ration during the summer months, and to supplement the rations with some form of green vegetation; during September and October, they should supplement their rations with cabbage, beets, turnips, carrots, etc., and feed raw cereals as the major portion of the cereal content of the ration.

(c) Factors Influencing the Production of White Underfur

The production of white underfur appears to be caused by a form of gastritis or some other similar digestive disturbance which does not undermine the health of the foxes to an extent that becomes apparent, except as it affects the development of the underfur. In the great majority of cases, where for some reason or other the foxes have shown a pronounced weakness or other signs of indisposition, when the disturbance occurred during the period of growth of the fur, the underfur, as it developed, was a very pronounced white in colour, particularly in the tail. As the foxes showed an improvement, the underfur, as it grew, had a normal dark colour, but when a relapse occurred, the underfur came in white again; so that in many mild cases five or six alternate bands have been observed in the tails of different foxes.* When foxes have been fed mixtures of red meat, milk, cereals, etc., daily, for an extended period, there has been a very pronounced production of white underfur and in this case not only was the underfur white, but the foxes had grey snouts. Grey hairs developed underneath the jaw, and the guard hairs underneath the belly and in the tail were grey in colour, the foxes being affected along the abdominal region from the tip of the nose to the tip of the tail. When mixtures of milk, tripe and cereals were fed, there was a very favourable development of the fur with regard to both colour and texture.

When high meat rations have been fed for an extended period, the foxes have developed a pronounced white underfur, more particularly when the rations were not supplemented with ground green bone or bone in other forms. On the other hand, in the majority of cases, when high meat rations, supplemented with bone, have been fed, the underfur has developed a fairly favourable dark slate colour.

RECOMMENDATIONS

Breeders are warned against feeding a mixture of red meat and milk at the same meal. Tripe and milk may be fed at the same meal, and red meat and tripe can be fed with favourable results. The continued feeding of a mixture of red meat and milk will not only produce grey snouts and grey hairs on the abdomen, but will lead to ulcers of the stomach, which is liable to result in deaths through persistent haemorrhage from the stomach. Breeders are advised, whenever meat is fed to the foxes, to feed a certain amount of ground green bone or bone meal. It should be a general practice to add one pound of ground green bone or its equivalent of bone meal to every twelve pounds of meat that is being fed.

* Production of white underfur, pages 43-45, Report of the Superintendent, Experimental Fox Ranch, for 1926-7, Dominion Experimental Farms, Department of Agriculture.

PROJECT No. 9—FACTORS INFLUENCING THE SHEDDING OF THE GUARD HAIRS AND UNDERFUR DURING THE SUMMER MONTHS

According to the observations made in the experimental work, foxes should shed the underfur first, leaving the guard hairs intact, the guard hairs falling out only when the new fur develops in the early fall months. In many cases where there has been a normal shedding of the fur, when the entire underfur has come out, the foxes have looked as well furred as they did during the winter months. A very large number of females have shed the underfur during the time they were nursing their pups in May and June, while a great number of other females, and practically all of the males, have not shed their underfur until the month of July.* In table 3 the average amount of guard hairs and underfur of the foxes during the four years from 1931 to 1934, is given. July would appear to be rather late in the summer months for foxes to retain their winter coat of fur, but a great number of foxes in the Experimental Fox Ranch have consistently shed their underfur during the month of July and still have maintained a healthy condition and have been prolific breeders year after year. On the other hand, when the foxes have retained their fur until the month of August, or later, generally there has been something radically wrong with them. One of the most important factors in the natural shedding of the fur is that there should be, in the first place, a normal growth of the fur during the previous fall months. If the conditions have been such that there has been an underfur of a silky lustre and texture and a dark slate colour, there has been a tendency for the fur to shed in a favourable manner during the following summer months. On the other hand, if the underfur and the fur as a whole has been dry and coarse, with a tendency to mat, it has been very difficult to bring about a proper shedding of the fur, and the foxes have retained such coats of fur until very late in the summer months.

TABLE 3—AVERAGE AMOUNT OF FUR RETAINED BY FOXES AT THE EXPERIMENTAL FOX RANCH, SUMMERSIDE, P.E.I., DURING THE YEARS 1931 TO 1934, INCLUSIVE

—	—	June				July				August				
		7	14	21	28	5	12	19	26	2	9	16	23	30
		%	%	%	%	%	%	%	%	%	%	%	%	%
1931	Guardhairs	....	90	85	80	80	75	75	70	55	40	30	20	10
	Underfur	....	80	75	70	65	60	45	40	20	10	5	0	0
1932	Guardhairs	....	95	90	85	85	85	85	80	75	60	40	30	10
	Underfur	....	90	80	80	80	70	60	50	30	20	10	5	0
1933	Guardhairs	100	95	95	95	95	95	90	90	80	55	40	15	5
	Underfur	90	90	90	85	85	85	80	70	45	20	5	0	0
1934	Guardhairs	95	90	90	90	85	80	80	70	60	45	30	15	5
	Underfur	85	80	80	75	70	65	55	40	30	15	5	0	0

When the cereal portion of the rations has consisted of whole wheat flour, cornmeal and oatmeal, during the summer months, the foxes have had a tendency to retain their fur. On the other hand, when the cereal ration consisted mostly of rice, the foxes tended to lose their fur in a very favourable manner. The most favourable results with regard to the shedding of the fur have been when the diet consisted of rice as the cereal portion, freshly killed meat, fresh milk and green vegetables. On the other hand, with diets that consisted of whole wheat flour, cornmeal and oatmeal and cold storage meat, the

* Page 13, Table No. 6, Report of the Superintendent, Experimental Fox Ranch, for 1928-9-30, Dominion Experimental Farms, Department of Agriculture.

fur of the foxes remained tightly adhered to the body during the month of August, and they shed their fur only in September when the new hair started to grow.

Foxes that have been kept fat throughout the summer months shed their fur in a most unfavourable manner, and, in some cases, extremely fat foxes retained one coat of fur for two consecutive seasons. Some females have shed their entire underfur during the month of April when they were nursing their pups. While some of these produced healthy and vigorous pups in succeeding years, others failed to breed in the following year. Those conditions, which tend to produce milk fever at whelping time, may also cause an early sloughing of the fur during the lactation period. It seems advisable that the females should not shed their underfur until the latter part of the lactation period. The results have demonstrated very clearly that the more the foxes are fed in step with the season, the more naturally will the fur be shed.

RECOMMENDATIONS

Fox breeders are recommended to feed a quarter of an ounce of ground green grass at each meal as soon as the grass starts to grow in the early summer months and to make a practice of feeding it as long as the grass is making a luxurious growth. The cereal portion of the ration should consist of rice or rice products or other substances having a low protein content. Fox breeders should avoid feeding too much cold storage meat, fat mutton or other forms of fat meat during the summer months.

PROJECT No. 10—INFLUENCE OF SHADE ON THE DEVELOPMENT OF FOXES IN CAPTIVITY, AND THE VARIATION, IF ANY, DURING DIFFERENT SEASONS

(a) Factors Influencing the Colour of the Fur

Covered sheds have proven to be a great boon to the silver fox industry, and in the experimental work a better class of pelts has been produced in covered pens than in open pens, with regard to the different characteristics of the fur:—colour, length, texture, etc.

According to observations, the unfavourable results of ranching foxes in open pens are not entirely due to the unfavourable influence of the rays of light on the fur, but are brought about partly on account of the fact that the foxes are exposed to very wet and inclement conditions. In open pens, under the climatic conditions of the Experimental Fox Ranch, foxes will acquire a very pronounced brown shade. When foxes are exposed to rain, the exterior portion of the underfur will become sodden with the rain, particularly with foxes that have very coarse underfur. When the fur begins to dry, the water will readily evaporate at the tips of the fur so that the overhang will readily dry, while the guard hairs at the area of the exterior portion of the underfur will remain wet for a relatively long time, depending on the coarseness of the fur. It is the area at the exterior portion of the underfur that is most affected with foxes in open pens. The tips of the guard hairs, may be a clear black colour, but there is a very pronounced brown shade in the centre portion of the hairs, and the silver colouring is affected to a very great extent, becoming badly off colour. Also, the exterior portion of the underfur acquires a pronounced brown shade, and, while the major portion of the underfur may be a clear slate colour, the tips being off colour will give a pronounced brown shade to the pelt as a whole. Further, it has been noticed that foxes in open pens are not so liable to go off colour in dry seasons as in wet seasons, and the foxes in open pens have been a satisfactory blue-black colour during very dry seasons.

Some strains of foxes, when kept in open pens and exposed to inclement conditions, will maintain a clear black colour at the tip of the guard hairs, silver hairs included, while the centre portion of the hairs may acquire a pronounced brown shade, due to being exposed to wet weather. It has been noted that with other strains of foxes, when kept in open pens, the guard hairs will acquire a brown shade as a whole. This has occurred particularly with foxes that have a very coarse fur, and it has also been noted that the same tendency occurred with some of their ancestors. When the guard hairs acquire a brown shade as a whole, it is an indication of a poor strain of foxes, but even with good foxes that are exposed to wet weather, it appears a practical impossibility to keep the centre of the hairs from acquiring a brown shade to some extent.

RECOMMENDATIONS

Every fox ranch should have sufficient accommodation in covered sheds for its entire pup crop and for all adult foxes that are being pelted that year, so that the foxes are not exposed either to the direct rays of the sun or to inclement weather. The foxes should have a good bed of hay or some other bedding material, and the feces should be removed periodically in order to keep the foxes as dry and the fur as clean as possible. Breeders are recommended to eliminate from their breeding stock, as quickly as possible, those foxes that readily acquire a brown shade throughout the entire length of the hairs, as it is an indication not only of poor furring qualities but also of poor breeding qualities. Foxes that have a tendency to readily acquire a brown shade very rarely produce foxes that are consistently prolific breeders.

PROJECT No. 11—THE DETERMINATION OF THE NORMAL CYCLE OF BREEDING FOXES DURING THE ENTIRE YEAR AND THE FOOD REQUIREMENTS NECESSARY FOR THE CHANGES DURING THE DIFFERENT SEASONS

(a) The Dietary Factors That Control the Normal Reduction in Weight During the Summer Months, and the Extent to Which the Reduction should Take Place for Successful Fur and Breeding Results

Females that have remained fat during the summer months have given very unfavourable breeding results. In the majority of cases such females did not come in heat the following breeding season. In the few cases where such females did come in heat and mate, while the great majority of them became pregnant and produced pups, these pups never made a normal growth and never developed into breeders of any value. Males that were fat during the summer months have also been very indifferent breeders and practically all of them, when used for mating purposes, were incompetent of locking with the females.

The evidence has been conclusive, both from a fur and a breeding standpoint, that both male and female foxes should be reduced to a minimum weight during the summer months. The maximum loss of weight should take place during May and June, and at the end of June foxes should have made the greater percentage of their loss of weight during that year. During the months of July and August, there should be a still further slight decrease in weight. It is not advisable that the foxes should gain weight during July and August. The extent to which foxes will lose in weight has not been dependent upon the amount of food that has been fed, but upon the class of food. The same factors that have tended to produce a natural shedding of the fur also tended to a reduction in weight of the foxes. When the foxes have not shed their fur, they have not been reducing in weight. If foxes were subject to a heavy worm infestation or to other conditions that developed a pronounced anemic con-

dition, they did not shed their fur. Apart from an anemic condition, when the foxes are not shedding their fur in a normal manner, it is an indication that they are being fed in such a manner that there is not a normal reduction in weight.

RECOMMENDATIONS

Breeders are advised to examine and weigh all the foxes on the first of September for the potential breeders during the next breeding season. Females that are fat at that time will be very questionable breeders. While they may appear to be in good condition, probably it would be advisable that they should be eliminated from the breeding stock and put among the foxes that are intended to be pelted. Also, all males that are fat on the first of September should probably be eliminated from the breeding stock and should be pelted that season. If such males are kept for breeding purposes it will only lead to a great deal of humbug trying to get them to mate with the females, as the majority of such males are incompetent of locking with the females.

Breeders are warned against feeding their adult foxes during the summer months so that they will put on weight. That worm-free foxes lose weight during the summer months is not detrimental either from a fur or breeding standpoint, but breeders should differentiate between a normal loss in weight and a loss in weight through external or internal parasitic infestation. Breeders should systematically examine their foxes during the summer months for both external and internal parasites, which may lead to a pronounced anemic condition.

(b) The Dietary Factors That Control the Normal Increase in Weight During the Fall Months and the Rate and Extent to Which the Gain in Weight Should Take Place

By far the most satisfactory breeding results have been obtained when the females have been reduced to a minimum weight during August and then have made a gradual increase during September and the first part of October, not exceeding on the average four ounces per week, but after the fifteenth of October making an average gain in the neighbourhood of eight ounces per week until the end of the year. When the increase in weight has been made in that manner, the fatter the foxes, the better the breeding results. These females have come in heat in a favourable manner and invariably they became pregnant with minimum losses of pups at birth.* On the other hand, with females that have made a slight gain in weight during the fall months, a large percentage did not become pregnant after mating and there were a great number of deaths among the new-born pups. The post mortem examination of these pups revealed the fact that either the ribs or the skull had been fractured.

In the experimental work, where the foxes have made a rapid increase in weight during September and the early part of October, they failed to make a further gain in weight to any marked extent during the late fall months. Not only have they failed to make any further gain in weight, but at the end of November or early in December they started to lose weight very rapidly and were not in good condition at the end of the year. Both from a fur and breeding standpoint, the results would indicate that it is not desirable to force the development of the foxes during September and the first part of October. The results as a whole indicate that condition is the most important factor with regard to making a favourable increase in weight during the fall months. Forcing the foxes during September will readily put them out of condition.

*Factors controlling reproduction of silver foxes, pages 3-10, Report of the Superintendent, Experimental Fox Ranch, for 1928-29-30, Dominion Experimental Farms, Department of Agriculture.

When the foxes have been fed in such a manner that they either have continued to lose weight or made very little or no gain in weight during September, it has been detrimental to making a satisfactory increase in weight during the later fall months and it has not been conducive to good fur or breeding results. For satisfactory results, it appears necessary that the foxes should be fed in a manner that will induce a gain in weight after the first of September and most certainly in such a way that there should not be a continued loss in weight after that time.

In the Experimental Fox Ranch, there have been many efficient polygamous males that have mated successfully with four or five females for several years in succession. The successful males have invariably made an increase in weight of forty to sixty per cent during the fall months, and the greater the increase in weight, and the more uniformly the increase has been made from year to year, the more successful have been the polygamous qualities of these males. On the other hand, there have been several adult males that were light in weight on the thirty-first of December, and, although they were very efficient in locking with the females, all of their matings were sterile, or in some cases only a single pup was produced after mating with females that in previous and subsequent years produced litters of four and five. With regard to male pups, smears have been taken from the vagina after mating. In several cases no evidence of spermatozoa could be obtained. In these cases the pups had not made a satisfactory gain in weight and were relatively light in weight at the end of the year. On the other hand, where the male pups have made a favourable growth and were heavy in weight at the end of the year, the smears taken from the vagina of the females after the matings with these males have shown the presence of an abundant number of spermatozoa.

The experimental work indicates that the favourable gain in weight during the fall months is dependent upon the vitamin content of the food. When the foxes have been fed a ration during the fall months, and the entire ration has been cooked under steam pressure and the vitamin content destroyed, the foxes only made a slight increase in weight, while they made a very favourable increase in weight when the same rations had not been cooked. It has been further noted that the foxes will make a favourable gain in weight when the rations have been supplemented with vitamins B and C. The results indicate that in order to obtain a favourable increase in weight during the fall months, the foxes should be fed a good variety of foods with a relatively high vitamin content.

RECOMMENDATIONS

Breeders are advised to make a change in their rations that will ensure an increase in weight after the 1st of September, but are warned not to induce a too rapid gain in weight. The increase in weight between the 1st of September and the 15th of October should not exceed two pounds. Fox breeders should take steps to ascertain whether their foxes are losing or gaining weight during September, as a decrease in weight may lead to very unsatisfactory results, both from a fur and a breeding standpoint. After the 15th of October, when the cold weather sets in, the danger from feeding excessive quantities of meat is reduced, but before that time excessive feeding of meat should be avoided. Continued overfeeding should be rigidly avoided. The foxes may gain in weight at first, but overfeeding will throw them out of condition. It would be to the advantage of all breeders to take every step to ensure that their breeding foxes are as fat as possible at the end of the year. If the foxes were thin at the 1st of September, the fatter they are at the 31st of December, the better will be the breeding results.

All foxes should be weighed at the end of the year. All adult foxes that are light in weight should be pelted and not retained for breeding purposes. This

rigidly applies to adult foxes. Only male pups that are heavy in weight should be selected for breeding purposes, and whenever male pups that by chance were light in weight at the end of the year are used for breeding purposes, a smear should be taken from the vaginae of the females that they may mate with to ascertain if these males are depositing spermatozoa. Female pups that are light in weight at the end of the year may be good breeders, but only those female pups that made a uniform growth before they were six months of age should be kept for breeding purposes. The increase in weight during the fall months does not appear to be the limiting factor with regard to the breeding results with female pups as it is with adult female foxes.

(c) The Dietary Factors and Conditions That Induce Oestrus

Throughout the silver fox industry, there is a very high percentage of "misses"; the fact that a large number of females, having locked with the males, do not become pregnant is a source of great loss of revenue to fox breeders. In the experimental work, where the females were fed a high meat ration, they came in heat much earlier than in previous years, but a very large percentage of these females after mating did not become pregnant, more particularly the females that were underweight on the thirty-first of December. The majority of females that were heavy in weight at the thirty-first of December became pregnant when fed a high meat ration before mating. Under certain conditions, it seems quite possible that the females may have been forced to come in heat and mate before there was a simultaneous development in the ovarian tissue. Also, certain diets may detrimentally influence ovulation, and this is more liable to occur with females that are light in weight than with females that are fat. Females that have been fed high cereal rations or very rich rations containing cod liver oil, etc., were late in coming in heat. Many of the females on these rations, while showing very marked typical symptoms which precede oestrus, never came in heat. In those cases the vulva was swollen much above the average and remained swollen for several weeks, but as far as could be observed the females never came in heat. Males were placed with them each day during the period that the vulva was swollen, and after the swelling had receded, but none of the males made any attempt to mate with them. It has been further noted that when females were fed high cereal rations or very rich rations during the pre-oestrus period, if they came in heat and mated, invariably they became pregnant.

The Origin of the Hormones that Induce Oestrus.—In the experimental work it was observed with females that were prolific breeders that during the fall months, when the foxes put on weight, there was an accumulation of adipose tissue on the medial line of the abdomen between the hind legs. On the other hand, with the great majority of females that failed to come in heat or did not produce pups after matings, there was very little, if any, accumulation of adipose tissue on the medial line of the abdomen. The amount of the adipose tissue between the hind legs has been estimated by an external examination before female foxes have been pelted; after the foxes have been pelted the fat has been removed and weighed. It has been found that with proper care the amount of the adipose tissue can be estimated within ten to fifteen grams (approximately one-quarter to one-half an ounce) by an external examination. The post mortem examination also showed that there are two layers of fat, one on the medial line of the abdomen, in which are imbedded the lymphatic vessels, which pass along the inguinal groove and are directly connected with the lymphatic vessels leading to the ovaries, and another layer of fat attached to the inside of the skin.

A record has been kept for a number of years of the complete cycle with regard to the presence of this fat; the readings were made weekly from the first of September until the fifteenth of January, and then tri-weekly until the females came in heat. Over four hundred cases were thus observed. As the females put on weight during the fall months, there was a gradual accumulation of the adipose tissue; with favourable breeding females it reached a maximum between 125 and 150 grams (4½ to 5 ounces). At the beginning of the breeding season, the fat has been gradually absorbed, in many cases while the females were still maintaining the weight they had gained in the fall, but entirely by the time the females came in heat. Some females have lost weight at the beginning of the breeding season, but on the average the females, at the time they came in heat and all the fat had disappeared, have retained seventy-five per cent of the weight gained in the fall months when the adipose tissue was accumulating on the medial line of the abdomen. In all cases in the Experimental Fox Ranch there was an entire absence of fat on the medial line of the abdomen when the females came in heat. In two cases only there was still fat on the inside of the skin, but in over ninety-nine per cent of the cases there was an entire disappearance of both layers of fat at the time the females came in heat.

In the great majority of the cases, there was a gradual absorption of the fat after the beginning of the year, but in some cases there was still a large accumulation in the neighbourhood of one hundred grams when the vulva started to swell preceding oestrus. In those cases the swelling of the vulva persisted over abnormally long periods, but before the females actually came in heat all of the fat had been absorbed, as far as could be determined by the external examination.

It is a well known fact that females of other species cannot be sexually excited when there is a lack of skin circulation. It was noted in those cases where the females failed to come in heat, that the fur was exceedingly dry and lacking in life and lustre. As the absorption of the fat was in step with the females coming in heat, the evidence appeared to indicate the probability of hormones that induce oestrus originating in the subcutaneous regions. Experiments were carried out to ascertain the effect of promoting a vigorous hide circulation as a stimulant to the females coming in heat. It had already been noted that when the rations were supplemented with vitamin B and potassium iodide, a very healthy condition had been promoted in the hide, and there was a great improvement in the life and lustre of the fur which indicated a stimulus to the hide circulation. The rations of breeding foxes were, therefore, supplemented with dried brewer's yeast and potassium iodide in relatively large amounts during the breeding season. The results were most successful; the females came in heat in a most satisfactory manner; the majority of the females, particularly the pups, came in heat early in the season; there was a more pronounced and more natural swelling of the vulva, and a very favourable production of pups, which may have resulted from the satisfactory conditions under which oestrus was induced.

This project is still under investigation, but the evidence obtained so far indicates that while some hormones inducing oestrus may originate in the internal portion of the body, there are other hormones that originate in the subcutaneous regions, which may be complementary to those that originate in the internal portion of the body. The results clearly indicate that it would be an advantage to breeders to supplement their rations with potassium iodide and with liver and other substances, rich in vitamin B, during the pre-oestrus period.

RECOMMENDATIONS

Breeders are warned against feeding excessive amounts of meat before the foxes mate, especially to females that are light in weight. On the other hand,

the ration should consist mostly of a good quality of lean meat, particularly with females that are fat and heavy in weight, but not in excessive amounts, and in that respect a good quality of horse meat tends towards favourable results. Fox breeders are advised to feed from five to eight ounces of horse meat daily to the foxes before they mate, according to the size of the fox. It is not advisable to feed milk and cod liver oil. If any females that are light in weight are kept for breeding purposes, it would probably be advisable to feed them a mixed ration, as on an entire meat ration they would probably not become pregnant after they were mated.

(d) Food Requirements for the Male During the Pre-Oestrus Period

The most important factor that has been determined in the experimental work with regard to getting the males into good condition for mating with the females has been with respect to the live weight. In the Experimental Fox Ranch, there has been a number of efficient polygamous males that have been successfully mated with four, five, six females or more in successive years for a period of three or four years. The more successful and the more consistent breeders have made a pronounced gain in weight during the fall months, and it has reached a peak on the thirty-first of December. During January the majority of these males have lost two pounds in weight and a further two pounds have been lost during February. So far, in the experimental work, there has been no evidence to show that the requirements of the male vary in any way from the requirements of the female, and throughout the entire year it seems advisable that those foxes should be fed along approximately the same lines, except that there is a different requirement for the females during the gestation and lactation period.

RECOMMENDATIONS

It is condition that counts with polygamous males and every care must be taken, in the first place, during the fall months, to get the males in condition so that they will gain weight. After the first of the year, it is necessary that the males should be placed in large pens and given the opportunity to take the maximum amount of exercise in order to be in good condition for the mating season.

(e) Food Requirements During the Gestation Period

In the experimental work, when pregnant females were fed twenty to thirty per cent above a maintenance ration, the results have been most unfavourable. On the other hand very favourable results have been obtained when the females have been fed from ten to twenty per cent below a maintenance ration. High meat rations also have led to very unfavourable results and numerous losses of litters have occurred immediately after birth; in many of these cases there was a pronounced caking of the milk glands with an excessive amount of milk. The analysis of some of these cases showed that the milk had a very low fat and protein content. As already pointed out in project No. 2 (b), the experimental work as a whole indicates that there is not a high protein food requirement during the gestation period. In the experimental work, the more the development of the foetus has been forced at the expense of the maternal tissue, the less the complications at whelping time, and stronger and healthier pups have been produced. Females that have lost their litters for two and more years in succession, when fed twenty per cent below a maintenance ration during the time that they were pregnant, have raised healthy and vigorous pups that had very favourable breeding qualities. On the other hand, where the females were fed high meat rations for successive seasons, any pups that were raised were most indifferent breeders.

According to the experimental work, there is a great vitamin B requirement during the time the females are carrying their young, in order to produce a favourable hide condition and circulation. It has been noted that at the time the females whelp there has been a pronounced dampness of the abdomen. The condition promoted by the circulation to the abdominal regions has induced a sloughing of the fur. When the results have been favourable at whelping time the pups have had a moist and glossy appearance and the females were entirely bare around the teats with a pronounced dampness in the nest. On the other hand, where fatalities have occurred immediately after birth, the pups have had a dry and unhealthy appearance and the whole nest has been dry and in quite a number of cases there has been only a partial sloughing of the fur off the abdomen. In the experimental work, when the rations have been supplemented with yeast and potassium iodide, the pups have had a very glossy and silky appearance at birth, and the entire nest had a moist and oily appearance, which has always been indicative of favourable results.

According to the experimental work, the influence of vitamins A and D during the gestation period is a most important factor. When pregnant females have been fed rations deficient in vitamins A and D during the gestation period, the pups have been stunted and poorly developed and have been susceptible to rickets. The conditions have not been so pronounced the first year, but in the second year where pregnant females have been fed rations deficient in vitamins A and D, the whole group of pups has been affected with a very pronounced form of rickets. Cod liver oil and fresh milk have been fed to the pups when the abnormalities in the bone structure were first observed, but in no case has the condition been rectified by supplementing the rations with substances rich in vitamins A and D after the pups were two months of age. On the other hand, our records show that the most prolific breeders and the best developed foxes have been produced from females whose rations have been supplemented with vitamins A and D during the gestation period. The results indicate that in order to produce healthy and vigorous pups with a good bone structure and good breeding qualities, it is necessary that vitamin A and vitamin D, the growth and bone producing vitamins respectively, should be present during the initial stages of the development of the tissue of the sexual organs and of the bone tissue during the foetal growth. If these vitamins are not present in the rations at that time, the condition that is produced cannot be corrected by any method of feeding after the pups are born.

The experimental work has demonstrated that when the foxes have been fed during the summer and fall months with rations that have been supplemented with vitamin C, the pups produced from the foxes the following year have not been susceptible, as a whole, to infantile scurvy or to tail trouble. But, in the experimental work, there have been cases where foxes that have been fed such rations during the summer months have been subject to a heavy worm infestation and other disturbances before they whelped in the subsequent season and have produced pups with marked symptoms of infantile scurvy, and the entire litter lost their tails. The experimental work would indicate that there may be slight disturbances that may counteract, to a certain extent, the favourable conditions that have been induced by feeding vitamin C during the summer and fall months. The results as a whole indicate that it is advisable to supplement the rations with vitamin C during the latter part of the gestation period. When the rations have been supplemented with lemon juice during the last three weeks of the gestation period, and during the lactation period, there is no evidence of infantile scurvy or tail trouble. There appears to be a very high vitamin C requirement at whelping time for the pregnant females.

RECOMMENDATIONS

Breeders are advised to rigidly avoid overfeeding their pregnant females, as it is liable to lead to milk fever and fatalities among pups at birth. The pregnant females should not be fed more than four to five ounces of meat daily, feeding as wide a variety of meat as possible and making it a practice to feed a good quality of beef liver at least two or three times each week. As far as possible, freshly killed meat should form the main portion of the meat ration of pregnant females.

It is most important that cod liver oil should be fed to all the pregnant females, feeding one-eighth to one-quarter of an ounce daily, in order to insure a good bone structure of the pups and to guard the pups against the development of rickets, ulceration of the teeth and other infections.

Breeders are advised to supplement the rations of their pregnant females with yeast and potassium iodide to promote a healthy hide condition,

Two weeks before the females whelp, and throughout the lactation period, fox breeders are advised to supplement their rations with either lemon juice, tomato juice or canned tomatoes, to insure a supply of vitamin C in order to counteract the occurrence of any tail trouble. As soon as the weather permits milk should be included in the ration.

PROJECT No. 12—NORMAL GROWTH OF FOX PUPS IN RESPECT TO WEIGHT AND LENGTH

In table No. 4 are given the average weights and lengths each week during the stages of growth of male and female pups that in after years have developed into the most prolific breeders in the Experimental Fox Ranch. The males have been very successful polygamous foxes and the females consistent breeders. With the different pups there was a variation in the weights at four weeks. Some of them weighed only 1¼ pounds, while others weighed 1¾ pounds, but as the pups grew the variation became less and there was a minimum amount of difference when they were thirteen weeks old. When the pups were fully grown, some of the males weighed 11 pounds, while others weighed over 12 pounds. According to the records of the weights of the foxes, it would appear that the fox pups had arrived at the adult stage and were fully grown between twenty-four and twenty-five weeks of age. The majority of pups are in the neighbourhood of twenty-four and twenty-five weeks old around the 15th of September. It was noted in the following year that at the middle of September the foxes were approximately the same weight as they were the preceding year as pups. After that, the growth curve, at least during September and October, was identical with the growth curve of the preceding year as pups, but generally the adult foxes were of a greater weight at the end of the year than they were as pups. Further, very little, if any, growth in length has been observed after the pups were twenty-five weeks old; in the great majority of cases there is no growth after the pups are twenty-four weeks of age. With the great majority of foxes the length of the foxes in subsequent years has been the same as it was when they were six months of age.

According to the evidence obtained in the experimental work, male pups should make a favourable growth and should weigh 11 pounds or more when they are six months old. The males that have made the most favourable growth have developed into the best breeders. It has been observed that some

male pups that have grown into relatively large foxes with respect to length, but were relatively light in weight, would readily mate with females during their first breeding season, but a number of them failed to deposit any spermatozoa. So far, when male pups that were heavy in weight at six months of age and at the end of the year were used for breeding purposes, they invariably deposited an abundant number of spermatozoa when mating with the females. For successful breeding, it seems advisable that male pups should make a uniform growth and should be heavy in weight at the end of the year.

TABLE 4—GROWTH OF FOX PUPS IN RESPECT TO WEIGHT AND LENGTH

Age in weeks	Average of select male pups					Average of select female pups			
	Weight	Measurements			Weight	Measurements		
		Body	Tail	Total		Body	Tail	Total
	lb. oz.	in.	in.	in.	lb. oz.	in.	in.	in.
4	1 7	11¼	5½	16¾	1 7	10½	5	15½
5	1 15	12¼	6½	18¾	1 14	11¾	6	17¾
6	2 7	14	7¾	21¾	2 6	13	7	20
7	3 0	15¼	9	24¼	2 14	14	8	22
8	3 8	16½	10	26½	3 5	15½	9	24½
9	4 0	17½	11	28½	3 12	17	10½	27½
10	4 8	18½	12	30½	4 6	18	11½	29½
11	5 0	19	12½	31½	5 0	18¾	12¼	31
12	5 8	19½	13½	32¾	5 8	19½	13½	32½
13	6 0	20¾	14¼	35	6 0	20¼	14	34¼
14	6 10	21½	15	36½	6 8	20¾	14½	35¼
15	7 3	22¼	15½	37¾	7 0	21½	15	36½
16	7 8	22½	16½	39	7 6	21¾	15½	37¼
17	8 0	23¼	16¾	40	7 12	22¼	16	38¼
18	8 6	24	17	41	8 0	23	16½	39½
19	8 14	24¼	17	41¼	8 4	23¼	16½	39¾
20	9 8	24½	17¾	42¼	8 10	23½	16¾	40¼
21	9 11	24½	18	42½	9 0	23¾	16¾	40½
22	10 4	25¼	18¼	43½	9 7	24	17	41
23	10 8	25½	18¼	43¾	9 10	24	17	41
24	10 14	25½	18¼	43¾	9 13	24¼	17	41¼
25	11 4	26	18¼	44¼	10 0	24½	17	41½
26	11 8	26	18½	44½	10 2	24½	17	41½

With regard to the growth of the female pups, the most important factor appears to be the growth before they are thirteen weeks old. In the Experimental Fox Ranch, the most successful female breeders have been those that made a favourable growth up to the time they were thirteen weeks of age. In the Experimental Fox Ranch, there are some relatively small females, that have been consistent breeders, that weighed over six pounds when they were thirteen weeks old. On the other hand, there are some females that have developed into very large foxes, yet only weighed four pounds when they were thirteen weeks old, but made a rapid growth afterwards. Those females that were light in weight when they were thirteen weeks old have been very poor breeders. A number of them bred and raised a litter the first year, but although kept for several years after that failed to raise or produce litters in later years. When there is a lack of growth before three months of age, it appears to indicate that there is a lack of development of the sexual organs. Practically all the consistent breeding females in the ranch made a favourable growth during the first three months.

RECOMMENDATIONS

Breeders are advised to weigh all their pups when they are three months old. The female pups used for breeding purposes should be selected from those

that are over five pounds at that time. Any pups that are under four pounds should be set aside and pelted that year, and it might be advisable to pelt all female pups that are much under five pounds in weight. All the male pups should be weighed when they are six months old and only those males that are in the neighbourhood of 11 pounds should be retained for breeding purposes. It is advisable also that the male pups should be heavy in weight at the end of the year.

PROJECT No. 13—ACTUAL AMOUNT OF FOOD, IN TERMS OF CALORIC VALUE, REQUIRED TO PRODUCE A GIVEN GAIN IN WEIGHT IN A NORMALLY GROWING FOX PUP, DURING DIFFERENT STAGES OF GROWTH

In studying the nutritional problems, in the first place, the exact amount of food to be fed to adult foxes and growing pups was held to be of paramount importance; the further the experimental work has progressed, the more important this factor appears to be. The minimum amounts of food that produced well developed and fully matured pups have invariably induced the most favourable fur and breeding qualities. On the other hand, feeding excessive amounts has led, in the majority of cases, to most disastrous results, in many cases to fatalities. Similar results have been experienced also with adult foxes; the normal minimum amount on which foxes would gain weight in the fall has invariably led to the most favourable results. Not only has it led to better fur and breeding qualities but the foxes actually made a greater gain in weight than when greater amounts were fed.

Condition is the all important factor in raising silver foxes in captivity and it appears to be a practical impossibility to keep a group of foxes in condition by any system of overfeeding. The actual amounts of food required for both adult foxes and pups have been major projects in the experimental work. Therefore, the rations have been rigidly drawn up according to the caloric value as calculated from the composition of the food, which has been determined by analysis.

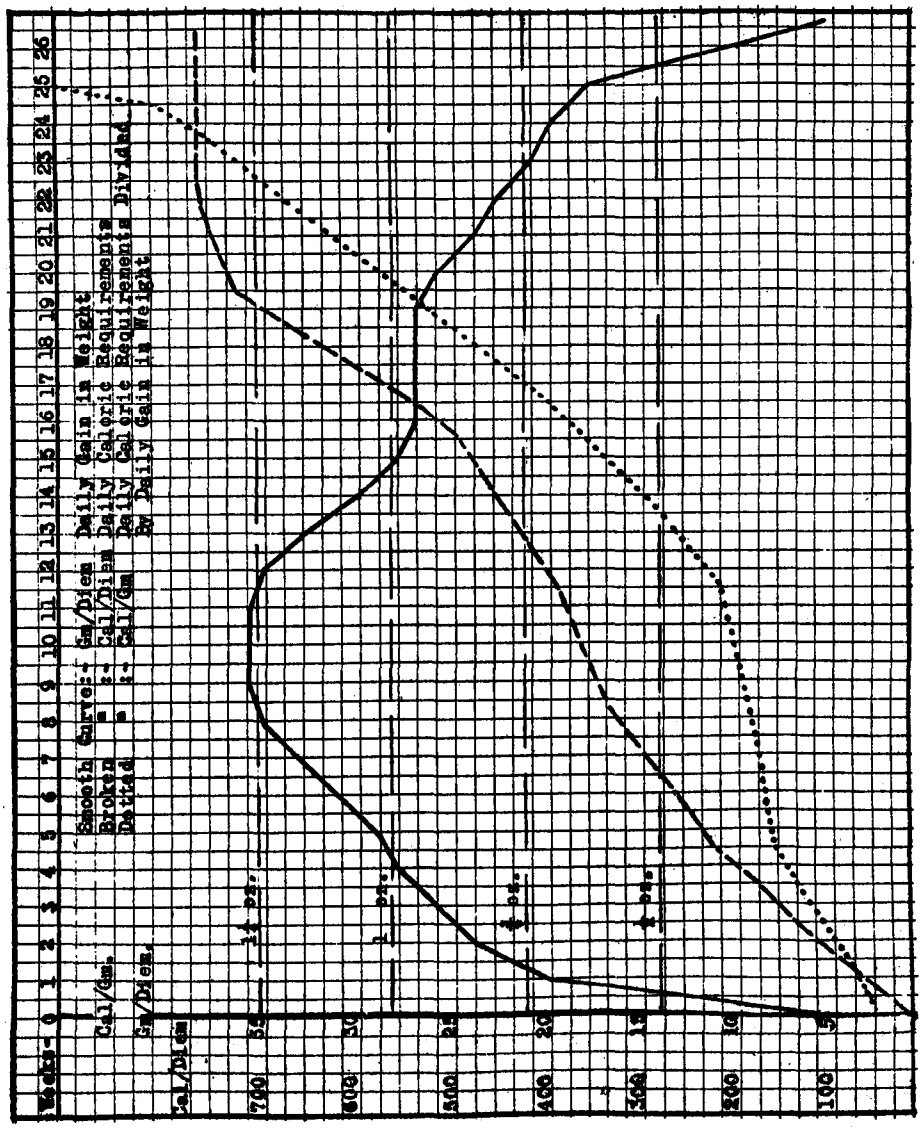
The pups were weighed each week during their stages of growth. A careful record of the caloric value of the daily rations fed to the pups was also kept. It was noted that the ratio between the caloric value of the daily rations and the daily gain in weight was the same for pups of the same age, and this ratio gradually increased during the different stages of growth. Whether the pups were slightly underfed or slightly overfed up to a certain age, if they were free of worm infestation or other disturbances, the ratio between the two values with the pups of the same age was so close that it would indicate that it was a constant factor for each particular age of the pup. That is to say, that a definite amount of food produced a definite gain in weight with healthy pups, the amount of food being calculated by its caloric value.*

In graph No. 1, on the smooth curve (gm/Diem), and in table No. 5, is shown the average daily gain in weight of healthy fox pups, which is the average of over 50 per cent of the pups raised in the Experimental Fox Ranch. For convenience, this curve is shown both in the metric and avoirdupois systems of weights, in grams and in ounces. It will be seen from this curve that the healthy pups made an average gain of one-half an ounce daily during the first week, and of three-fourths to one ounce from then until they were four weeks of age, the rate of growth reaching a maximum during the 9th, 10th and 11th week, slightly over 1¼ ounces daily. After the pups were three months old there was a marked decline in the daily gain in weight, which decreased rapidly until the

* For the benefit of those fox breeders who may not be familiar with the terms used in scientific nutritional research work, it may be said that the metric system only is used in scientific work. The live weight of animals is expressed in grams or kilograms, and the amount of food is determined by its caloric value and expressed in calories.

pups were four months old. For the subsequent six weeks, the average rate of growth remained constant and then there was a rapid decline in the daily gain in weight. As stated previously, the pups completed their growth at the time they were six months of age. The experimental work has shown that any further gain in weight after that time was simply a part of the annual cycle of the variation in the natural live weight of foxes during different seasons of the year.

GRAPH NO. 1—GROWING FOX PUPS—DAILY GAIN IN WEIGHT, DAILY CALORIC REQUIREMENTS AND THE RATIO BETWEEN THE CALORIC REQUIREMENTS AND THE GAIN IN WEIGHT



In the experimental work, the rations fed to the pups have been increased in some cases once each week; in others every two weeks, and with still others every four weeks. The average amount that has produced the most favourable

growth is shown as a broken even curve (Cal/Diem), the amount being expressed in calories (see graph No. 1 and table No. 5). It will be seen from this curve that at birth the daily caloric requirements have been in the neighbourhood of twenty calories. There was a gradual increase during the first four weeks, when the daily caloric requirements increased to over 200 calories, and a further gradual increase up to 400 calories during the next eight weeks, so that by the time the pups were three months of age, the food requirements were equal to those of the average small female. When the pups were five months old, the food requirements increased to 750 calories daily, in the neighbourhood of one and one-half times the amount for the average large size fox.

The dotted curve portrays the ratio of the daily caloric value of the food to the daily gain in weight, and in table No. 5 is given the calculated weight of the normal growing fox pup, the daily gain in weight of which, has been according to the smooth curve shown in graph No. 1.

For several years, pups at the Experimental Fox Ranch have been fed a ration having on the average the caloric value as given in table No. 5. If the rations were increased once every two weeks, the average was taken of the two weeks; when increased once every month, the average was taken for the four weeks. The majority of the pups whose daily rations were increased once each month grew into what was considered well developed pups of normal size. During the first week of the month, immediately after the rations had been increased, the pups were slightly overfed, while during the last week of the month they were slightly underfed, but the pups made ultimately as great a growth as when the rations were increased uniformly each week. The experimental work would indicate that slightly overfeeding or slightly underfeeding for one week does not materially affect the growth of the pups, whereas, continued overfeeding or continued underfeeding has led invariably to disastrous results.

TABLE 5—GROWING FOX PUPS—
DAILY GAIN IN WEIGHT, DAILY CALORIC REQUIREMENTS, AND THE RATIO BETWEEN THE TWO

Weeks	Daily gain in weight in grams	Ratio of the total caloric value of the rations to the daily gain in weight	Total daily caloric requirements	Calculated weight of pup from Gm/Diem
	Gm/Diem	Cal/Gm.	Cal/Diem	lb. oz.
1	13	3·2	41	5½
2	22	4·4	97	11
3	25	5·5	140	1 01
4	27	6·8	180	1 08
5	28·5	8·0	228	1 15
6	30	8·4	252	2 06½
7	32	8·8	281	2 14
8	34	9·2	312	3 07
9	35·5	9·6	340	3 15½
10	36	10·0	360	4 08
11	36	10·4	375	5 01
12	35·5	11·0	390	5 10
13	34	12·5	415	6 03
14	31·5	14·0	440	6 10
15	29	16·0	465	7 01
16	27·5	18·0	495	7 07
17	27	20·0	540	7 14
18	27	22·5	608	8 05
19	27	25·0	675	8 11½
20	26·5	27·5	730	9 02
21	25	30·0	750	9 09
22	23·5	32·5	760	9 14
23	23·0	35·0	770	10 04
24	20·5	37·5	770	10 09
25	19	40·5	770	10 13
26	14	55·0	770	11 00

PROJECT No. 14—FOOD REQUIREMENTS FOR THE NORMAL GROWTH AND DEVELOPMENT OF FOX PUPS

LACTATION PERIOD

During the first week of the growth of the pups, favourable results have been obtained by feeding the same amount as during the gestation period. There is a drain on females during the lactation period, but it has been observed that when fat nursing females made no reduction in weight, there was a pronounced disturbance in the growth and development of the pups during the first two or three weeks. The results as a whole indicate that for a favourable development of the pups there should be some pull on the mother's tissue, and it is advisable that that should take place during the first week of the lactation period.

The results of the experimental work indicate that a favourable growth before and following birth has been dependent upon the manner in which the mothers were fed during the previous summer and fall months and throughout the gestation period.

In the Experimental Fox Ranch, when the evening meal has consisted only of meat, after the pups were two weeks old, the females have invariably carried the meat to the pups, which retarded the growth of the pups, and in some cases led to grave disturbances. The experimental evidence indicates that during the first four weeks the entire digestion with pups takes place in the intestines, and the stomachs of fox pups under four weeks of age have not acquired the ability to digest meat. To obtain a favourable growth, a certain amount of meat should be included in the rations. Favourable results have been obtained from feeding finely ground meat, mixed with either porridge, bread or biscuits. While the females have carried this mixture to the pups, before they were a month old, so far it has not led to any gastric disturbances or retarded the growth of the pups. A number of post mortem examinations have been made of pups that have died between three and four weeks of age. The great majority of these deaths was due to severe haemorrhages of the stomach; in some cases meat was found in the stomach, but in all cases of fatalities from haemorrhages of the stomach the fox breeders had been feeding meat in chunks to the mothers.

In the experimental work, attempts have been made to ascertain if pups could be raised on cow's milk only. Females and pups have been fed a ration consisting mostly of cow's milk, from the time the pups were four weeks old. On a milk ration, the pups made a very pronounced growth for two weeks, then the whole group lost weight, with a number of deaths. In all these cases there were haemorrhagic spots throughout the stomach with large quantities of blood in the intestines. Partly digested milk was found in the stomach but there was no trace of milk in the intestines. In post mortem examinations of pups under four weeks of age the vixen's milk was found throughout the entire length of the intestines in different stages of digestion and very rarely has any vixen's milk been found in the stomach. The experimental work indicates that cow's milk and vixen's milk digest under opposite conditions. The vixen's milk is digested in the intestines and the cow's milk in the stomach. When cow's milk has been modified by the addition of cereals, the milk being absorbed so that the pups have not had the opportunity to drink the milk by itself, and tripe has been added, most favourable results have been obtained with regard to the growth and development of the pups.*

The proper digestion of the food is a very important factor in fox ranching. In a number of ranches the pups are continually subject to bloating, diarrhoea, and other digestive disturbances. Each year, during the last four years, a large

* Milk requirements during the lactation period and during the growth of the pups, pages 25-29, Report of the Superintendent, Experimental Fox Ranch, for 1926-27, Dominion Experimental Farms, Department of Agriculture.

number of fatalities throughout the industry have been referred to the Experimental Fox Ranch. Bloating has far outnumbered all the other causes of death. Ranches have been visited where from 20 to 30 pups have been lost in a single day through bloating. The pups would lie down after eating, bloat, the stomach burst, the contents of the stomach shooting across the pen. The post mortem examination of foxes that have died through bloating, also through diarrhoea, has shown partly digested cereals throughout the entire intestinal tract. In the initial experimental work, when high cereal rations were fed, a great deal of bloating occurred, but when bran and ground green grass or some other green vegetable were added to the rations, there was a complete digestion of the food without any occurrence of either bloating or diarrhoea. The experimental work indicates that some suitable roughage should be added to the rations in order to make the food porous to the digestive juices, which will inhibit fermentation of the food in the stomach, counteract the possibility of bloating and lead to a complete digestion of the food in the intestines. This will guard against diarrhoea, a common ailment among pups during the hot weather.

RECOMMENDATIONS

In table No. 6 is given an outline of daily rations with the approximate amounts for 24, 12, and 6 vixens and litters, and in table No. 7 are given the amounts that should be fed to the different vixens, according to the size of the litter and the age of the pups.

TABLE 6—RATIONS DURING LACTATION PERIOD

APPROXIMATE DAILY RATION FOR 24 VIXENS AND LITTERS

Morning meal—		*Noon meal—*		*Evening meal—*	
Biscuits	3 pounds	Milk	5 pounds	Meat	8 pounds
Milk	5 pounds	Tripe	2 pounds	Cereals	4 pounds
Tripe	2 pounds	Bread	2 pounds	Bone	½ pound
Yeast	4 ounces	Eggs	1 pound	Cod liver oil	½ pound
Weak Potassium iodide solution	2 ounces			Tomato juice	1 pound
				Yeast	½ pound

APPROXIMATE DAILY RATION FOR 12 VIXENS AND LITTERS

Morning Meal—		*Noon meal—*		*Evening meal—*	
Biscuits	1½ pounds	Milk	2½ pounds	Meat	4 pounds
Milk	2½ pounds	Tripe	1 pound	Cereals	2 pounds
Tripe	1 pound	Bread	1 pound	Bone	½ pound
Yeast	2 ounces	Eggs	½ pound	Cod liver oil	½ pound
Weak potassium iodide solution	1 ounce			Tomato juice	½ pound
				Yeast	2 ounces

APPROXIMATE DAILY RATION FOR 6 VIXENS AND LITTERS

Morning meal—		*Noon meal—*		*Evening meal—*	
Biscuits	12 ounces	Milk	20 ounces	Meat	32 ounces
Milk	20 ounces	Tripe	8 ounces	Cereals	16 ounces
Tripe	8 ounces.	Bread	8 ounces	Bone	2 ounces
Yeast	1 ounce	Eggs	4 ounces	Cod liver oil	2 ounces
Weak potassium iodide solution	½ ounce			Tomato juice	4 ounces
				Yeast	1 ounce

Preparation of potassium iodide solution: Take one ounce of potassium iodide and dissolve it in one pint of water. Label this "Strong Solution of Potassium Iodide." Take one ounce of the strong solution and add sufficient water to make one quart. Label this "Weak Solution of Potassium Iodide".

TABLE 7—LACTATION PERIOD—DAILY RATION FOR VIXEN AND DIFFERENT SIZED LITTERS AMOUNT FOR EACH MEAL AND APPROXIMATE CALORIC VALUE

Weeks	1st	2nd	3rd	4th	5th	6th	7th	8th
Vixen and 1 pup—a.m.	4 oz. 200	4 oz. 200	4 oz. 200	4 oz. 200	4 oz. 200	6 oz. 300	6 oz. 300	6 oz. 300
m.								
p.m.	4 oz. 200	4 oz. 200	6 oz. 300	6 oz. 300	6 oz. 300	6 oz. 300	6 oz. 300	6 oz. 300
Total calories	400	400	500	500	500	600	600	600
Vixen and 2 pups a.m.	4 oz. 200	4 oz. 200	6 oz. 300	6 oz. 300	6 oz. 300	6 oz. 300	6 oz. 300	6 oz. 300
m.				4 oz. 140	4 oz. 140	6 oz. 210	6 oz. 210	6 oz. 210
p.m.	4 oz. 200	6 oz. 300	6 oz. 300	6 oz. 300	6 oz. 300	6 oz. 300	8 oz. 400	8 oz. 400
Total calories	400	500	600	740	740	810	910	910
Vixen and 3 pups a.m.	4 oz. 200	4 oz. 200	4 oz. 200	6 oz. 300	6 oz. 300	8 oz. 400	8 oz. 400	8 oz. 400
m.		6 oz. 210	6 oz. 210	6 oz. 210	6 oz. 210	8 oz. 280	8 oz. 280	8 oz. 280
p.m.	4 oz. 200	4 oz. 200	6 oz. 300	8 oz. 400	8 oz. 400	8 oz. 400	10 oz. 500	10 oz. 500
Total calories	400	610	710	910	910	1,080	1,180	1,180
Vixen and 4 pups a.m.	4 oz. 200	4 oz. 200	6 oz. 300	8 oz. 400	10 oz. 500	10 oz. 500	12 oz. 600	12 oz. 600
m.		6 oz. 210	6 oz. 210	6 oz. 210	8 oz. 280	8 oz. 280	8 oz. 280	10 oz. 350
p.m.	6 oz. 300	6 oz. 300	8 oz. 400	8 oz. 400	10 oz. 500	12 oz. 600	12 oz. 600	12 oz. 600
Total calories	500	710	910	1,010	1,280	1,380	1,480	1,550
Vixen and 5 pups a.m.	4 oz. 200	6 oz. 300	8 oz. 400	10 oz. 500	10 oz. 500	12 oz. 600	12 oz. 600	14 oz. 700
m.		6 oz. 210	6 oz. 210	10 oz. 350	10 oz. 350	12 oz. 420	12 oz. 420	14 oz. 490
p.m.	6 oz. 300	6 oz. 300	8 oz. 400	10 oz. 500	12 oz. 600	12 oz. 600	14 oz. 700	14 oz. 700
Total calories	500	810	1,010	1,350	1,450	1,620	1,720	1,890
Vixen and 6 pups a.m.	6 oz. 300	6 oz. 300	8 oz. 400	10 oz. 500	12 oz. 600	14 oz. 700	15 oz. 750	16 oz. 800
m.		6 oz. 210	8 oz. 280	10 oz. 350	12 oz. 420	14 oz. 490	15 oz. 540	16 oz. 560
p.m.	6 oz. 300	8 oz. 400	10 oz. 500	12 oz. 600	12 oz. 600	14 oz. 700	15 oz. 750	16 oz. 800
Total calories	600	910	1,180	1,450	1,620	1,890	2,040	2,160
Vixen and 7 pups a.m.	6 oz. 300	6 oz. 300	10 oz. 500	12 oz. 600	14 oz. 700	16 oz. 800	16 oz. 800	18 oz. 900
m.		6 oz. 210	10 oz. 350	12 oz. 420	14 oz. 490	16 oz. 560	16 oz. 560	18 oz. 630
p.m.	6 oz. 300	8 oz. 400	10 oz. 500	12 oz. 600	16 oz. 800	16 oz. 800	18 oz. 900	18 oz. 900
Total calories	600	910	1,350	1,620	1,990	2,160	2,260	2,430

In table No. 5 the total daily caloric requirements of growing pups in weekly stages are given. As already stated, in the experimental work the rations of fox pups have been increased each week, every two weeks and every four weeks. As far as can be ascertained from the growth of the pups and the fur qualities, the results were quite as satisfactory when the rations were increased every four weeks as when increased at shorter intervals. In table No. 8 are shown the daily caloric requirements during each week of the growth of the pups, from the 9th to the 24th week and the average for each four weeks. Examination of that table will show that if the foxes should be fed according to the average for each four weeks, there will be a slight overfeeding during the first week, but during the two middle weeks they will be receiving approximately the normal amount of food, while there will be a slight underfeeding during the last week. As already pointed out in project No. 13, slightly overfeeding or slightly underfeeding for one week does not have any detrimental effect on the growth of the pups, whereas continued overfeeding or continued underfeeding has led to most unfavourable results, so that the breeders are recommended to increase the rations weekly or only every four weeks, whichever system is most convenient; according to the experimental work, the one method will give quite as satisfactory results as the other.

In table No. 10, an outline of daily rations for fox pups during the different stages of growth from the 9th to the 24th week is given. For the cereal content of the rations a well-cooked biscuit, shredded wheat, rice crispie waste, or any other well-cooked cereal may be used. In table No. 11 an outline of daily rations for fox pups where a well-cooked porridge is used as the cereal portion of the ration is given. Until the pups are three months old, breeders are advised to use rice as the chief portion of the cereal content of the porridge. After the pups are three months old, the porridge can be made out of equal parts of whole wheat flour, cornmeal, rolled oats and rice. When pups are fed a well-cooked biscuit made entirely from wheat products and a porridge consisting mostly of whole wheat, cornmeal and oatmeal, from the ages of one to three months, it is very liable to lead to a form of paralysis of the hind legs, and instead of having a normal gait, they will have a tendency to hop like a rabbit. If at any time this condition should be observed in young pups, breeders are advised to make an immediate change in their ration and to feed rice or rice products as the main portion of the cereal content of the ration.

TABLE 8—DAILY CALORIC REQUIREMENT OF GROWING FOX PUP FOR EACH WEEK AND AVERAGE FOR EACH WEEK

Week	Daily caloric requirement	Week	Daily caloric requirement	Week	Daily caloric requirement	Week	Daily caloric requirement
	cal.		cal.		cal.		cal.
9th	340	13th	415	17th	540	21st	750
10th.....	360	14th	440	18th	608	22nd	760
11th.....	375	15th	465	19th	675	23rd	770
12th.....	390	16th	495	20th	730	24th	770
Average for each month..	366	.....	454	.....	638	.....	762

TABLE 9—CALORIC VALUE OF DAILY RATIONS OF GROWING FOX PUP, AS RECOMMENDED TO FOX RANCHERS

Weeks	Morning meal	Evening meal	Total
	cal.	cal.	cal.
9-12	225	150	375
13-16	225	225	450
17-20	335	300	635
21-24	335	375	710

TABLE 10—DAILY RATIONS FOR FIFTY FOX PUPS FOR FOX BREEDERS WHO HAVE NOT FACILITIES FOR PREPARING PORRIDGE

Rations	2 months old 9-12 weeks		3 months old 13-16 weeks		4 months old 17-20 weeks		5 months old 21-24 weeks	
	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.
Morning meal—								
Milk	10	0	10	0	15	0	15	0
Tripe	4	0	4	0	6	0	6	0
Cereals	2	0	2	0	3	0	3	0
Bread	2	0	2	0	3	0	3	0
Eggs	1	0	1	0	1	8	1	8
Ground green grass	1	0	1	0	1	8	1	8
Yeast	..	6	—	6	—	9	—	9
Amount to be fed to each pup	—	6	—	6	—	9	—	9
Evening meal—								
Cereals	2	0	3	0	4	0	5	0
Meat	6	0	9	0	12	0	15	0
Ground green grass	1	0	1	8	2	0	2	8
Ground bone	—	8	—	12	1	0	1	4
Weak potassium iodide solution	—	1	—	1½	—	2	—	2½
Amount to be fed to each pup	—	3	—	4½	—	6	—	7½

TABLE 11—DAILY RATIONS FOR FIFTY FOX PUPS AS RECOMMENDED BY THE EXPERIMENTAL FOX RANCH

Rations	2 months old 8-12 weeks		3 months old 13-16 weeks		4 months old 17-20 weeks		5 months old 21-24 weeks	
	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.
Morning meal—								
Milk	10	0	10	0	15	0	15	0
Tripe	4	0	4	0	6	0	6	0
Porridge	16	0	16	0	24	0	24	0
Eggs	1	0	1	0	1	8	1	8
Ground green grass	1	0	1	0	1	8	1	8
Yeast	—	6	—	6	—	9	—	9
Amount to be fed to each pup	—	9	—	9	—	13½	—	13½
Evening meal—								
Porridge	10	0	15	0	20	0	25	0
Meat	6	0	9	0	12	0	15	0
Ground green grass	1	0	1	8	2	0	2	8
Ground bone	—	8	—	12	1	0	1	4
Weak potassium iodide solution	—	1	—	1½	—	2	—	2½
Amount to be fed to each pup	—	6	—	9	—	12	—	15

PROJECT No. 15—INHERITANCE OF THE INHERENT CHARACTERISTICS OF THE FUR OF SILVER FOXES

(a) The Black Phase

When silver black foxes were first raised in captivity the original breeders were aware of the fact that red foxes predominated in the wild state; therefore, there was a wholesale fear that the foxes would revert to the red colour, and that was the attitude taken by all those who took up silver fox ranching. No trace of red and rust, was the main stipulation in the purchasing of the silver foxes. The fact that the silver black colour breeds true has been established in fox ranches throughout the country, and there is now no fear of a reversion to the red.

As regards the black phase and the red phase, the red is dominant and the black recessive, and the evidence shows that they breed true according to the Mendelian segregation. When the two phases are crossed, in the first generation all of the offspring are reds, showing the dominant phase. Sometimes these are spoken of as bastard reds, but in general they are called red foxes and are sold as red fox pelts in the fur trade. The only apparent difference between a pure red and a bastard red is that a pure red fox has a white snout and white on the breast and abdomen, while a bastard red has a darker snout and may have a smaller or larger amount of black hairs on the breast and abdomen. When the crosses, or bastard reds, are bred together the offspring produced are on the average near the true Mendelian ratio of the F_2 generation, namely, twenty-five per cent pure reds, fifty per cent crosses and twenty-five per cent pure blacks. The pure blacks produced from the cross reds breed true in accordance with the Mendelian segregation and there is no reversion to the red. Silver black foxes produced from red foxes will breed quite as true regarding the silver black phase as silver foxes produced from pure-bred silver black foxes for a number of generations.

There is a wide variation in the shade of the black phase in different strains of silver black foxes. With some strains this phase may develop into an excellent blue-black colour, with others the colour is less intense, and, with other strains still, the black phase may be bordering on a grey or a brown shade. The microscopic examination has shown that the black colour is due to the pigment within the hairs, and with the different strains of foxes there is a different amount of pigment within the hairs, also a distinct difference between the intensity of the colour of the granules. With those foxes susceptible to a brown shade in the early fall months, there has been a lesser amount of pigment within the hairs than with the foxes that maintain a favourable black colour. It would appear that those foxes that have a tendency to acquire a brown shade during the fall months have not the inherent traits to produce a favourable amount of the black pigment, or there is a tendency for the pigment to be oxidized, or in other ways destroyed, during the early fall months.

With close inbreeding, there has been a very pronounced improvement in the colour of the black phase and invariably it has been found that the offspring have a more intense black colour than the parents. On the other hand, where two different strains of foxes have been bred together, in some cases the results have been most unfavourable, the fur of the offspring produced having a tendency to acquire a pronounced brown shade.

(b) The Silver Phase

The silver phase gives the character and individuality to silver fox furs. There are no two silver fox furs alike and there are all classes of variations with regard to this phase. The area in which the hairs appear on the body

varies with different foxes; there is a variation also in the colour of the silver phase, as well as in the width of the band. Some foxes have a very wide band, others a very narrow band.

In the experimental work with inbreeding, there has been a decrease in the amount of silver. When inbreeding has been carried on for several generations, the decrease of the silver phase has been more pronounced in each successive generation. Starting with medium silver foxes and inbreeding closely for three or four generations, the offspring have been eventually entirely black. On the other hand, with outcrossing or breeding distantly related animals, there has been an increase in the silver phase.* In many cases, where the ancestors on the average were dark silver foxes, by systematically outcrossing and breeding with foxes that were in no way related, as far as known, many of the offspring produced have been pale and extra pale foxes.

When black and dark foxes have been mated to pale or extra pale foxes, the results have not been satisfactory. In the majority of cases the litters were part black and part pale, with an occasional pup that was medium silver. When mating dark foxes and pale silver foxes together, the vast preponderance of the offspring produced was the extreme in one or the other direction, and the medium silver was very rare. The most favourable results have been obtained in general when silver foxes have been mated to like silver foxes.

Can a silver phase be fixed? This is a most important question with regard to silver fox ranching. Up to the present time no conclusive evidence has been obtained regarding this point. With inbreeding with pale silver foxes, there has been a great improvement in the character of the fur, and an increase in the black phase, more particularly on the tips of the fur, giving a desirable veiled appearance to the silver and improving the character of the fur. On the other hand, when breeding different strains together, there has been an increase in the amount of silver, but in many of the cases the silver band has been extremely narrow, giving a "pepper and salt" appearance to the fur, reducing the pelt value.

The evidence as a whole would indicate that in order to carry out any system of inbreeding in the hope of producing super foxes, it is necessary to start with either pale or extra pale silver foxes.

(c) The Cuticle

In the Experimental Fox Ranch, with the various strains of foxes, there are a number of different types of cuticles, which determine the nature of the fur, those with soft, flexible cuticles, having a soft, smooth fur; those with horny cuticles, a strong, harsh fur; those with coarse cuticles, an extremely coarse fur. These different types of cuticles play a very important part in the economic value of the pelt, as some cuticles have primed and gone off colour very readily and were also very readily affected by inclement conditions. On the other hand, some cuticles have been very resistant to priming and have withstood the weather without tarnishing. According to the observations, in general, the coarse and horny cuticles, when exposed to the sun or weather, have gone overprime, which gave a tarnished appearance to the silver and a pronounced brown shade to the fur. The soft and flexible cuticles do not appear to prime readily and foxes with soft and flexible cuticles, that have been ranched in open pens, have retained a relatively clear black, and a bright silver colouring.

In the experimental work, inbreeding has invariably led to a great improvement with regard to the texture of the fur. The fur had a softer and smoother texture and the foxes have had a tendency to maintain a clear black and a bright silver colour even when ranched in open pens. On the other hand, in breeding foxes that were distantly, or in no way, related to each other, the offspring had

* Silver colouring, pages 19-24, Report of the Superintendent, Experimental Fox Ranch, for 1928-29-30, Dominion Experimental Farms, Department of Agriculture.

a fur that was very coarse and harsh with a tendency to become overprime early in the season. In some cases the types of cuticles appeared to be opposed to each other. The two types failing to blend together led to an inhibition of the development of both the cuticle and cortex of the hairs, so that very few guard hairs developed, and those that did develop were extremely weak, the fur of the foxes being very streaky and open, bordering on a samson condition. It appears probable that in many cases where samson foxes have been produced it has been due to breeding together two different types of cuticles that will not blend with each other.

(d) The Underfur

In the experimental work, different types of underfur have been noted, varying in colour, texture, density and length; dark slate, light slate, white, dark muddy and light muddy underfur have been observed with different foxes; all gradations between coarse and fine silky textures have been noted at different times, sometimes in the same foxes, but generally in different foxes. In some cases there has been a fairly favourable density, giving a large volume to the fur; in other cases, while the underfur had good length, it was lacking in quantity; and in extreme cases, the underfur has been lacking both in length and quantity, making a very flat pelt.

While the different conditions met with have been, to a great extent, dependent upon the manner in which the foxes have been fed and managed, inheritance and the manner in which the foxes were mated played an important part with regard to the production of the different types of underfur.

When different strains of foxes have been mated, the offspring have generally had a large volume of underfur, but it has not been of a favourable lustre, colour or texture, and the general tendency has been for the underfur to go off colour, giving a very pronounced brown shade to the fur. On the whole, outcrossing has led to an increase in the volume of underfur, but not of a desirable quality. With inbreeding there has been invariably a great improvement in the texture and colour of the underfur. With long-furred foxes there has been a favourable volume of underfur, as well as an improvement in the colour and texture, but it has been noted with inbreeding of short-furred foxes, there has been a decrease in the density of the underfur, tending to produce a flat pelt. The experimental work indicates that it is not advantageous to inbreed with short-furred foxes. The evidence as a whole would lead to the conclusion that it is not advisable to have short-furred foxes in the breeding stock, and they should be eliminated as quickly as circumstances will allow.

RECOMMENDATIONS

There is a great danger in promiscuous breeding of silver foxes. The system of breeding foxes as distantly related as possible should not be countenanced; it is liable to lead to foxes having a brown shade, indifferent silver colouring, and a coarse, harsh underfur, foxes that will readily go overprime and have poor fur and breeding qualities. Breeders are warned against indiscriminately mixing different strains of foxes. It is not advisable to introduce foxes of different strains into their breeding stock, unless there is direct evidence that they will blend with their own strain of foxes. Given a fair strain of foxes, breeders can produce better animals with better pelt value and better breeding qualities by proper arrangement of the mating of their own breeding stock, than by continually introducing new blood into their breeding stock.

It would be advantageous to mate pale foxes as closely related as possible, perhaps as close as father and daughter, son and mother, or brother and sister. Grandfather and grand-daughter, grandson and grandmother, uncle and niece, nephew and aunt or first cousins should make ideal matings with pale silver foxes. Dark silver foxes should be mated to fairly distantly related foxes

within the ranch's own breeding stock. It is not advisable to mate black foxes with extra pale foxes. Such matings have rarely been known to produce good results. Generally the litter is a mixture of unfavourable types. It is advisable to mate silver with like silver, pale silver with pale silver, dark silver with dark silver, the pales closely related, while the darks should be distantly related. Foxes with a wide silver band should be mated with those having a similar band of silver, and foxes having a narrow band of silver should be mated with those having a narrow band.

A favourable underfur, with a silky lustre and a dark slate colour, is a very important factor in the production of an economic pelt, and breeders should take particular note that they are mating their foxes in such a manner as to produce a favourable type of underfur. According to the results of the experimental work, this can be obtained only by a careful system of inbreeding.

Breeders who have foxes in their breeding stock that acquire a pronounced brown shade early in the fall months should take steps to eliminate them as quickly as possible from the breeding stock, as it is an indication that those foxes are a conglomerate of a large number of strains. Retaining such foxes among the breeding stock will tend to spread through the ranch a large number of different types of foxes, increasing the difficulty of producing a pure-bred, high-class animal. Short-furred foxes are a financial liability to any fox ranch. Many of these foxes may look like a good class of fox early in the fall months but tend to produce flat pelts. The trade demands fur of good depth and volume and will pay a relatively high price for it. There is very little hope of ever making any decided improvement with short-furred foxes.

On the average, foxes with wide silver bands will produce better financial returns than those with narrow silver bands. By breeding with foxes with a wide silver band, in the great majority of cases the entire litter has a uniformly desirable type of pelt.

PROJECT No. 16—INFLUENCE OF INBREEDING AND OUTCROSSING ON THE FUR OF SILVER FOXES

The highest price obtained for any pelt from foxes raised in the Experimental Fox Ranch was $275.40. This pelt was taken off a female fox that had two immediate generations of samson male ancestors; the two males came from the same ranch and were first cousins on both sides. A female, partly related to the males, was bred to one of the samson males and a daughter from this mating was bred to the other samson male. Two other pelts from the same breeding stock averaged over $239.00. Inbreeding has led to a general improvement of the fur.

The foundation stock of the Experimental Fox Ranch is made up of foxes from a large number of different ranches. As a result, this has naturally led to a great number of cases of outcrossing, which led in the first instance to very unsatisfactory results from a fur standpoint. An improvement has been made in the fur of the foxes by a systematic method of inbreeding.

Dalton and Oulton, the original pioneers of the silver fox industry, produced some remarkably fine foxes. Starting from a relatively small number of foxes, under the circumstances, there must have been some very close inbreeding. Some of the other older fox breeders, with a small number of foxes, produced some outstanding animals that formed the foundation stock of a number of ranches. These foxes had excellent fur qualities and bred successfully for eight and ten years in succession. When these foxes were raised, close inbreeding had been practised. As the number of foxes increased in the ranch, some of these fox breeders made a practice of mating foxes as distantly related as possible. In a few years, in some cases, when the size of the ranch grew to the neighbourhood of one hundred pairs, an inferior type of animal was being produced with both poor fur and breeding qualities. To-day, those ranches, together with their

strains of foxes, have passed out of existence. The fox breeders started with high-class foxes. As long as they were forced to inbreed on account of the limited stock available, they produced a high-class type of fox that earned a world-wide reputation, but by a system of breeding foxes as distantly related as possible, many strains of foxes have been reduced to an inferior type of animal lacking in constitutional vigour.

Ranches established by a collection of foxes from different ranches have had a most unfortunate history, although it was an undoubted fact that outstanding foxes, selected by most capable judges, formed the foundation stock. As long as the foxes were bred together in pairs, as purchased from the breeders, high-class foxes were produced, but in the second and third generation, when the offspring were crossed with those produced from foxes from other ranches, there was a wholesale production of foxes of a most inferior type, bordering on the samsons.

Other breeders have established ranches with high-class, select silver foxes and have, year after year, combed other ranches for new blood. Some of these breeders, reliable judges of silver foxes, have carried on a system of breeding foxes as distantly related as possible. Considering the high quality of silver foxes that formed their breeding stock and the ability of these breeders to accurately recognize fur qualities, which placed them in a position not only to select high-class foxes, but also to eliminate inferior animals and retain the cream of their offspring for breeding purposes, after a few years the results have been most disappointing and not up to the standard that would be expected. The general history of such ranches has been that prize-winning foxes were produced in the first or second generation and the foxes then deteriorated to mediocrity or an inferior type. On the other hand, an examination of the pedigrees of the champion foxes at the leading shows has shown that the outstanding animals and the champions of the shows have been evolved by a system of intense inbreeding.

RECOMMENDATIONS

It would appear that hybrid vigour does not apply to silver foxes. In any case hybrid vigour is very much a " will of the wisp " for any animal breeder. Breeders might by chance obtain a favourable result by an outcross, but it would be the exception rather than the rule. Breeders are warned against adopting a system of breeding distantly related animals. No matter how capable judges breeders may be of the fur of foxes, no matter how rigidly they may eliminate inferior stock and select the cream of their offspring for breeding purposes, no matter how excellent may have been the foxes that formed their foundation stock, a system of breeding animals as distantly related as possible in large ranches will inevitably lead to a deterioration in the fur of the animals which will become more pronounced in succeeding years. One thing is absolutely certain, it will never lead to a decided or continued improvement in either the fur or breeding qualities of the foxes. If it should be expedient to outcross it should be confined to inbred foxes, on both sides, the product of matings as close as father and daughter or at least as close as grandfather and granddaughter.

PROJECT No. 17—THE EFFECT OF INTENSE INBREEDING ON THE VITALITY AND FERTILITY OF SILVER FOXES IN CAPTIVITY

In the experimental work, over fifty cases of close inbreeding, mating father and daughter, or mother and son, or brother and sister, have been carried out, and ten cases of close inbreeding for two successive generations with brother and sister matings, or father and daughter, then son and mother, or vice versa. The results have demonstrated some very interesting and important facts.

A particular male was very efficient, never fought with the females, was always very gentle with them and mated within a few minutes after being placed in pens with strange females that were in heat, whether the females were cross or otherwise. A brother and a sister produced from this particular male were mated together. The male offspring showed the same favourable polygamous characteristics as the sire. They readily mated, even as pups, with four and five females in one season, and the favourable characteristics persisted for two generations of outcrossing. Another efficient male was mated to his own daughters and some of the male offspring were mated back to their mothers. The male offspring, after two generations of close inbreeding, showed improved polygamous characteristics. In the experimental work, close and continued inbreeding has not affected any strong inherent traits. In fact the results have demonstrated very clearly that the strong traits are intensified and improved in each succeeding generation.

In the Experimental Fox Ranch, there have been several males that for several years were entirely indifferent to females in heat. They were placed in pens, year after year, with females in heat, but made no attempt to mate. In subsequent years some of these males were given one-twenty-sixth of a grain of Yohimbine Hydrochloride for a period of twenty days and some mated with several females within a few days. The male offspring showed the same characteristics of the sires and were entirely indifferent to females that were in heat and made no attempt to mate with them. Some of the sires were mated to their sisters and there were other forms of close inbreeding; in every case either the pups died at birth or the females did not become pregnant. In these cases the lack of desire of mating was a physical weakness, more deep-seated than simply a trait connected with the mating ability. The evidence of the experimental work would indicate that it is impossible to carry on inbreeding with foxes showing physical weaknesses or disabilities.

Where the dam ancestors of the foxes had a large litter production of five and over, inbreeding increased the size of the litter and the female offspring successfully raised pups in succeeding years. But in inbreeding, where the dam ancestors of the foxes had small litters, either the mating was barren in the first place, or the female offspring failed to become pregnant when mated or else lost their pups at birth. In some cases there was malformation of the pups.

When the Experimental Fox Ranch was first established, the average size of the litter was relatively small for the first few years. By carefully inbreeding efficient polygamous males and females, whose dam ancestors had favourable litter productions, a stage has been reached where the size of the majority of litters is five or more.

The experimental work would indicate that a low litter production is evidence of a weakness in the inherent traits, which is more deep-seated and has a more far-reaching effect than simply the production of small litters. On the other hand, a large litter production has been associated with a desirable constitutional vigour, and any reasonable form of inbreeding would intensify both of these desirable traits.

From the evidence obtained in the experimental work and also from that gathered in other ranches, females that were either the product of or only one generation removed from some form of very close inbreeding, raised litters for eight and ten years consecutively. In a large number of ranches the great majority of the females produce only two, or at the most three litters, before their breeding days are ended. Some breeders state that when a female has raised three litters, they are through with her. The evidence in the experimental work would indicate that the breeding qualities of the foxes cannot be maintained without reverting to some form of close inbreeding and it is not advisable to go more than two generations without inbreeding.

In the Experimental Fox Ranch, the large-size foxes have been the most prolific breeders and have had the most favourable constitutional vigour. There have been some cases where some vigorous and very prolific males and females have been relatively small in size, but invariably these foxes have produced offspring that have been large, and extremely so after inbreeding. On the other hand, there have been small foxes in the ranch that have always produced small-size foxes and these have been lacking in constitutional vigour. Undoubtedly there are some small foxes that have inherent qualities of largeness. The evidence obtained in the Experimental Fox Ranch indicates that it is not desirable to breed with small foxes. Small size appears to be evidence of a constitutional weakness and, unless small or medium-size foxes produce foxes that are relatively large, they should be eliminated from the breeding stock. Certainly, inbreeding should be carried out only with large foxes or foxes that have the inherent quality of largeness.

As already pointed out, inbreeding with dark or medium foxes has invariably led to the offspring being entirely black after a few generations, and it has been impossible to make any improvement with inbreeding with short-furred animals. Therefore, the evidence of the experimental work indicates that inbreeding should be confined to long-furred, pale silver foxes with strong inherent breeding traits.

RECOMMENDATIONS

Breeders are warned against using any males that do not have strong polygamous characteristics for any form of inbreeding, or as a matter of fact for any breeding purposes whatever. Both males and females should have dam ancestors that have had a large litter production. It would be fatal also to use foxes for inbreeding whose ancestors have a small litter production. While some success may be obtained with outcrossing with such females, still the inherent weaknesses will be transmitted to the offspring. It is, therefore, advisable to eliminate all foxes with dam ancestors having a low litter production, from the breeding stock.

If dark silver foxes are used for inbreeding purposes, it will become a financial burden to the ranch. It does not pay breeders to have their ranches overrun with black and dark silver foxes. Using long-furred, pale silver foxes, with male ancestors having favourable polygamous characteristics, and with dam ancestors having a high litter production, there appears to be every possibility of improving the fur and the breeding qualities of the foxes, and increasing the size of the litter in each succeeding generation, eventually outstanding foxes should be produced that will have a high litter production of six, seven or more, by a rational form of inbreeding such as mating grandfather and grand-daughter, grandson and grandmother, or first cousins. But, as already pointed out in this report, it is very necessary that those foxes should have a dense black colour of the fur, and there appears to be very little hope of successful results with inbreeding with foxes with a brown shade, as it is too great a conglomerate of different inherent traits. The more diversified the inherent traits, the more difficult it is to produce high-class animals.

PROJECT No. 18—BREEDING EXPERIMENTS WITH RED, CROSS RED, AND PATCH FOXES

So far in the experimental work, only a limited number of reds, cross reds, and patch foxes have been used. From the observations made in the experimental work and in different ranches, the evidence has been conclusive that the red is dominant and the silver black recessive. Whenever pure silver black foxes have been bred to pure reds, the offspring invariably have been red foxes, the red being completely dominant except with regard to the snout, paws, and

breast, and their pelts are classed and sold by the fur trade as red furs, the same as pure reds. When cross reds have been bred back to Prince Edward Island silver black foxes the offspring, on the average, have been near to the true Mendelian generalization of 50 per cent silver blacks and 50 per cent cross reds. The silver black foxes produced by mating cross reds to Prince Edward Island silver black foxes have always bred true with the Prince Edward Island silver black foxes and there has been no reversion to the red in subsequent generations.

The patch fox, the so-called cross fox of the fur trade, is not a cross between a silver black fox and a red fox, but is a cross between two different varieties of silvers. When Alaskan silver black foxes that have bred true among themselves have been bred to Prince Edward Island silver black foxes, the offspring have been patch or cross foxes, showing a greater or a lesser amount of the red phase. The amount of the red phase has been a very variable factor; on the one hand some cross foxes have only a trace of the red fur around the ears and on the edge of the hips, the pelts selling as silver black furs; while, on the other hand, some cross foxes have been observed where the amount of red was approximately the same as in pure reds and they looked like red foxes except that the red was of a darker shade. All variations between these two extremes have been observed at different times.

It appeared probable that there were two complementary factors with regard to the production of the red phase, the same as with purple sweet peas and red-grained corn, the one complementary factor being absent in the Prince Edward Island silver blacks and the other absent in the Alaskan silver blacks. Consequently, it was thought that if cross or patch foxes were mated back to either Prince Edward Island silver black foxes on the one hand, or Alaskan silver black foxes on the other, the offspring on the average would be two silver blacks, one patch or cross fox, and one cross red fox. In the first litter observed after making that deduction the pups were in that ratio, and a large number of litters have since been observed in the same ratio. As would be expected, there have been many variations from that ratio, but generally the three types of foxes, silver black foxes, cross or patch foxes, and cross red foxes have been present in each litter, although in some cases the litters have been all silver blacks, while in others all cross reds.

When silver black foxes, produced from mating silver black foxes and patch foxes, have been mated with other silver black foxes, in the majority of the cases a number of patch foxes have been produced, while silver black foxes produced from cross red foxes have bred true in succeeding generations without showing any red phase.

RECOMMENDATIONS

Patch or cross foxes are a cross between two different types of silver black foxes. Any silver black foxes produced from patch foxes may belong to one or the other type. Unless such silver black foxes are mated back to the type to which they belong, part or all of the offspring produced may be patch or cross foxes. Therefore, it would require at least three or four generations of breeding back to Prince Edward Island silver black foxes before it could be definitely determined that the silver black phase in silver black foxes produced from patch foxes would breed true with Prince Edward Island silver black foxes. On the other hand, any silver black foxes produced from silver black and cross red foxes will breed true. Breeders are advised not to attempt to derive a pure strain of silver black foxes by breeding from patch or cross foxes. If any breeder has an idea that he can improve his silver black breeding stock by introducing the desirable traits of foxes in the wild state, it would be more feasible to use high-class red or cross red foxes rather than patch or cross foxes.

The offspring of a cross between pure silver black foxes and pure red foxes should be designated as cross red foxes, and the offspring of a cross between two different types of silver as patch or cross foxes. Some breeders have correctly called the latter silver crosses. The "cross silver" term truly expresses the breeding of the foxes, but unfortunately not the colour phase. On the other hand, the term "cross foxes" used by the fur trade, expresses correctly the colour phase of the pelt, but is misleading with regard to the breeding of the foxes.

PROJECT No. 19—CONTROL OF INTERNAL PARASITIC INFESTATION

(J. C. Jack, Animal Physiologist)

(a) Prevention and Control of Internal Parasitic Infestation by the Use of Dry Wooden Floors

During the first three years that the Experimental Fox Ranch was in operation the pups were maintained in soil-bottomed pens which had been newly built when the ranch was established. Each year an increase was found in the worm infestations. During the third year many pups began to wheeze shortly after they were nine weeks of age, became thin, and failed to make normal gains in weight. Many of the sturdier pups showed severe hookworm infestations after they were three months old and some females bled slightly from the vulva during the summer, indicating the presence of bladderworms. A number of wooden floored pens * were constructed and the wheezing pups were placed in them. In from five to ten weeks after so doing, the breathing of the majority of these pups became normal; and although they still continued to pass lungworm eggs yet they made complete recoveries from the lungworm infestations and resumed satisfactory growth rates. Furthermore, the discharge of blood from the vulvae of the females ceased, the hookworms became less numerous, but the ascarids did not appear to diminish appreciably. Since then, for six successive years all vixens with their litters have been removed from soil bottoms to wooden floors when the pups were not older than five weeks. During these six years the growth and development of the pups have not been affected by lungworm, hookworm, or bladderworm infestations, although ascarids were found to continue until repeated pilling removed them.

The first year that all the pups had been maintained upon wooden floors after five weeks of age, one group was transferred to soil-bottomed breeding pens during the first week of November. Some of these pens had been newly built. Another group was transferred at the end of December when frost and snow had become permanent for the winter. The majority of the pups transferred in November contracted lungworm infestations and some died during the early winter as a result; but those transferred at the end of December were not affected by either lungworm or bladderworm infestations during the winter. For five successive years, in accordance with the weather prevailing late in the fall, the pups have been transferred to snow-bottomed breeding pens without incurring either lungworm or bladderworm infestations during the winter.

At the Experimental Fox Ranch many vixens which had whelped or nursed pups in soil-bottomed pens after the snow had disappeared, have been found suffering from lungworm and bladderworm infestations. In such instances the

* See Report of the Superintendent, Experimental Fox Ranch, 1928-29-30, pages 39-41.—These wooden floors were built a foot or two clearly off the ground to keep the structure dry underneath. Accumulation of rain water and urine upon the floor surfaces has been avoided by providing a gentle slant and by raising the side frames with iron angle supports. Matched spruce was used for flooring, some pens, one and one half inches thick, others, two inches in thickness. The feces have been removed regularly by ranch workmen and periodical cleansing by washing with water, disinfectants, or oils has been practised. With seven years of continual use these floors are still well preserved and practically no repair has been necessary.

dam and her pups were moved to the wooden floored pens and weaning took place at five weeks or as soon after as possible. Some of these vixens died after weaning but due to the wooden floors the pups were reared free from similar infestations. When vixens, due to whelp late, had been placed in wooden floored breeding pens before the snow had disappeared, both the vixens and their pups have been found to be fully protected from lungworm, bladderworm and hookworm infestations. It has been observed that the foxes reared upon wooden floors required protection from lungworm infestations, not only as pup-breeders, but also as yearlings. Furthermore, adult animals which had been protected during puppyhood from lungworm infestations appeared to have been much more susceptible to infection and suffered more severely from the seizures than adult animals which had been reared upon soil bottoms.

Certain defects in the use of wooden floors have been revealed by the examination of carcasses and living foxes brought to the Experimental Fox Ranch by the public. Such floors had been kept damp and thereby rendered useless for parasitic control, in one case by over-zealous washing, in another by warped boards exposed to continual rainy weather, and in several instances by having been laid too closely to the ground. The rare lungworm has been found thriving in foxes upon wooden floors, and the same has applied to coccidia. Cases, showing clearly the effect of dry wooden floors upon infestations of flukes and tapeworms, have not yet been found, due to the infrequent occurrence of these parasites. Instances of very unsanitary conditions have been found in ranches using partially successful schemes for ridding floors of feces, such as the slatting of hemlock floors and the covering of apertures in spruce floors with wire mesh, due to neglect in regularly cleaning the floors and the areas beneath them.

RECOMMENDATIONS

Pups whelped in soil-bottomed pens should be moved to dry wooden floors at or before five weeks of age to protect them from the common lungworm, hookworm, and bladderworm. Breeding stock reared upon wooden floors should not be moved to soil-bottomed breeding pens until the frost and snow have become permanent for the winter. Vixens due to whelp late should be placed in wooden floored breeding pens before the snow has completely disappeared. Lactating vixens found suffering from lungworm or bladderworm infestations should be moved with their litters to dry wooden floors and the vixen should be separated from her litter as soon after five weeks as possible.

(b) Common Lungworm Infestation*

Seventy-nine pens at the Experimental Fox Ranch have soil bottoms. Systematic methods have been tried without success to control internal parasitic infestations by treatment of the soil with either disinfectants, spading lime into the ground, keeping the grass cut, or by burning the surface with a firegun. It has been necessary to determine frequently the intensity of lungworm infestation in all foxes occupying such pens except during the winter. This has been accomplished weekly by sounding the chests with the unaided ear. The fox was caught in the left hand by the hind legs and tail, then the neck was taken in the right hand so that the shoulder of the fox was lying in the palm while the first finger and thumb encircled the neck loosely. The chest was then placed against the observer's ear. The most satisfactory observations have been made by listening to the unhurried breathing of a comfortable animal rather than when the chest had been squeezed or the fox had been run about beforehand.

* See Report of the Superintendent, Experimental Fox Ranch, 1926-27, pages 17-19; also 1928-29-30, pages 34 and 39-41.

So long as such foxes maintained the practically soundless breathing of normal animals, the lungworm infestation was not considered dangerous under the circumstances. Such consideration recognized that infection with lungworm was to be expected in these pens and that relatively harmless infestations had been observed to proceed for periods of variable duration in the majority of these foxes; these infestations had been below the intensity required to produce wheezing and they had been found by microscopic examination of the feces. As soon as a wheeze was heard, upon sounding, the fox was transferred to a dry wooden floored pen. The lungworm origin of the wheeze was either confirmed by the regular records of the microscopic examinations of the feces or, in cases of doubt, the feces were examined for lungworm eggs and the throat was carefully inspected. A number of cases have been observed where fish bones, bits of straw or hay, oat-hulls, pieces of wood, etc., have been drawn into the windpipe and have caused sounds like the wheeze of lungworm origin. Heaves or emphysema have been found in some foxes after recovery from severe infestations, and such animals did not always show lungworm eggs upon microscopic examination of their feces. However, the exceptions, where wheezings had been due to other origins than lungworm, have been so few in occurrence in comparison with those of lungworm origin that the soundings without microscopic confirmation have served as a rapid and accurate method for estimating the extent and intensity of the infestations in the herd of foxes.

Any of these foxes that had suffered severe infestations and recovered upon wooden floors usually wheezed continually during eight to twelve weeks. The earliest sounds were like the crackling of paper, soon afterwards mixed flute or pipe-like noises were heard, developing later into a medley of gurgles, roars and highly pitched notes. During the severest period the notes were damped, the breathing was laborious, and many foxes stood with the mouth continually open and the nose slightly elevated. When recovery set in, the mixed sounds from the chest frequently gave way to notes resembling the washing of water. A week or so afterwards, it was not unusual to find normal breathing once more prevailing and the fox regaining its weight lost during the seizure.

The majority of the foxes that were transferred to the wooden floors as soon as the wheeze was heard, recovered from the infestations. The appetites were found to be erratic during the suffering and it was necessary to observe these closely and maintain, where possible, a food intake greater than that required by a normal fox.

Autopsy of those that died showed that death occurred in at least two distinct ways. The most frequent form was stoppage of the windpipe and bronchi with the phlegm that accompanied the presence of numerous lungworms in these organs. The less frequent form was haemorrhage from the lungs caused by the violent coughing which occurred during the infestations.

(c) Bladderworm Infestation*

Except during the winter all the vixens maintained in soil-bottomed pens have been examined weekly for indications of bladderworm infestations. Incrustation of blood about the vulva, sometimes accompanied by enlargement of the organ, and in advanced cases the passing of blood-tinted urine, have been observed as symptoms indicative of bladderworm infestation. Upon the appearance of any of these symptoms the vixen has been transferred to a wooden floor. In almost all cases the symptoms disappeared by a few weeks afterwards and no deaths have been sustained.

Except for the passing of blood-tinted urine by the males, other symptoms have not been found indicative of such infestations. By placing such males immediately upon wooden floors recoveries have occurred in all cases except one

* See Report of the Superintendent, Experimental Fox Ranch, 1928-29-30, page 42.

which died due to the losses of blood sustained. The public has brought many carcasses for examination where the urethra of the male had become blocked with tissue debris, bladderworms and sediment at the level of the bone in the penis.

(d) Hookworm Infestation*

Since the installation of wooden floors at the Experimental Fox Ranch light hookworm infestations have been reduced and controlled by simply maintaining the infested animals upon them. Where severe infestations were found by microscopic examination of the feces, such foxes were pilled with tetrachlorethylene (8 minims for pups, 6 to 8 pounds, 16 minims for adults; the capsule was delivered into the gullet with a pilling gun after a 24-hour fast; food was given within 4 hours after administration; dietary fat was reduced to minimum 2 days before and after pilling; dry bone meal was fed daily in diet commencing 2 days before, until 10 days after pilling).

(e) Ascarid Infestation*

The pups at the Experimental Fox Ranch have been protected from ascarids by pilling at 3, 4 and 5 weeks of age with oil of chenopodium in castor oil. Burroughs Wellcome "Tabloid" Worm Capsule (for fox pups) has been used in a variety of dosages, depending upon the size, age, and condition of the pup. The following scale of dosages has been found satisfactory to use as a guide; at 3 weeks, pups less than 1 pound, one capsule; pups more than 1 pound, 2 capsules; at 4 weeks, pups less than 1½ pounds, 2 capsules; pups more than 1½ pounds, 3 capsules; at 5 weeks, pups more than 1½ pounds, 3 capsules.

A solution of oil of chenopodium in castor oil has also been used for dosing pups from three weeks to three months of age. This solution was composed of 6·2 cc. of oil of chenopodium made up to 100 cc. with castor oil. This solution had an oil of chenopodium content of approximately one minim per cubic centimetre. It has given satisfactory results with safety to the pups when administered by stomach tube in the dosage of ¼ cc. (i.e. ¼ minim of oil of chenopodium) per pound of live weight. Pups old enough to consume food have been fed shortly after the administration.

Many fox pups under six weeks of age have been brought to the Experimental Fox Ranch by the public in a comatose state after having been pilled with tetrachlorethylene. Some rather extensive losses have also been observed in commercial ranches. Furthermore, leg-weaknesses and appearances suggesting rickets have been observed in some of the above instances a week or two after the pilling with tetrachlorethylene. Such disorders have been noted both where capsules containing only tetrachlorethylene had been used and where it had been present in the capsules along with other substances. Tetrachlorethylene has been found very efficient for the removal of hookworms, but hookworms have rarely been found to produce serious infestations in pups under three months of age. It was the ascarid that had caused the difficulties in the very young pups. The prescribed dosages of oil of chenopodium in castor oil, either in the commercial capsules mentioned or in the solution made up for the purpose, have proved to be safe and reliable in the course of the work at the Experimental Fox Ranch.

* See Report of the Superintendent, Experimental Fox Ranch, 1926-27, pages 16-21; also 1928-29-30, pages 34-39.

* See Report of the Superintendent, Experimental Fox Ranch, 1926-27, pages 16-21.

PROJECT No. 20—CONTROL OF EXTERNAL PARASITIC INFESTATION

(J. C. Jack, Animal Physiologist)

The methods previously described* for relieving individual foxes from severe infestations of fleas and earmites still continue to give satisfaction in severe cases. However, the desirable objective was to prevent the occurrence of external parasites upon the ranch property. The use of the torch or firegun upon the nests, kennels, floors, and other pen structures afforded temporary relief at the Experimental Fox Ranch, but the necessity for repeating the treatment frequently, the labour involved, and the expense incurred, suggested that some other method might prove more suitable. Such a method has been found in the application of fuel oil or kerosene sprays to the woodwork and surroundings of fox pens.

Some years ago fuel oil was used in comparison with other disinfectant sprays upon certain respective groups of pens. Soon after periodical spraying had commenced it was observed that the fleas and earmites were almost totally absent upon the foxes in the fuel oil group. During the past three years either fuel oil or kerosene sprays have been used for the control of these external parasites. These substances have proved very efficient, inexpensive, and non-injurious to the fur or health of the fox when properly and carefully applied to the woodwork of pens and other surroundings of the fox.

The oil must not be sprayed upon the foxes; nor should it be exposed in such a manner that the animals will ingest it with the food. Treated pens, kennels, nests, and sheds should be left vacant for at least one week. The treatment need not be repeated more frequently than once every three months and sometimes once every six months is sufficient. With some attending risk sheds may be sprayed and the foxes replaced during the same day, provided that: a light spraying is done, all surplus oil is mopped up, a fresh deep bedding is used, the food is distributed in pans and in such consistency that masses of food cannot be removed by the fox, and the drinking water is not contaminated with oil.

* See Report of the Superintendent Experimental Fox Ranch, 1926-27, page 16.—A fox infested with fleas, should be dusted with flea powder (either derris root extracts or pyrethrum powders from sealed containers); when infested with earmites, the ears, if the skin is unbroken, should be swabbed lightly but uniformly with glycerine and iodine earmite lotion (dissolve 1 ounce of potassium iodide in 1 ounce of distilled water; add 1 ounce of sublimed iodine; dissolve and add 28 ounces of glycerine; dissolve completely); if the skin is broken, the ears should be cleaned out with warm water and a swab, rinsed, and wiped dry, then 5 per cent silver nitrate solution should be applied to the broken flesh.

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