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A GASTRIC INTUBATION TECHNIQUE FOR PREWEANLING RABBITS AND ITS APPLICATION IN CREEP FEED EVALUATION

By

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GENERAL ABSTRACT

Two studies were conducted to examine the effect of creep feed supply on the performance of preweanling New Zealand White rabbits. In the first experiments a gastric intubation technique was developed to force feed a suspension of starter diet containing a high level of good quality protein. Over the course of the main trial 67 g of diet were fed to 13 to 24 day old rabbits. At 25 and 28 days of age body weight was increased by 22 and 26 g, respectively ($P<.05$). It was concluded that the force feeding technique could be employed for comparing different starter diets. As the procedure imposes physical stress on the animals the economics of creep feed supply should be evaluated through an ad libitum feeding trial.

In the second study starter diet was made available free choice to test whether resulting feed intake and body weight gains would justify a creep feeding program in a commercial situation. Two different feeding regimens were followed where starter diet was supplied either inside and outside the nest box (R1) or only outside the nest box (R2). When feed was available body weights were 15 and 17 g heavier at 25 and 28 days of age, respectively, as compared to non-fed control rabbits ($P>.05$). Supplying creep feed as in R1 was associated with a decrease in body weight by 15 g ($P>.05$) and 27 g ($P<.05$) at the respective times. From this study the conclusion was drawn that the supply of a high quality starter diet does not lead to sufficiently higher weight at weaning time (28 days) to realize a profit over the expense for feed and creep feeders. Instead it is suggested to place greater emphasis on the formulation of a more suitable lactation diet for the dams.

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FOREWORD

This thesis has been prepared in manuscript style in order to submit two papers to the Journal of Animal Science for publication. For the purpose of the dissertation at hand the common sections of the two literature reviews were extracted and combined into a general review (ref. p. 3-8). A pilot study to the force feeding trials was not included for publication but is described in the present report. A broader background to the studies and more detailed data interpretations were also added.

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GENERAL INTRODUCTION

The New Zealand White and the Californian are two breeds of rabbits dominating today's rabbit meat production in North America and Europe. With an adult weight of about 4.5 kg they are lighter than the traditional European breeds and are well adapted to living in wire cages under housing conditions similar to those in the laying hen industry.

Rabbit farming in North America is a very small sector of agriculture and in recent years deficient profit margins have forced many medium and large sized Canadian producers out of business. Profit is directly related to the number and weight of rabbits reared annually from each female. Due to prevalence of disease, especially pneumonia and enteritis, and due to the absence of strict breeding and selection programs average yearly production per dam has been approximately 21 rabbits or 48.0 kg of market weight. This stands in opposition to a conservative estimate of 48 rabbits or 110.0 kg of market weight potential (Presch, 1983). The rabbit is a highly prolific domestic animal with an inherent growth efficiency close to that of broiler chickens. Thus efforts to improve the economics of rabbit meat production are well justified.

The present study is concerned with improving weaning weights as one aspect of production efficiency. Body weight at weaning, i.e. at 28 days of age, is positively and significantly correlated with 49 day weight ($r = .80$, $P < .01$, Presch, 1983, unpublished data) and with 56 day weight ($r = .44$, $P < .05$, Lukefahr et al., 1981). Therefore heavier animals at weaning tend to maintain their advantage to market age and supplying rabbits with a suitable supplemental feed before weaning may be economically important. Hence, one goal was to determine the advantages of supplying starter diet ad libitum to young rabbits as uncertainty exists about the economic value of creep feeding for rabbit meat production.

However, creep feeds are very expensive due to their high content of good quality protein such as dried skim milk powder and soybean meal. In order to increase profit, cheaper rations have to be formulated by using different feed ingredients such as canola meal while lowering the content of the expensive sources to a minimum. One objective of the present research was therefore to develop a force feeding technique for young rabbits which allows the comparison of at least two starter diets in an efficient way.

LITERATURE REVIEW

Young rabbits possess a high potential for growth. Hardmann et al. (1970) used surrogate mothers for twice a day suckling of one to three week old rabbits (California White) and found that the young grew significantly faster than normal. Body weight at weaning (21 days of age) was doubled and the observed advantage in growth and body weight resulting from extra feeding was still present at 28 days of age. Hardmann et al. (1970) concluded from their studies that under normal rearing conditions young rabbits are undernourished in relation to their inherent growth potential and do not reach their limit for gaining weight.

In commercial meat production systems supplemental milk cannot be provided to the young, thus progeny performance is greatly affected by the doe's milk production (Partridge and Allan, 1983). In large litters, especially with poorly milking dams, much of the growth potential is foregone before weaning at 28 days of age. Hence, supplying a palatable, high quality starter diet to preweanling rabbits may aid in exploiting their ability to grow and may lead to improved weaning and marketing weights.

Creep feeds are distinguished from milk replacers which are given in lieu of the dam's milk as practiced in the dairy industry. Particularly in pork production creep feeding for increased meat production has been profitable. Starter feed is made available to young pigs in feeders inaccessible to the sows in the second week of life. The purpose is to encourage early solid feed intake and to supplement the sow's milk. Pig starter diets are usually formulated to contain 50 to 60% of ground yellow corn and 30 to 40% of soybean meal, dried whey or skim milk, and dried fish solubles supplying 18 to 22% crude protein (Cunha, 1977; Krider et al., 1982). To increase palatability, 5 to 10% of sugar is normally added.

Krider et al. (1982) reviewed the literature relative to the value of creep feeding young piglets. In a study by Terrill et al. (1952) sows were fed free choice a simple diet of ear corn and minerals. One-half of their litters were supplied with a creep diet (21% crude protein) of yellow shelled corn and protein supplement made from two parts of tankage and one part of soybean meal. This feed was made available from 15 to 26 days of age. The other half of the litters did not receive creep feed. Survivability to weaning (56 days) was 5% higher in the creep fed pigs and daily gains increased by 15 g so that the fed pigs weighed 1040 g more at weaning than the control animals. In the creep fed lots 128 kg less feed was required per 100 kg net gain than in control lots (sows and litters combined).

Terrill et al. (1954) subsequently fed more complex, pelleted creep diets to piglets. These diets contained 51% rolled oats, 16% ground yellow corn, 10% soybean meal, 3% brewers' yeast and 3% condensed fish solubles. The sows were maintained on shelled yellow corn and on free choice rye pasture. In this case, the creep fed piglets gained 50 g more per day than the control animals and the difference in weight at weaning (56 days) was 2500 g. When creep feed was provided the sows and their litters consumed about 100 kg less feed per 100 kg weight gain.

English et al. (1980) provided piglets with a highly palatable pre-starter diet from week one to weaning at four weeks of age. Overall, those litters offered creep feed gained 7% more body weight during this time period. Yet, differences in weekly weight gain were not significant except for the last week when gains were 23% above the control animals. Mortality was not significantly different for the two treatment groups. The authors also found that piglets supplied with starter diet before weaning gained faster after weaning. As well, these pigs tended to show better feed efficiency postweaning but the effect was not significant.

Other authors reported similar results. Stevenson et al. (1954) found that supplying a creep feed to suckling piglets resulted in 56 day body weights being about 3600 g above the body weight of the control animals.

In another study (Lasley, 1953) pigs were fed a starter diet free choice between three and eight weeks of age. The difference in final weight was 1400 g in favour of the supplemented piglets. Jones (1970) showed that creep feeding results in heavier and more uniform pigs at eight weeks of age with fewer runts.

Other than increasing body weight due to greater nutrient supply creep feeding has a second major advantage in pork production. Since solid feed intake starts at a very early age - presuming the feed offered is highly palatable - piglets can be weaned at 3 weeks, just after the peak of milk production. In theory, the sows can therefore be rebred earlier increasing the number of litters born per year. Early weaning also leads to fewer piglet losses due to crushing and starvation. Smaller weight loss and decreased consumption of lactation diet by the sow are other benefits.

Controversy exists, however, about the value of providing young rabbits with a preweaning ration. Fox and Guthrie (1968) fed a creep diet (22% crude protein) to pups between 14 and 56 days of age. At 28 days the weight increase of 17 g for rabbits given the pelleted diet was not significant ($P > .05$). However, at weaning time (56 days of age) the difference was 1016 g ($P < .05$). Guthrie (1966) estimated a 7.5% increase in profit due to supplemental feeding in a production system employing weaning at 56 days (five litters per doe per year). In a stepped up breeding program with does raising nine litters per year a 22% growth in returns was calculated. The author does not specify how much of this increase was due to creep feeding alone and how much was due to the larger number of litters obtained.

In a study by Hunt and Dunkelgod (1981) one-half of the does in the herd were kept on the stepped up breeding schedule, i.e., the females were rebred on day 14 after kindling and the young were weaned at 28 days of age. The other half of females were rebred at about 45 days after kindling and weaning took place at 49 days. A creep feed containing 22% crude protein was available ad libitum to one-half of the rabbits from each of the two groups of does until 28 days of age. For either weaning time no significant improvement of body weight was observed in response to supplying starter diet. At 28 days of age there was no difference in weight between the fed and the unfed rabbits while at 49 days of age the rabbits with access to creep feed were 17 g lighter. Due to the differences in methodology this study contradicted the results found by Guthrie (1966) and Fox and Guthrie (1968). Hunt and Dunkelgod (1981) concluded that although the findings of their experiments "did not show an economic advantage to creep feeding of the young rabbit" more research was needed to further investigate the merits of creep feeding.

Study 1: Development of a Gastric Intubation Technique for Preweanling Rabbits

ABSTRACT

Three experiments were conducted to investigate a force feeding technique for evaluating different creep feeds for young rabbits. An additional objective was to determine whether a commonly used creep ration would produce a growth response when force fed. In three trials 586 unweaned New Zealand White (NZW) rabbits were force fed via stomach tube either water alone or ground suspended starter diet; one control group was intubated without delivery of water while a second control group was not handled at all. Rabbits were subjected to treatment between 10 and 21 days of age in experiment 1, between 10 and 24 days of age in experiment 2 and between 13 and 24 days of age in experiment 3. The effects of intubation and early creep feed supply were assessed by measuring body weight on days 22 (experiment 1), 25 and 28 (experiments 2 and 3) and by recording mortality rate for the time period between the start of the trial and weaning at 28 days. Lasting treatment effects were estimated by 49 day body weight and by mortality rate between 28 and 49 days.

All treatments involving gastric intubation decreased survival by 14 to 40 percentage units. Death was mainly attributable to pneumonia and enteritis. By the end of the trial mean body weight of untreated controls in experiment 1 was 423 g (22 days old) while untreated control animals in experiments 2 and 3 weighed approximately 440 g (25 days old). Intubation with water in experiment 1 decreased average weight at 22 days by 35 g whereas in experiments 2 and 3 the same treatment depressed 25 day weight by 20 g and 22 g, respectively. In experiment 2 intubation without water resulted in 25 g less body weight on day 25 while force feeding of starter diet (experiment 3) caused a 24 g improvement. All treatment effects were significant at 25 days ($P<.05$). However, most treatment differences disappeared by 28 days of age. It was concluded that tube feeding could be used for comparing and ranking different creep feeds but cannot be employed for estimating increases in body weight to be expected from ad libitum feeding of the same ration.

(Key words: Rabbits, Creep Feed Evaluation, Gastric Intubation, Growth Response, Survivability).

INTRODUCTION

The largest single cost in rabbit production is the expense of feed. In 1978 the feed contributed 82% to the total operating expenses in British Columbia (Ference Consulting, 1979). To reduce this cost research should be conducted to find cheaper feed ingredients for growing rabbits. To evaluate new feed ingredients an efficient feed evaluation technique is required and would be advantageous to the researcher. Evaluating the effect of a certain diet on the growth of preweanling animals represents a special problem in litter bearing species. Confounding of treatment with maternal effects has to be overcome by either assigning a large number of females and their litters to a treatment or by requiring several litters from the dams such that each female is present in each treatment. Both approaches are time consuming and often the experimental design is deficient due to culling or death of some does before the end of their test period.

These difficulties can be avoided by feeding known amounts of the experimental diet individually. Due to individual handling a litter can be divided into a number of treatment groups yet still be left with the dam as one litter. Thus the maternal or blocking effect is equalized over all treatments which allows for a single pregnancy per doe. Therefore, the time needed to complete a feed test can be shortened greatly compared to conventional ad libitum trials especially if the experimental herd is small.

Several researchers describe artificial handrearing methods for newborn rabbits (Akuzawa et al., 1978; Bernard, 1963; Broadfoot, 1969;

Pleasants et al., 1964). The animals were fed from nipple bottles or similar feeding devices. Bernard (1963) encountered problems when trying to handfeed young rabbits starting at four days of age which was probably due to the fact that they were accustomed to natural feeding by their dams. In all other studies mentioned above none of the young had access to the doe. For the purpose of this study bottle feeding had been preferred. Using different nipple bottles and various types of adaptors at the end of a syringe we attempted to feed 10 and 13 day old rabbits, yet the pups did not learn how to suck from these nipples.

Since bottle feeding had failed it was decided to force feed. Gastric intubation is a commonly used method in the nutritional and pharmaceutical fields. Crossland and Holloway (1971) successfully intubated caries producing diets to newborn rats. McCracken and McNiven (1983) tube fed adult rats without encountering major difficulties; only three out of 42 rats died because of food entering the lungs. Houpt et al. (1983) used a size 12 French feeding tube to force feed piglets which were less than one week old; apparently there were no complications. However, information on intubation of rabbits in this field of research is lacking in the literature.

Development of a force feeding technique suitable for testing creep diets for preweanling rabbits was a primary objective for this study. A second major objective was to test the hypothesis that force feeding young rabbits via gastric tube will result in significant increases in body weight at weaning.

MATERIALS AND METHODS

General Management. A herd of four males and approximately 50 females of NZW rabbits were kept in wire mesh cages and were housed indoors under an artificial lighting program of 16 hours light and eight hours darkness. Does were bred on day 14 after kindling and pups were weaned at 28 days of age. The basic stock diet was a commercial, pelleted ration of 16% crude protein. For rabbits between 28 and 49 days of age the feed contained .05% Amprol[1] for controlling coccidiosis. Fresh water was available at all times.

Experiment 1. This trial was a pilot study to experiments 2 and 3. Its purpose was to gather first information about gastric intubation in young rabbits and to determine what effect force feeding of water has on preweaning growth.

A total of 83 pups from 12 does were placed on trial. At 10 days of age each litter was divided into groups of two according to similar body weight (called "weight categories" or "categories"). One pup out of each group was assigned to treatment (1) and the other one to control (2). Any odd numbered individual was added to the control group. Randomization was achieved by drawing numbers. The treatment consisted of force feeding lukewarm water ($\simeq 32^{o}C$) through a stomach tube starting on day 10 with 10 ml and ending on day 21 with 45 ml. Initially, volumes were supposed to increase in regular daily steps of 5 ml. However, on day 14 rabbits were too small to take in 30 ml of water, consequently, the volume was not increased on that day. Similarly, the

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[1]Merck, Sharp and Dohme Canada Ltd., Kirkland, Quebec.

amount of water intubated on days 17, 20 and 21 were kept constant. For further detail refer to table 1.

For gastric intubation two sizes of infant feeding tubes were used, the smaller kind (size 5 French[2]) between days 10 and 13 and a larger one (size 8 French[3]) between days 13 and 21. After estimating the distance between mouth and stomach the catheter -lubricated with vaseline and filled with water to prevent air bubbles- was pushed gently through the esophagus into the stomach. For delivery of water a syringe containing warm tap water (≃32°C) was attached to the feeding tube and the liquid was slowly injected. Between intubation of animals of the same litter the feeding tube was rinsed with water; between litters it was also cleaned with ethanol. Tubes were replaced with new ones when the plastic became rough due to chewing by the older pups.

The effect of treatment was determined by body weight at 22 days of age and by mortality rate between 10 and 28 days of age. Any residual effect was estimated by analysis of 28 and 49 day body weight and mortality rate between days 28 and 49. Weights at 22 and 28 days were analyzed using the least squares general linear models procedure (SAS, 1982). Initial weight, i.e. weight at 10 days of age was entered as a covariate. Survival analyses for the two time periods were carried out with program 1L of BMDP (1981). Assuming that the probability of dying was equal within each period, differences in survival rates were evaluated with the Breslow test (BMDP, 1981).

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[2]Medicraft,; B.C. Stephens Ltd., 8868 Laurel St., Vancouver, B.C.

[3]Cutter Resiflex; 8241 - 30th St. SE, Calgary, Alberta.

Table 1. Volumes of water and creep feed suspension force fed during three experimental periods

	Experiment 1	Experiment 2	Experiment 3	
Day	Volume (ml)	Volume (ml)	Volume (ml)	DM (g)[a]
10	10	10.0	-	
11	15	12.5	-	
12	20	15.0	-	
13	25	17.5	10.0	2.3
14	25	20.0	12.5	2.9
15	30	22.5	15.0	3.5
16	35	25.0	17.5	4.0
17	35	27.5	20.0	4.6
18	40	30.0	22.5	5.2
19	45	32.5	25.0	5.8
20	45	35.0	27.5	6.3
21	45	37.5	30.0	6.9
22	-	40.0	32.5	7.5
23	-	42.5	35.0	8.1
24	-	45.0	37.5	8.6

[a]23% dry matter.

Due to high mortality treatment one was not represented in one of the litters on day 49. In order to proceed with the analysis of variance the average body weight (arithmetic mean) of all 49 day old rabbits on treatment one was added to the data of this particular litter.

Experiment 2. The second trial was designed to determine how body weight of pups at 25 and 28 days of age is affected by intubation with and without water. At the same time the technique of force feeding young rabbits was to be further developed.

A total of 123 rabbits from 15 litters participated in this experiment. At 10 days of age they were weighed and each litter was split into three treatment groups by random selection without replacement. The litters were not divided into weight categories since the analysis of experiment 1 showed that categories did not remove significant variation ($P>.05$, table 3). Pups two standard deviations above or below the litter mean were rejected from the experiment but remained with their dams and litter mates.

The three treatments applied starting from day 10 were (a) intubation with water (42 pups), (b) intubation without water (42 pups), (c) no intubation, i.e. control (39 pups). Volumes of water force fed were increased daily in increments of 2.5 ml from 10 ml at 10 days to 45 ml at 24 days at which time the trial was terminated (table 1). The same kinds of infant feeding tubes as described in experiment 1 were used. In case of the sham intubated group the tube was left in place for about five seconds and was then withdrawn.

As suggested by Crossland and Holloway (1971), to reduce stress on the tube fed animals from overfilling, all young were separated from their dams 1.5 hours before handling to ensure partial emptying of the stomach. After the treatment, litters were kept apart from the does for another 1.5 h as suckling shortly after handling would have favoured the control animals. Uniform handling of the litters at the same time each day was to achieve best possible adaptation of the gastrointestinal system to a higher demand on digestive activity (Fabry, 1969).

To prevent access of the young to the doe's diet, the doe's feeder was elevated by 5 cm to a total of about 15 cm above the cage floor. On day 25 after kindling the feeder was lowered to prepare the young for weaning on day 28.

Treatment effect was determined by 25 and 28 day body weight and by mortality rate between 10 and 28 d. Any residual effects were estimated by analysis of 49 d weight and of mortality rate between 28 and 49 d of age. Survival analyses were carried out as described for experiment 1.

In trial 2 treatment one was not represented in one litter as all pups on this treatment died. The data for treatments two and three of this particular litter were excluded from the analysis of body weights. However, for the analysis of survival rates this litter was included in the data base. If the overall treatment effect was significant in the analysis of variance two linear contrasts were included testing treatments one and two against the control. The significance level for any pairwise comparison of the three treatment groups was adjusted according to the formula P/2m where P = .05, the overall significance level of treatment effect, while m equaled the number of paired comparisons made

(Dunn and Clark, 1974). Thus the adjusted critical level for contrasts in the ANOVA was .012 (two contrasts) while it was .008 for pairwise comparisons of survival rates (three paired contrasts). The testing terms for the sources of variation were determined through a calculation of expected mean squares assuming that "Litter" was a random effect (SAS, 1982).

Experiment 3. The objective of the experiment was to determine whether the creep diet formulated by Hunt and Dunkelgod (1981), which did not lead to a significant growth response when fed ad libitum, would increase body weight at 25 and 28 days of age when force fed. Moreover, several technical problems arising with the tube feeding method were still to be resolved.

Three treatments were tested using 52 litters or a total number (N) of 380 rabbits: (a) gastric intubation with water (N = 127), (b) gastric intubation with suspended creep feed (N = 123) and (c) no intubation (control) (N = 130). Eight and nine litters had to be excluded from the 25 and 28 day analyses, respectively, because not all three treatments were represented in these litters due to mortalities. At 10 days of age weighing and treatment assignment was accomplished as in experiment 2. The trial however, did not start until day 13. Only the larger sized feeding tubes (8 French) were used. Volumes of water and suspended creep feed given were 10 ml initially and increased daily by 2.5 ml, hence the animals received 37.5 ml on day 24 (table 1).

The pelleted creep diet was similar in composition to commercially available feeds. Ingredients and chemical analysis are presented in table 2. Pellets of this ration were ground twice in a hammer

Table 2. Ingredients and proximate analysis of starter diet[a]

Ingredient	g/kg
Alfalfa meal, dehydr., 17% protein (IFN 1-00-023)	218
Oats, pulverized (IFN 4-03-999)	186
Soybean meal, dehydr., 46.5% protein (IFN 5-04-600)	125
Wheat, grd., 14% protein (IFN 4-05-268)	100
Barley, grd., 12% protein (IFN 4-00-939)	100
Wheat bran, 16% protein (IFN 4-05-190)	64
Skim milk, dried (IFN 5-01-175)	55
Distillers solubles, dried, 28% protein (IFN 5-28-237)	40
Fishmeal, herring, 70% protein (IFN 5-02-000)	36
Brewers yeast, dried, 45% protein (IFN 7-05-527)	30
Rapeseed meal, 37% protein (IFN 5-03-870)	25
Molasses, beet (IFN 4-00-668)	10
Vitamin and mineral premix[b]	7.5
Salt, iodized	5.0
Anise oil powder	.5
NF-180, 22% concentrate[c]	.25

Proximate Analysis (air dry basis)

Dry matter	91.0%
Fat	2.9%
Crude fibre	11.1%
Crude protein	20.6%
Calcium	.9%
Phosphorous	.6%

Continued ....

Table 2 (Continued)

[a]Diet formulation by Hunt and Dunkelgod (1981). Pellet size 4x6 mm.

[b]The premix supplied the following per kg diet: Vit. A, 26250 I.U.; Vit. D_3, 3648 I.C.U.; Vit. E, 30 I.U.; menadione sodium bisulfite complex, 4.5 mg; riboflavin, 13.5 mg; pantothenic acid, 15.0 mg; niacin, 37.5 mg; choline chloride, 525 mg; Vit. B_{12}, 18.8 mg; biotin, .23 mg; pyridoxine, 6.0 mg; folic acid, 3.8 mg; ethoxyquin, 187.5 mg; bacitrin, 22.5 mg; manganese, 74.3 mg; cobalt, 0.4 mg; iron, 66.0 mg; iodine, 3.8 mg; copper, 9.0 mg; zinc, 74.3 mg.

[c]Nitro furasol.

mill[4] using .25 and .08 mm screens. Care was taken not to lose any of the ingredients as the process of milling tended to separate out fat and fine fibre particles. The air dry, ground material was mixed in a Waring blender with tap water such that the dry matter content of the suspension approximated 23%. Feed was prepared fresh daily and any unused suspension was kept in the refrigerator until the following day. Before feeding the suspension was placed in a water bath to increase its temperature to approximately 32°C. During feeding time the liquid was agitated frequently to prevent settling of the solid matter.

All other procedures and measurements were the same as in experiments 1 and 2.

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[4]Weber Bros. & White Metal Works Incl., Chicago, Ill.

RESULTS AND DISCUSSION

Interpretation of Data. Results from the three experiments show that intubation of water tends to decrease body weight by the end of the study period. The difference was 35 g at 22 days of age in experiment 1 ($P<.05$, tables 3 and 4). For 25 day old rabbits differences in body weight were 20 g ($P>.012$, tables 5 and 6) and 22 g ($P<.012$, tables 7 and 8) in experiments 2 and 3, respectively. The differences for the same contrasts on day 28 were 24 g in experiment 1 ($P<.05$, tables 3 and 4), 17 g in experiment 2 ($P>.012$, tables 5 and 6), and 26 g in experiment 3 ($P<.012$, tables 7 and 8).

Intubation without water (trial 2 only) caused a 25 g decrease in body weight on day 25 ($P<.012$, tables 5 and 6) which indicates that handling and insertion of the tube laone was at least as severe as intubation with water. The weight difference of 25 g persisted until day 28 but at this date it was no longer significant ($P>.012$).

Force feeding of creep feed (trial 3 only) increased body weight by 24 g at 25 days of age ($P<.012$, tables 7 and 8). This increment is a net effect composed of body weight depression due to intubation and force feeding of water and of body weight gain due to supplying extra nutrients. After terminating the experiment this advantage in weight decreased rapidly such that by day 28 the differences between the control and the force fed groups was 15 g ($P>.012$). Thus the fed pups did not gain as much in the time period between 25 and 28 days as the control animals indicating a reduced level of voluntary feed intake. It

Table 3. Analysis of body weights at 22, 28 and 49 days of age - Experiment 1

	22 days			28 days			49 days		
Source	DF	SS (Type III)	PR>F	DF	SS (Type III)	PR>F	DF	SS (Type III)	PR>F
Litter (L)	10	58452	.0037	10	132871	.0160	10	97731	.2120
Category (litter)[a]	35	60865	.3584	35	175417	.5958	34	485541	.2945
Treatment (T)	1	28116	.0135	1	27379	.0364	1	27986	.0532
L x T[b]	10	31351	.0719	10	46956	.5816	10	50911	.8053
WT10	1	21471	.0011	1	65802	.0031	1	29528	.1196
Error	21	31216		16	86973		10	101935	

[a]Testing term for litter, category refers to weight group within a litter.

[b]Testing term for treatment.

Table 4. Least square means of body weight at 22, 28 and 49 days of age - Experiment 1

Treatment	22 days			28 days			49 days		
	N	B. wt. (g)	SE[a]	N	B. wt. (g)	SE	N	B. wt. (g)	SE
Intubation with water	34	381	12	30	563	21	25	1430	22
Control	44	416	17	44	587	21	42	1465	22

[a]SE = SQR (MSE/(#Litters/Treat.)). MSE used is the term used for testing treatment differences in the ANOVA table.

Table 5. Analysis of body weights at 25, 28 and 49 days of age - Experiment 2

	25 days			28 days			49 days		
Source	DF	SS (Type III)	PR>F	DF	SS (Type III)	PR>F	DF	SS (Type III)	PR>F
Treatment[a] (T)	2	10466	.0035	2	9084	.1534	2	3654	.8835
T1:T3	1	5227	.0132						
T2:T3	1	9318	.0015						
Litter (L)	13	119895	.0001	13	300501	.0001	13	1226583	.0001
T x L[b]	26	19195	.6951	26	58562	.2153	24	352218	.4845
BWT 10[c]	1	61898	.0001	1	46540	.0001	1	251175	.0002
Error	47	42006		46	79779		35	510646	

[a]T1 = intubation of water, T2 = intubation w/o water, T3 = control, critical significance level for contrasts is α = .012.

[b]Testing term for treatment, litter and contrasts.

[c]Body weight at 10 days of age (covariate).

Table 6. Least square means of body weight at 25, 28 and 49 days of age - Experiment 2

	25 days			28 days			49 days		
Treatment	N	B. wt. (g)	SE[a]	N	B. wt. (g)	SE	N	B. wt. (g)	SE
Intubation with water	24	422	8	24	542	13	24	1343	34
Intubation w/o water	32	417	8	32	534	13	29	1367	34
Control	34	442	8	34	559	13	33	1343	34

[a]Ref. footnote table 4.

Table 7. Analysis of body weights of 25, 28 and 49 day old rabbits - Experiment 3

	25 days			28 days			49 days		
Source	DF	SS (Type III)	PR>F	DF	SS (Type III)	PR>F	DF	SS (Type III)	PR>F
Treatment[a] (T)	2	82984	.0001	2	61972	.0001	2	2307	.9265
T1:T3	1	21756	.0009	1	27758	.0032	1		
T2:T3	1	24617	.0005	1	8756	.0919	1		
Litter (L)	43	656712	.0001	42	1168735	.0001	43	4167180	.0001
T x L[b]	86	159370	.1060	84	253105	.1853	86	1299093	.3673
BWT 10[c]	1	148884	.0001	1	229961	.0001	1	727800	.0001
Error	155	227761		150			143	2079606	

[a]T1 = intubation of water, T2 = intubation of creep feed, T3 = control, critical significance for contrasts is α = .012.

[b,c] Ref. footnotes Table 5.

Table 8. Least square means of body weights of 25, 28 and 49 day old rabbits - Experiment 3

	25 days			28 days			49 days		
Treatment	N	B. wt. (g)	SE[a]	N	B. wt. (g)	SE	N	B. wt. (g)	SE
Intubation with water	89	414	7	86	534	8	89	1441	19
Intubation with creep feed	83	460	7	80	575	8	84	1447	19
Control	108	436	7	106	560	8	105	1448	19

[a]Ref. footnote table 4.

was therefore shown that force feeding of the diet formulated by Hunt and Dunkelgod (1981) will lead to a significant weight increase by 25 days of about 24 g. A body weight difference greater than the observed 15 g may have been apparent at 28 days of age had the force feeding continued. In none of the three experiments did treatment effects last until 49 days of age (P>.05, tables 3, 5 and 7). The least square means show clearly that any differences seen in weight between treatment groups on days 22, 25 and 28 disappeared during the 20 days postweaning (tables 4, 6 and 8). For comparison, Hunt and Dunkelgod (1981) found an average increase in body weight of 1 g due to creep feeding ad libitum.

With the exception of experiment 1 (table 2) "Litter" in the analyses of variance was highly significant at all points in time (P<.01, tables 5 and 7). Since each litter represents a different doe selected at random the results of these experiments show that mothering ability has a strong and lasting effect on body weight. This is supported in the literature (Lukefahr et al., 1981). Although age and parity of the dam have an important influence on litter performance (Lukefahr et al., 1981) the doe herd was sufficiently homogenous in this respect to conclude that selection of females according to the 28 and 49 day weights of their offspring would lead to improved market body weights.

In all three experiments intubation of water decreased survivability in the preweaning period (tables 9, 10 and 11). An increase in severity of treatment when comparing no handling, intubation without and intubation with water in experiment 2 can be observed in the increase in

Table 9. Survival analysis[a] for the time periods of 10 to 28 days of age - Experiment 1

		Cause of death				Survived[b]	
Treatment	Total N	Gastritis	Pneumonia	Enteritis	Unknown	N	%
Intubation with water	38	2	3	0	3	30	79[c]
Control	45	0	0	1	0	44	98[d]

[a]BMDP (1982), program 1L.

[b]Percentages with different superscripts are significantly different ($P<.05$).

Table 10. Survival analysis[a] for the time periods of 10 to 28 days of age - Experiment 2

		Cause of death				Survived[b]	
Treatment	Total N	Gastritis	Pneumonia	Enteritis	Unknown	N	%
Intubation with water	42	0	9	4	6	23	55^{c}
Intubation w/o water	42	0	4	2	2	34	81^{cd}
Control	39	0	0	1	1	37	95^{d}

[a]BMDP (1981), program 1L.

[b]Percentages with different superscripts are significantly different (P<.008).

Table 11. Survival analysis[a] for the time periods of 10 to 28 days of age - Experiment 3

Treatment	Total N	Cause of death				Survived[b]	
		Gastritis	Pneumonia	Enteritis	Unknown	N	%
Intubation with water	127	0	20	4	0	103	81[c]
Intubation with creep feed	123	3	17	10	3	91	74[c]
Control	130	0	0	1	0	129	99[d]

[a,b]Ref. footnotes Table 10.

mortality associated with each additional step of treatment. Intubation alone raised mortality by 14 percentage units over the control ($P>.008$, table 10) while feeding of water caused an increase in mortality by 40 percentage points ($P<.008$). In experiment 1 the volumes of water intubated were larger than in experiment 2, yet mortality was only half of the rate observed in experiment 1. Although the percentages seem to differ widely the actual number of dead rabbits is small (tables 9 and 10). The survival analysis of experiment 3 is more reliable since a larger number of rabbits was tested. The results of the latter trial support the findings of experiment 1 as the difference in mortality between the water fed and the control groups in both experiments was 18 to 19 percentage points (tables 9 and 11).

The breakdown according to cause of death is also shown (tables 1 to 11). The increase in pneumonia is quite apparent suggesting mechanically induced lung disease. In comparison to the group intubated without water the cases of pneumonia were more abundant when water was given, leading to the conclusion that not only mechanical injury but also water aspiration was a problem. Broadfoot (1969) also observed problems with food aspiration when bottle feeding young rabbits. Force feeding of diet suspension imposed an even greater stress on the animals since survivability dropped by another seven percentage units compared to the water fed group (table 11, $P>.008$). This was due to a more than twofold increase in enteritis. Factors such as age when starting the experiment and volume of fluids given seem to be involved in the occurrence of this disease. In experiment 2, in which water volumes intubated were larger, mortality from enteritis was twice as high as in experiment 3 comparing the water fed animals only. Cheeke and Patton (1980) hypothesized that one form of enteritis, enterotoxemia, is initiated by poorly digested feed reaching the hind gut thus causing the proliferation of harmful bacteria. Presumably, the intubated water flushes partially digested milk into the lower digestive tract providing bacteria with an energy source. As well, force feeding of suspended creep feed in amounts too large for proper digestion can lead to a similar situation.

Survival rates for the age period between 28 and 49 days (tables 12 to 14) and body weights on day 49 did not indicate lasting treatment effects in any of the experiments ($P>.05$, tables 3 to 8).

For future research which employs force feeding several limitations have to be realized. Interpreting data from trial 3, growth of the fed rabbits was apparently hindered by the depressing effect of water intubation and enhanced by the provision of extra nutrients (table 8). Physiological side effects are to be expected when tube feeding animals (Fabry, 1969). Cohn (1963) found that force feeding is associated with decreased thyroid activity in rats. The same author (1963) demonstrated that force feeding diet leads to higher body fat content in rats. He suggested, however, that these two occurrences are independent of one another. Through sham intubation he also demonstrated that the higher body fat content is not associated with the force feeding procedure itself but only develops in those rats force fed diet. Earlier Cohn et al. (1957) also ruled out the possibility of water added to the intubated feed being the cause of the observed obesity. For these

Table 12. Survival analysis[a] for the time periods of 28 to 49 days of age - Experiment 1

		Cause of death				Survived[b]	
Treatment	Total N	Gastritis	Pneumonia	Enteritis	Unknown	N	%
Intubation with water	30	0	0	5	0	25	83[c]
Control	44	0	0	2	0	42	95[c]

[a,b]Ref. footnotes Table 9.

Table 13. Survival analysis[a] for the time periods of 28 to 49 days of age - Experiment 2

		Cause of death				Survived[b]	
Treatment	Total N	Gastritis	Pneumonia	Enteritis	Unknown	N	%
Intubation with water	24	0	0	2	0	22	92
Intubation w/o water	34	0	0	3	1	30	88
Control	38	0	0	5	1	32	84

[a]BMDP (1981), program 1L.

[b]In the overall analysis survival rates were not significantly different ($P>.05$).

Table 14. Survival analysis[a] for the time periods of 28 to 49 days of age - Experiment 3

		Cause of death				Survived[b]	
Treatment	Total N	Gastritis	Pneumonia	Enteritis	Unknown	N	%
Intubation with water	102	0	0	2	1	99	97
Intubation with creep feed	92	0	0	5	0	87	95
Control	129	0	0	5	1	123	95

[a,b]Ref. footnotes Table 13.

reasons absolute increases in body weight should be interpreted with caution in the present study. The proper control for a force feeding trial is water intubation to ensure a similar physiological state of all animals on trial. In reference to experiment 3 the difference in body weight between the creep and the water intubated rabbits is larger than the difference in weight between the creep intubated and the control animals, thus one advantage of using a sham control is that a clear treatment effect is demonstrated. Cohn (1963) observed similar weights in rats fed ad libitum and rats intubated the same diet in two large daily loads. "When the efficiency of the diet was calculated in the classical manner (weight gain/gm of food consumed) the diet was equally efficient, regardless of the rate at which it was consumed. However, if one calculates the efficiency on the basis of calories retained in the body/calories eaten... the diet was twice as efficient when given as spaced feedings". In future experiments, different creep feeds should thus be evaluated by their relative merits and not by their absolute effects on body weight or feed efficiency.

Development of the Force Feeding Technique. Since reports could not be found in the literature regarding gastric intubation of young rabbits, many procedural questions arose. The purpose of experiments 1 and 2 was to determine the effects on body weight and on mortality of intubation with and without water. These trials started at a very early time (10 days of age). For feeding of creep diet the experimental period had to begin at a later age when the rabbits' digestive system was able to at least partially hydrolize and absorb nutrients.

Voluntary feed intake starts at 14 days of age (Broadfoot, 1969) and by day 21 most of the intake is solid feed (Alus and Edwards, 1977). At that age the daily amount eaten varies between 10 (Lebas et al., 1971) and 20 grams (Aghina and Ladetto, 1973). A rapid increase in gastric proteolytic activity between days 14 and 21 accompanies the change in feed intake (Henschel, 1973). The activities of pancreatic amylase, lipase and chymotrypsin are low in relation to the adult levels and increase only slightly between 14 and 24 days of age (Lebas et al., 1971). An exception is pancreatic trypsin which at day 14 already is at the adult level of activity (Lebas et al., 1971). Hence, rabbits were placed on trial 3 at 13 days of age under the assumption that they were able to digest small amounts of solid feed by that time.

The frequency of feeding and the daily amount of fluids given to each pup had to be estimated. Broadfoot (1969) after noting that rabbits fed their young only once or twice per day handfed young rabbits from birth to weaning on a once per day basis. Akuzawa et al. (1978) were most successful with feeding twice per day when handrearing newborn rabbits. In this study it was therefore decided to force feed once daily while suckling by the doe was considered to be the other feeding. As intubation of the lungs by mistake was a concern treating once instead of twice per day minimized the chance of wrong placement of the tube.

The volume of water intubated in experiment 1 seemed to be excessive thus volumes were lowered in experiment 2 regulating daily increases at 2.5 ml. This schedule did not seem to adversely affect the animals.

However, after a few litters had been placed on trial in experiment 3 it was decided to feed the creep feed suspension (23% dry matter) in still smaller amounts. The volume given at 13 days was decreased from 17.5 ml to 10.0 ml for both the water and the creep fed groups (table 1). Dry matter intake of the latter group decreased accordingly from 3.03 g to 2.30 g on that day while daily volume increases by 2.5 ml remained. Statistical analyses were done using two groups of rabbits from experiment 3: those 13 litters which had received the high amounts and the first 13 of 52 litters which had been given the low volumes. The data of the first group were examined only to clarify the effects of two different volumes but were excluded from all other analyses. One test revealed that volume did not significantly influence body weight at 25 days in the water fed group but higher amounts of the creep feed suspension significantly increased weight by 66 g ($P<.05$). A survival analysis showed that volume did not affect mortality up to 28 days of age in either the water or the creep fed group ($P>.05$) despite a higher loss of those animals receiving larger aliquots of feed suspension. The higher rate in mortality was mainly attributed to a higher incidence of enteritis.

To maximize the effect of starter diet on body weight, large quantities should be force fed. Yet, uncertainty still exists about the amount of fluid and dry matter young rabbits can tolerate. From data presented by Lebas (1968) daily milk intake follows a curve which is approximately bell shaped (appendix 1). The stomach capacity approaches twice these volumes as can be concluded from studies by Hardmann et al.

(1970) as described earlier. Moreover, pups from very small litters (three or less) presumably consume close to double the amount of milk - in one feeding - compared to pups from larger litters. Hence the quantities intubated in experiment 2 and in the beginning of experiment 3 (table 1) were not expected to harm the animals particularly when the total intake per rabbit per day was distributed over two feeding sessions (a suckling and a treatment period).

In trying to optimize creep feed intake by 25 days one possibility is to balance decreasing milk consumption past 19 days (Lebas, 1968) with force feeding larger amounts of suspension. As well, the body weight of preweanling rabbits increases almost exponentially (Lang, 1981a) thus the physical size of the pups allows for a non-linear increase in daily volumes given. The amounts intubated should therefore be based on estimated milk intake and on body weight of the individual. Appendix 1 represents an exercise in estimated fluid and dry matter intake per rabbit from milk and creep suspension. Considering figures from this table in combination with the knowledge of stress signs of young rabbits being force fed, the observed growth rate, the incidence of mortality, especially enteritis, and the approximation of the digestive capacity of pups compared to adults (Henschel, 1973; Lebas et al., 1971) the proposed total fluid intake as a percentage of body weight is 16% between 13 and 16 days of age, 18% between 16 and 21 days and 20% between 22 and 24 days when the dry matter content of the suspension is about 23%.

Considering that solid feed intake of young rabbits varies between 10 g (Lebas et al., 1971) and 20 g (Aghina and Ladetto, 1973) on day 21 the quantities which were used in the present study could be increased by at least 4 g on day 22. The suggested limit of total dry matter force fed to pups is 5% of body weight up to 21 days of age and 6% beyond (compare appendix 1). Since the quantity of fluid given could not be increased much further the solution would have been to raise the dry matter content. However, suspensions of higher consistency congested the feeding tubes and larger sized catheters should not be used for rabbits under 25 days of age.

In a further attempt to reduce stress and bias, pups were removed from their dams' cages 1.5 hours before and after treatment following the example given by Crossland and Holloway (1971) as described in the Materials and Methods section of the present paper. However, this practice may not have been necessary. According to the literature does suckle their young only once, very seldom twice per day (Broadfoot, 1969; Lang, 1981b) and in our own observations does fed their litters once early in the morning.

A further question on technique was when to end the force feeding period. The original intention was to feed the animals until weaning at 28 days of age in order to determine the effect of starter diet on body weight at this time. Several difficulties emerged, however; for example, by 22 days of age the rabbits' teeth were well developed and despite pushing the feeding tube through the diastema piercing of the plastic catheter was a problem. Using a gag was without success. Secondly, by 25 days of age many pups were large enough to reach the doe's feeder even though it had been elevated. Since the doe's feed was then available to some of the litter mates there was a good chance of rabbits which were not force fed creep diet to compensate for feed intake hence eliminating the treatment effect on body weight. Thirdly, all young needed an adaptation period with access to the stock ration in preparation for weaning at 28 days. For these reasons the trial was terminated when a litter was 25 days old. The last treatment was on day 24 and the rabbits were weighed on day 25 at which time the doe's feeder was lowered again.

The force feeding procedure requires some training for the operator. Initially it was difficult to determine whether the feeding tube was placed correctly in the stomach or whether it was in the trachea. (If coughing indicated wrong intubation the catheter was withdrawn and the animal was not further treated that day). Early indication for correct placement was the ease with which the tube could be pushed forward and the longer distance to which it can be delivered into the stomach.

In conclusion the tube feeding technique could become a useful tool in ranking different starter diets if experimental approaches are adjusted as discussed above. In the experiments presented the only variables considered were body weight and mortality rate. If the technique becomes established assays to determine metabolizable nutrient content of rations may also be added. Several disadvantages are associated with this method, however, (a) skill and training are required for the experimenter. (b) Mortality among treated animals is high. (c) Since the average litter size of NZW rabbits is eight the number of treatment groups per trial is limited to three if, on average, at least two pups from each litter are to be assigned to each treatment. Since one treatment would be the water intubated control only two creep feeds can be evaluated in the same experiment. (d) Absolute increases in body weight must be interpreted with caution.

On the other hand, the tube feeding technique also has advantages over conventional feeding trials. (a) Two creep feeds can be compared using approximately 30 litters, less than half normally required. (b) Feed intake and time of feeding are controlled. (c) Maternal effects are distributed equally over all treatments. (d) The method may be applied in the evaluation of creep feeds for other litter bearing species.

In reference to the second objective of this study it is concluded that the creep diet used in experiment 3 will increase weaning weight if consumed in sufficient amounts. The method described here helps to determine relative merits of a ration but does not hold practical significance. Whether or not feeding of the present - or any other - starter diet will have a lasting and economically important effect on body weight must be determined through an ad libitum feeding trial which is described in the following paper.

Study 2: Creep Feed for Preweanling Rabbits

ABSTRACT

The effect of supplying preweanling New Zealand White rabbits with a starter diet (20.6% CP) and the type and location of specially designed creep feeders were tested in a two by two factorial experiment involving 80 litters from 20 does. Creep diet was made available between 10 and 28 days of age. Treatment group R1 had creep feeders in the nest box (type A) and outside the box (type B), while group R2 was supplied with an outside feeder only (type C) which was designed differently from the type B feeder used in R1. Litter creep feed consumption up to day 25 was influenced by the two types of feeding regimens (P<.05) where average intake was 470 g higher in R2. However, due to the design and attachment of the type C feeder (R2) some does were able to spill much of the feed which made interpretation of feed consumption data difficult. Feeding regimen had no effect on litter feed intake between 25 and 28 days nor on stock diet consumption between 28 and 49 days (P>.05). Despite the feed wastage in group R2 litter feed efficiency, which included the doe's intake of stock ration, was not affected up to day 25 or between days 25 and 28 (P>.05). Individual body weight was improved at weaning time by 27 grams (P<.05) when a type C feeder was installed, but the advantage disappeared by 49 days of age (P>.05). The two types of creep feeders used were not associated with preweaning or postweaning mortality (P>.05).

Supplying creep feed had no effect on litter feed efficiency ratio between days 0 and 25 and days 28 and 49 (P>.05) but depressed the

efficiency between 25 and 28 days of age (P = .05). On average individual body weight was 15 g heavier at 25 days of age when starter diet had been available (P>.05). Differences in 28 and 49 day body weight were 17 g and 19 g, respectively (P>.05). Providing starter diet during the preweaning period did not influence mortality either before or after weaning at 28 days (P>.05).

In conclusion, this study demonstrated that the supply of creep feed is not economical in commercial meat production and thus buying special creep feeders and starter diet is not justified. Since the performance of preweanling rabbits is largely associated with the milking ability of the doe efforts should be directed towards finding an appropriate lactation diet.

(Key words: Rabbits, Creep Feeding, Feed Intake, Feed Efficiency, Growth, Survivability).

INTRODUCTION

Young rabbits have a high potential for growth. Using surrogate mothers for twice-a-day suckling, Hardmann et al. (1970) found that from one to three weeks of age California White rabbits grew twice as fast as controls. The observed advantage in growth and body weight, resulting from extra feeding, was still present at 28 days. The authors expressed doubt that the rabbits had reached their full capacity to grow and concluded from their studies that, under normal rearing conditions, young rabbits are undernourished in relation to their inherited growth potential.

In commercial production systems extra milk cannot be provided to young rabbits thus progeny performance is greatly affected by the doe's milking ability and by the quality of the doe's diet (Partridge and Allan, 1983). With does that are poor milkers, much of the production potential is foregone before weaning. Furthermore, weight at 28 days is positively and significantly correlated with weight at 49 days ($r=0.80$, $P<.01$, Presch, 1983, unpublished data) and with weight at 56 days ($r=0.44$, $P<.05$, Lukefahr et al., 1981). It may therefore be economically important to supply rabbits with a suitable supplemental feed prior to weaning.

Creep feeding means supplying a palatable, highly digestible creep diet before weaning to take advantage of the growth potential. Creep feeds are distinguished from milk replacers which are given in lieu of the dam's milk as practiced in the dairy industry. While the pork producing sector profitably employs creep feeding controversy exists about the value of creep feed for rabbit production. Fox and Guthrie (1968) fed a creep diet (22% crude protein) to pups between 14 and 56 days of age. While a body weight difference did not exist at 28 d it was significant ($P<.05$) at 56 d. Guthrie (1966) estimated a 7.5% increase in profit due to supplemental creep feeding in a production system designed to produce five litters per doe per year. In a stepped up breeding program with does raising nine litters per year a 22% growth in returns was calculated, however, the author does not specify how much of the 22% increase is due to creep feeding and how much is due to the larger number of litters.

In a study by Hunt and Dunkelgod (1981), one-half of the does were kept on a stepped up breeding program (does rebred at 14 d after kindling and young weaned at 28 d) the other half on a relaxed breeding program (does rebred at 42 d and young weaned at 49 d). A creep feed containing 21% crude protein (Table 2) was available ad libitum to rabbits from 8 to 28 days of age. Weaning was at 28 or 49 days of age. At either weaning time no significant improvement of body weight was observed ($P<.05$). An increase in rate of growth due to creep feeding as reported by Fox and Guthrie (1968) were not repeated in this study which was likely due to the shorter time period of feeding the high protein creep diet.

To determine whether a significant effect on weaning body weight could be produced, a suspension of the creep feed (Hunt and Dunkelgod, 1981) (Table 2) was force fed from 13 to 24 d to young rabbits with a plastic infant feeding tube (ref. first study). Force feeding increased body weight at 25 d by 25 g ($P<.05$) compared to the controls (shams). As force fed animals were subjected to physiological stress, the force feeding procedure may be used in future for the ranking of different creep feeds according to their relative merits but absolute effects on body weight may not be reliable. These results plus the observation that pups do not leave the nest until 14 to 15 d of age, lead to the present study. The objective was to determine whether the provision of creep diet ad libitum and the location of creep feeders influenced body weights at market age. These data would provide an estimate of the profit to commercial producers from creep feeding in two locations with different types of creep feeders.

MATERIALS AND METHODS

Herd Management and Experiment Design. The herd and general management procedures are described in the Materials and Methods section of the first study.

A two by two factorial experiment was laid out in which creep feeding (F1, F0) and two creep feeder locations (R1, R2) were tested as follows:

R1F1: one creep feeder at the nest box (type A) plus
another creep feeder (type B) mounted at cage,
creep diet supplied on day 10

R1F0: creep feeders as in R1F1,
creep diet not supplied

R2F1: creep feeder (type C) mounted in cage,
creep diet supplied on day 10

R2F0: creep feeder as in R2F1,
creep diet not supplied

Nest boxes with mounted creep feeders (type A) were custom made from sheet metal and were identical to the standard nest box except that a small drawer-type trough was affixed to one long side (plate 1). Two holes of 5 cm diameter were cut into the long side of the box that the pups could reach into the creep feed trough. For hygenic reasons all nest boxes were removed on day 19. Feeders of type B had two holes of the same diameter as type A and were attached to the cage door from the outside as soon as the first pup left the nest (plates 2 and 3). Feeders of type B had four holes of 5 cm diameter and were mounted to the inside of the doe's cage (plates 2 and 3). The latter were the same feeders as employed by Hunt and Dunkelgod (1981).

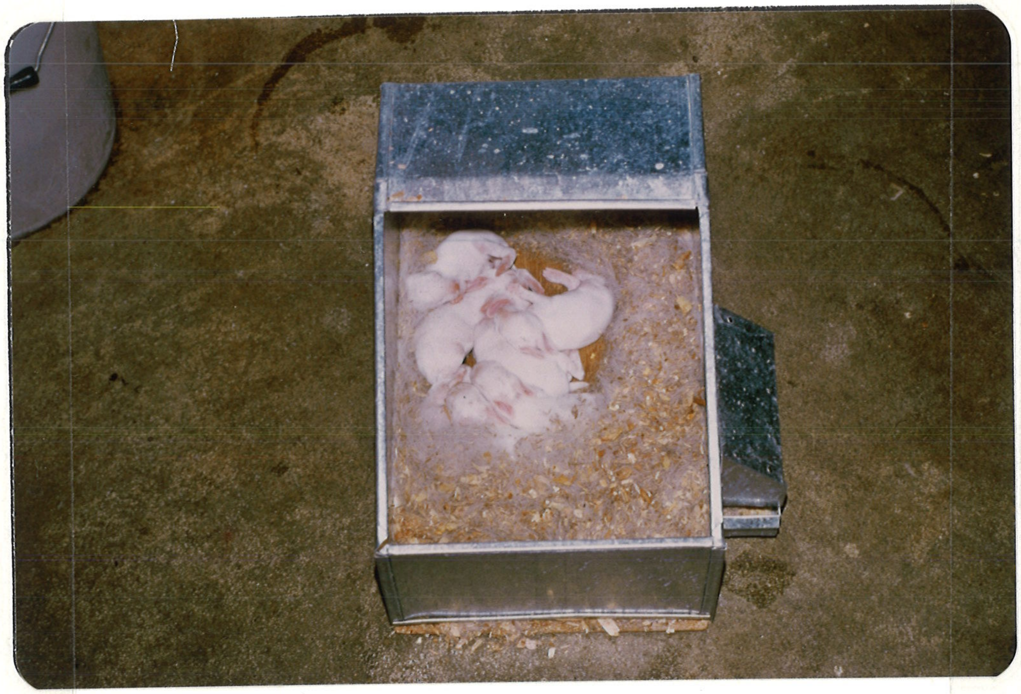


Plate 1. Creep feeder (Type A) at nest box.

Plate 2. Creep feeders used outside of nest box.

Type B (left).

Type C (right).

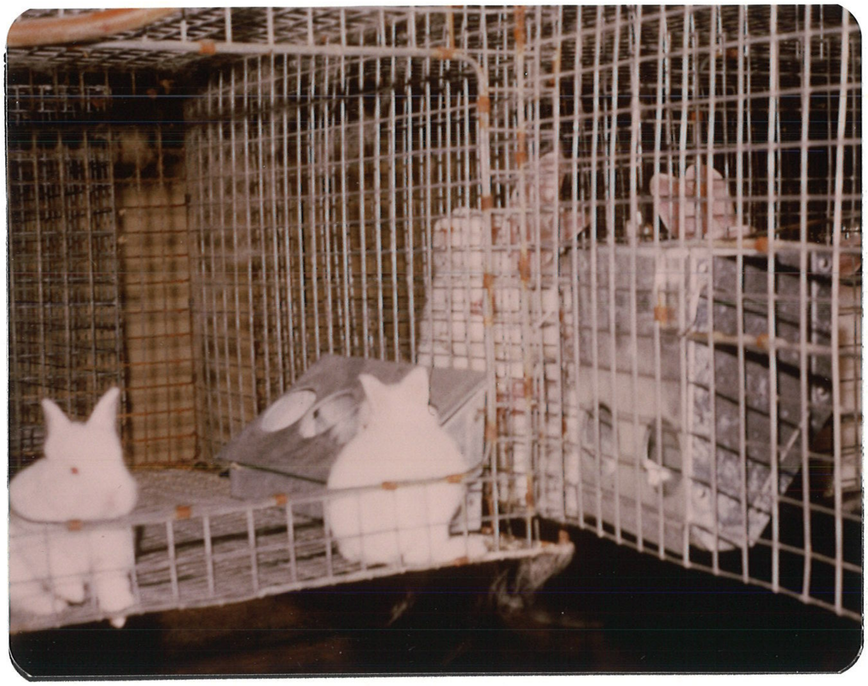


Plate 3. Creep feeders used outside of nest box.[a]

Type B (mounted from the outside of the cage door).

Type C (attached from the inside of the cage).

[a]Photograph taken for demonstration purposes only.

To prevent the young from eating the adult diet the doe's feeder was elevated by 5 cm to a total of 15 cm off the cage floor. The feeder was lowered again on day 25 to prepare all litters for weaning at 28 days of age. Creep feed was kept available to the respective treatment groups until day 28.

The experiment was arranged as a randomized complete block design. Since does were treated as blocks to remove the large maternal effect, four litters were required from each female. Out of 24 does, which had been selected at random from the herd, four had to be disregarded because they had not produced four litters by the end of the experimental period. Each doe had one litter from each male so that sire effects were equalized over the four treatments and no confounding occurred between buck and treatment.

The young rabbits were ear-marked with colored felt pens and were weighed individually on days 10, 16, 19, 22, 25, 28 and 49. Feed consumption by the whole litter was recorded at the same time. The doe's feed ration was weighed at breeding and kindling and on days 25 and 28.

<u>Data analyses</u>. All calculations excluded values from pups whose body weights were two standard deviations above or below the litter mean at 10 days of age.

The consumption of creep feed was determined on a litter basis, consequently the analysis of this variable included 40 observations, i.e. one-half of the total of 80 litters on trial. Analysis of litter creep feed consumption was done for the ages of 10 to 25 days and 25 to 28 days. The separation into two treatment periods was necessary because the does' feeders were lowered on day 25 and thus the young had access to two solid feed sources. Stock diet consumption between 28 and 49 days of age was determined for all of the 80 litters to estimate whether the previous feeding regimen had a lasting effect. Litter weight at 10 days of age (LWT10) and the number of pups per litter at the given age (LN25, LN28, LN49) were included as covariates to assure that the treatments were tested on a group of rabbits which was homogeneous in terms of initial weight and litter size. LN X is the number of young in a litter on day X taking into account pups which died between 10 and 25 days (for LN25), between 25 and 28 days (for LN28) and between 28 and 49 days (for LN49). For sample calculation refer appendix 2.

Feed conversion efficiency (FCE) for different age periods was calculated as follows:

$$FCE25 = \frac{CF25 + DF25}{LWT25}$$

$$FCE28 = \frac{(CF28 - CF25) + (DF28 - DF25)}{LWT28 - LWT25}$$

$$FCE49 = \frac{LF49}{LWT49 - LWT\ 28}$$

where FCE25 = FCE of litter from 0 to 25 days of age

FCE28 = FCE of litter from 25 to 28 days of age

FCE49 = FCE of litter from 28 to 49 days of age

CF25(28) = amount of creep feed consumed by litter up to 25 (28) days of age

DF25(28) = amount of stock diet consumed by doe up to 25 (28) days of age

LF49 = amount of stock diet consumed by litter between 28 and 49 days of age

LWT25(28,49) = weight of litter at 25 (28, 49) days of age

The body weights of pups which died were accounted for in the values of the last variable (refer to appendix 3). Thirteen missing values for DF25 had to be replaced by calculating expected figures from the amount of feed consumed up to 28 days and correcting the values for non-linear feed intake over the time period of 0 to 28 days. For calculations refer to appendix 4.

Covariates in the analyses of variance were litter weight at 10 days of age (LWT10) and number of pups per litter at the specified dates (LN25, LN28, LN49).

Survival analyses (BMDP, 1981) were conducted for the pre- and post-weaning periods, i.e. between 10 and 28 days and between 29 and 49 days. Within each period the chance of dying was assumed to be constant. Three separate computer runs tested the effects of the four treatment combinations, of feeding regimen (R1 vs R2), and of supply of creep feed (F1 vs F0). The overall significance level was P = .05.

Body weight at 25, 28 and 49 days of age were the dependent variables in three separate analyses of variance. The general linear models procedure (SAS, 1982) was used. The testing term for regimen, creep feed supply, dam effect and their first order interactions were determined by calculating expected mean squares, assuming that "Doe" was a random effect. Initial weight (WT10) was used as a covariate in these analyses.

RESULTS AND DISCUSSION

Analysis of Feed Consumption. NZW rabbits leave the nest box for the first time at about 15 days of age (Hunt and Dunkelgod, 1981) and from then on tend to enter and leave the box frequently. No creep feed was eaten from the small troughs in the nest box (type A) up to 16 days of age (table 15a, figure 1). Very little (20 g) was consumed from the nest box feeder (type A) and the outside creep feeder (type B) until day 19 when the nest box was removed. According to the literature voluntary feed intake of rabbits starts at 14 days of age (Broadfoot, 1969) and by day 21 most of the intake is solid feed (Alus and Edwards, 1977). At the latter age the daily amount eaten varies between 10 g (Lebas et al., 1971) and 20 g (Aghina and Ladetto, 1973). The findings of the present study tend to agree with the values cited. Assuming that the average number of pups per litter was 7.5 in the present study, individual creep feed consumption up to 16 days of age was 0 g for R1F1 and 14 g for R2F1 (tables 15a, b). Up to 19 days of age the intake was 2.3 g and 12.5 g, respectively, and on day 22 the respective values for total intake were 30 g and 57 g. The higher feed disappearance in R2F1 is due to several does spilling starter diet from the type C creep feeders by scooping it out with their feet (table 15b). The adult females were unable to do the same with type A or B feeders because of differences in attachment. Thus some does showed much interest in feeders of type C but not in feeders of type A and B, a behaviour apparently copied by the young. Pups were more likely to consume creep feed if the doe tried to reach into the trough, however, differences in intake due to feeding regimen and type of feeder must be interpreted with caution as it is not possible to distinguish between feed spilled by the doe and eaten by the young.

Table 15. Litter feed consumption over time (grams)

a) Treatment R1F1

	Creep feed						Stock diet
Doe #	10D	16D	19D	22D	25D	28D	49D
1	0	0	50	100	350	850	14800
2	0	0	0	50	550	850	14580
3	0	0	0	0	200	500	11550
4	0	0	50	250	500	450	18350
6	0	0	0	0	100	250	8150
7	0	0	0	100	250	700	14450
8	0	0	50	50	100	100	12000
9	0	0	0	50	200	300	8300
10	0	0	0	0	200	600	15850
11	0	0	50	150	200	200	8200
12	0	0	0	0	0	50	16500
14	0	0	0	0	350	1050	12000
15	0	0	0	0	100	200	9800
16	0	0	0	250	700	1150	5350
17	0	0	100	600	1000	2000	15650
18	0	0	50	50	150	350	15150
19	0	0	0	0	700	750	15800
21	0	0	50	250	700	1450	18350
22	0	0	0	0	200	550	21000
23	0	0	0	0	250	750	14800
Σ	0	0	400	1900	6800	13100	270650
$\bar{x}$	0	0	20	95	340	655	13533
SD	0	0	30	149	265	486	4027

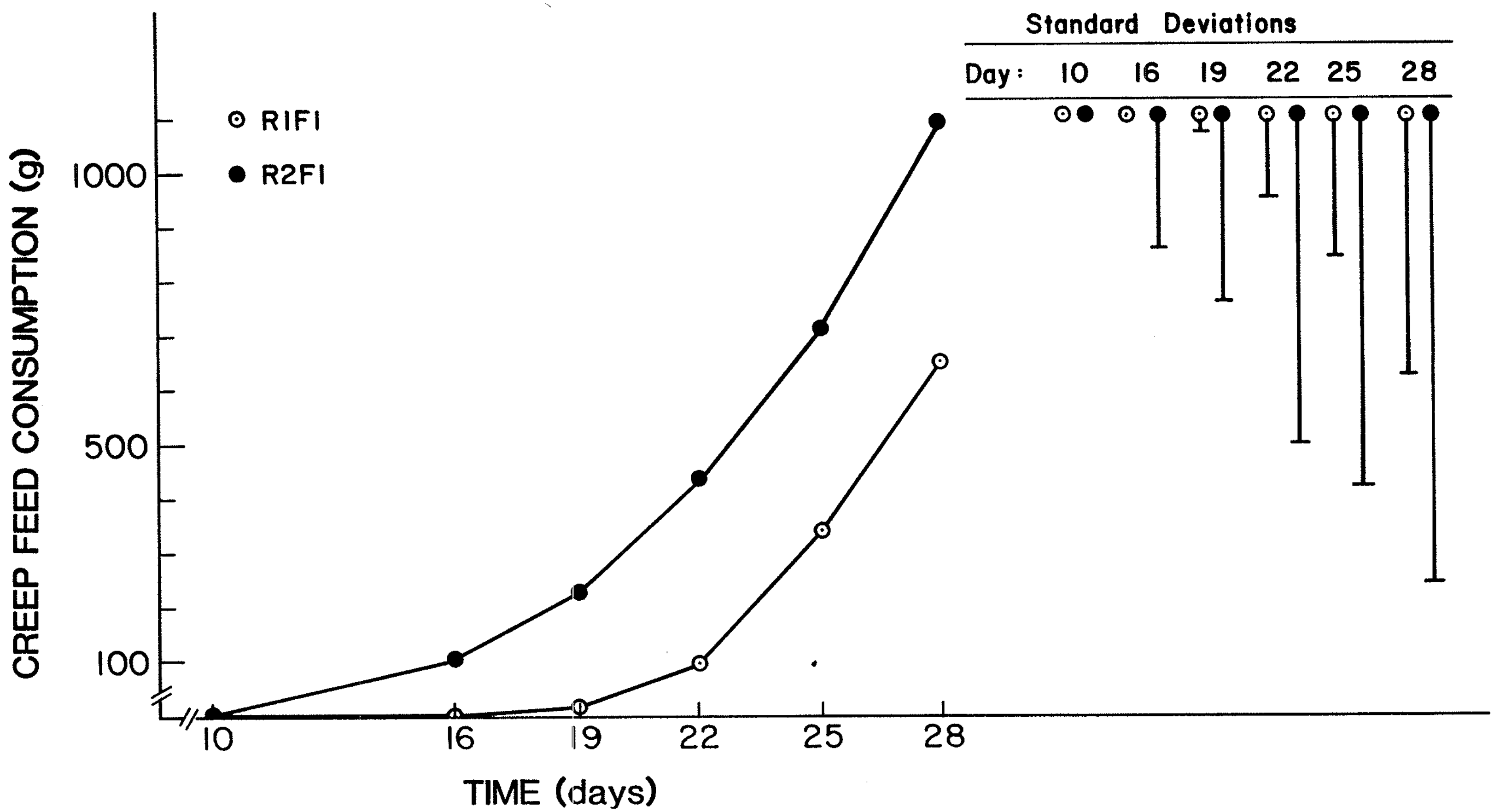
b) Treatment R2F1

	Creep feed						Stock diet
Doe #	10D	16D	19D	22D	25D	28D	49D
1	0	0	0	0	600	1200	20400
2	0	0	700	1050	1450	2200	18500
3	0	0	0	50	150	200	9600
4	0	0	00	400	800	1650	17800
6[a]	0	800	1100	2050	2550	3050	8500
7	0	0	200	300	700	1300	20800
8	0	0	50	100	300	600	14650
9	0	150	200	300	400	600	8250
10	0	100	200	300	450	600	8300
11	0	50	50	250	350	600	11250
12	0	50	50	50	50	50	15350
14	0	0	200	500	700	1400	13250
15	0	0	0	50	50	350	11950
16	0	0	50	50	200	250	9750
17	0	50	100	100	300	350	5350
18	0	0	300	600	1100	1550	19850
19	0	0	0	50	250	600	15700
21	0	0	0	150	450	850	15350
22	0	100	200	300	900	1400	20000
23[b]	0	800	1100	2050	2550	3050	19800
Σ	0	2100	4500	8700	14300	21850	284400
$\bar{x}$	0	105	225	435	715	1093	14220
SD	0	242	341	606	683	877	4878

[a]Some creep feed spilled by doe.

[b]Spillage excessive, values substituted with those of doe #6.

Figure 1. Litter creep feed consumption during the preweaning period - ad libitum feeding trial



The interaction between feeding regimen and dam (RxD) was used as the testing term for the two main effects (table 16) and was examined by graphing starter diet intake versus R1 and R2 for each female. The data for this graph are listed in table 15a, b. The plot for y = CF25 showed many line intersections indicating an important interaction. Due to insufficient replication RxD could not be tested in the analysis of variance presented in table 16. Instead, a t-test (SAS 1982) was conducted (R1 versus R2) which showed that variances of y were not equal ($P<.0001$). Therefore, the line intersections were likely due to differences in variance of y = CF25 for R1 and R2 and were likely not due to a significant interaction between feeding regimen and dam. Even though the assumption of homogeneity of variances is not met, the analysis of variance procedure in GLM using Type III sums of squares is sufficiently robust to allow for the interpretation of the main effects. The influence of the dam on CF25 was not significant ($P>.05$, table 16) while a difference existed according to creep feeding regimen ($P<.05$). Up to the age of 25 days litter intake was 370 g higher for R2 than for R1 (table 17). However, as mentioned before, this difference is mainly due to does being able to spill creep feed from feeders of type C used in R2F1 and is likely not due to a preference for a certain type of feeder.

The plot for y = (CF28-CF25) constructed from data presented in tables 15a and 15b showed many line intersections as well, thus it was necessary to test the variance in y for R1 and R2. Although the two variances were shown to be equal ($P>.05$), results are based on only three days of data collection, therefore main effects in the analysis of CF28 must be carefully evaluated. The analysis of variance (table 16) showed that feeding regimen and doe effects were not significant.

Table 16. Analysis of variance of litter feed consumption in three age periods

		Creep feed				Stock diet	
		10-25 days (CF25)		25-28 days (CF28)		28-49 days (LF49)	
Source	DF	SS (Type III)	PR>F	SS (Type III)	PR>F	SS (Type III)	PR>F
Regimen (R)	1	1334090	.020	20643	.519	1890402	.525
Feed supply (F)	1					2025846	.596
Doe (D)	19	5365768	.248	1411376	.182	114677170	.619
R x F	1					3285122	.307
R x D[a]	19	3447181		811168		85633623	.195
F x D[b]	19					132064850	.042
R x F x D[c]	17					50414560	
LWT10	1	67	.986	1884	.845	2760677	.348
LN(25, 28, 49)	1	1203460	.026	190770	.062	136639616	.0001

[a]Testing term for R and D in first two analyses, testing term for R in the third analysis.

[b]Testing term for F and D in the third analysis.

[c]Experimental error in third analysis.

Table 17. Least square means of preweaning creep feed consumption per litter for two feeding regimens

	10-25 days		25-28 days	
Feeding regimen	grams	SE[a]	grams	SE
R1	335	103	346	50
R2	705	103	392	50
$\bar{R}$	520		369	

[a]Ref. table 4.

Analysis of stock diet consumption between 28 and 49 days of age showed a significant interaction between previous creep feed supply and the maternal effect ($P<.05$, table 16), which was mainly due to an approximate .7 kg increase in feed intake of those rabbits which had been assigned to treatment R2F1 before weaning (table 18). This result supports the observation that rabbits tend to consume more starter diet if the doe was interested in the feeder. Possibly this behaviour pattern did not fade after weaning.

Analyses of Feed Conversion Efficiencies. In calculating the values for feed efficiency the assumption was made that the does did not catabolize body reserves during the lactation period as the females had not been weighed on days 0, 25 or 28. This assumption may have been valid because results of a study of New Zealand White-California White crossbred does showed that no weight loss occurred during the course of the milking period of 0 to 31 days (Partridge et al., 1983).

Feed conversion efficiency between 0 and 25 days was independent of the supply of creep feed or the creep feeding regimen ($P>.05$, table 19). FCE values ranged from 2.70 to 2.94 (table 20). The effect of the dam was also not important ($P>.05$).

Between 25 and 28 days neither doe nor creep feeder type had an effect on feed efficiency of the creep fed litters ($P>.05$, table 19). The supply of starter diet almost had a significant effect ($P =.055$). Providing creep feed worsened FCE (table 20) and creep feeders of type C (R2) were associated with a better feed conversion, whether or not creep feed was supplied. The first was due to the wastage of starter diet by some does; however, the latter finding is difficult to explain because R2 should have been associated with a higher value for feed efficiency due to wastage of

Table 18. Least square means of postweaning stock feed consumption per litter for two preweaning feeding regimens and according to previous creep feed supply

	Creep feed		No creep feed		
Feeding regimen	kg	SE[a]	kg	SE	$\bar{R}$
R1	13.2	.4	13.3	.4	13.25
R2	13.9	.4	13.2	.4	13.55
$\overline{CF}$	13.55		13.25		

[a]Ref. table 4.

Table 19. Analysis of variance of feed efficiency in three age periods

Source		DF	0-25 days SS (Type III)	0-25 days PR>F	25-28 days SS (Type III)	25-28 days PR>F	28-49 days SS (Type III)	28-49 days PR>F
Regimen	(R)	1	.081	.695	4.418	.098	.299	.388
Feed supply	(F)	1	.015	.873	4.381	.055	1.311	.084
Doe	(D)	19	17.891	.128	29.242	.203	5.446	.753
R x F		1	.589	.241	.197	.621	1.086	.145
R x D[a]		19	9.712	.306	24.723	.100	7.271	.661
F x D[b]		19	10.523	.251	19.831	.274	7.488	.639
R x F x D[c]		17	6.783		13.232		7.906	
LWT10		1	.017	.837	3.331	.054	.219	.502
LN(25, 28, 49)		1	.335	.372	.001	.970	.338	.406

[a]Testing term for R.

[b]Testing term for F and D.

[c]Experimental error.

feed in treatment R2F1.

Between 28 and 49 days of age feed efficiency was not dependent on either preweaning feeding regimen, provision of creep feed or mothering ability of the does (P>.05, table 19). Feed efficiency values ranged from 2.13 to 2.63 (table 20). As before there was a tendency of improved efficiency when no creep feed had been supplied previously.

Feed efficiency ratios found in the literature agree well with those of the present study. In a review, Lang (1981b) quoted values of 2:1 for rabbits up to 3 weeks of age and of 3:1 up to 8 weeks of age. Whether or not the first numbers included the feed consumption of the does was not mentioned. Chen et al. (1978) who accounted for the dam's feed intake gave a conversion ratio of 2.31:1 ($\pm$.08) up to 8 weeks of age for rabbits weaned at 4 weeks. Hunt and Dunkelgod (1981) observed an average feed efficiency up to 49 day of 2.48 (including does fed).

Analyses of Survivability and Body Weight. The profitability of rabbit meat production is dominated by the number and total weight of rabbits a doe can produce in a year. Thus survival analyses and analysis of body weight at 25, 28 and 49 days of age were most important. All surveys of survivability in this study between 10 and 28 days and between 28 and 49 days showed that an association with treatment did not exist (P>.05, tables 21 and 22). The single main cause for decreased survivability was enteritis. Average mortality figures in the present study were 4.5% (0-4 weeks) and 10% (4-7 weeks) which agree with those reported by Chen et al. (1978). These workers found an overall mortality rate of 7.1% for pups between 0 and 4 weeks of age and of 8.0% for rabbits between 5 and 8 weeks of age.

Table 20. Least square means of litter feed efficiencies for three age periods

a) Age period 0 to 25 days

Feeding regimen	Creep feed kg/kg	Creep feed SE[a]	No creep feed kg/kg	No creep feed SE	$\bar{R}$
R1	2.80	.14	2.94	.14	2.87
R2	2.90	.14	2.70	.14	2.80
$\overline{CF}$	2.85		2.82		

b) Age period 25 to 28 days

Feeding regimen	Creep feed kg/kg	Creep feed SE	No creep feed kg/kg	No creep feed SE	$\bar{R}$
R1	2.96	.20	2.39	.20	2.68
R2	2.39	.20	2.01	.20	2.20
$\overline{CF}$	2.68		2.20		

c) Age period 28 to 49 days

Feeding regimen	Creep feed kg/kg	Creep feed SE	No creep feed kg/kg	No creep feed SE	$\bar{R}$
R1	2.26	.15	2.24	.15	2.25
R2	2.63	.15	2.13	.15	2.35
$\overline{CF}$	2.45		2.19		

[a]Ref. table 4.

Table 21. Survival analysis[a] according to treatment for the period of 10 to 28 days

Treatment[b]	Total N	Cause of death				Survived	
		Gastritis	Pneumonia	Enteritis	Unknown	N	%[c]
R1F1	159	0	0	3	8	148	93[d]
R1F0	155	0	1	0	2	152	98[d]
R2F1	159	0	5	0	2	152	96[d]
R2F0	141	0	2	5	0	134	95[d]

[a]BMDP (1981), program 1L.

[b]For explanation of treatment combinations refer to Materials and Methods.

[c]Percentages with different superscripts are significantly different ($P<.05$).

Table 22. Survival analysis[a] according to treatment for the period of 28 to 49 days

Treatment[b]	Total N	Cause of death				Survived	
		Gastritis	Pneumonia	Enteritis	Unknown	N	%[c]
R1F1	148	0	2	9	1	137	93[d]
R1F0	152	0	0	7	1	144	95[d]
R2F1	152	0	0	13	7	132	87[d]
R2F0	134	0	1	14	2	117	87[d]

[a,b,c]Refer to footnotes in table 21.

Figure 2 shows the increase in body weight over time for each of the four treatment groups. Each point on the graph represents the arithmetic mean of body weight of approximately 150 rabbits (table 23). Average body weights at 25, 28 and 49 days of age and the analyses of variance of these three variables are shown in tables 24 and 25. Feeding regimen was not significant in terms of 25 day body weight (P>.05), although rabbits on treatment R2 were 15 g heavier on average. At 28 days of age the increase in weight of the same treatment group (R2) was 27 g (P>.05). This shows that the feed wastage from type C feeders might not have been as crucial as first assumed since feed efficiency for rabbits assigned to treatment R2 were not impaired while body weight tended to improve. However, a difference of 27 g in weaning weight represents a 5% improvement which is not significant in practice since it does not persist until 49 days (P>.05, tables 24 and 25). At the latter time weight improvement for R2 is 19 g or 1% of average body weight which is less than the value for standard error and which is therefore not important for commercial production. Despite a significant correlation between weaning weight and 49 day weight (Presch, 1983, unpublished data) or 56 day weight (Lukefahr et al., 1981) the results of this experiment show that the relationship is not important in practical terms.

At 25 and 28 days of age the dam effect was significant (P<.05, table 25). Studies have shown that body weight of preweanling rabbits is mainly determined by the amount of milk supplied by the dam (Hardmann et al., 1970) while milk production and traits such as litter weight at weaning depend partially on parity and age of the dam (Lukefahr et al., 1981). In contrast to the force feeding trials dam effect was not important at 49 days in the present study (tables 3, 5, 7 and 25). The experimental

Figure 2. Individual body weight gain during the preweaning period - ad libitum feeding trial

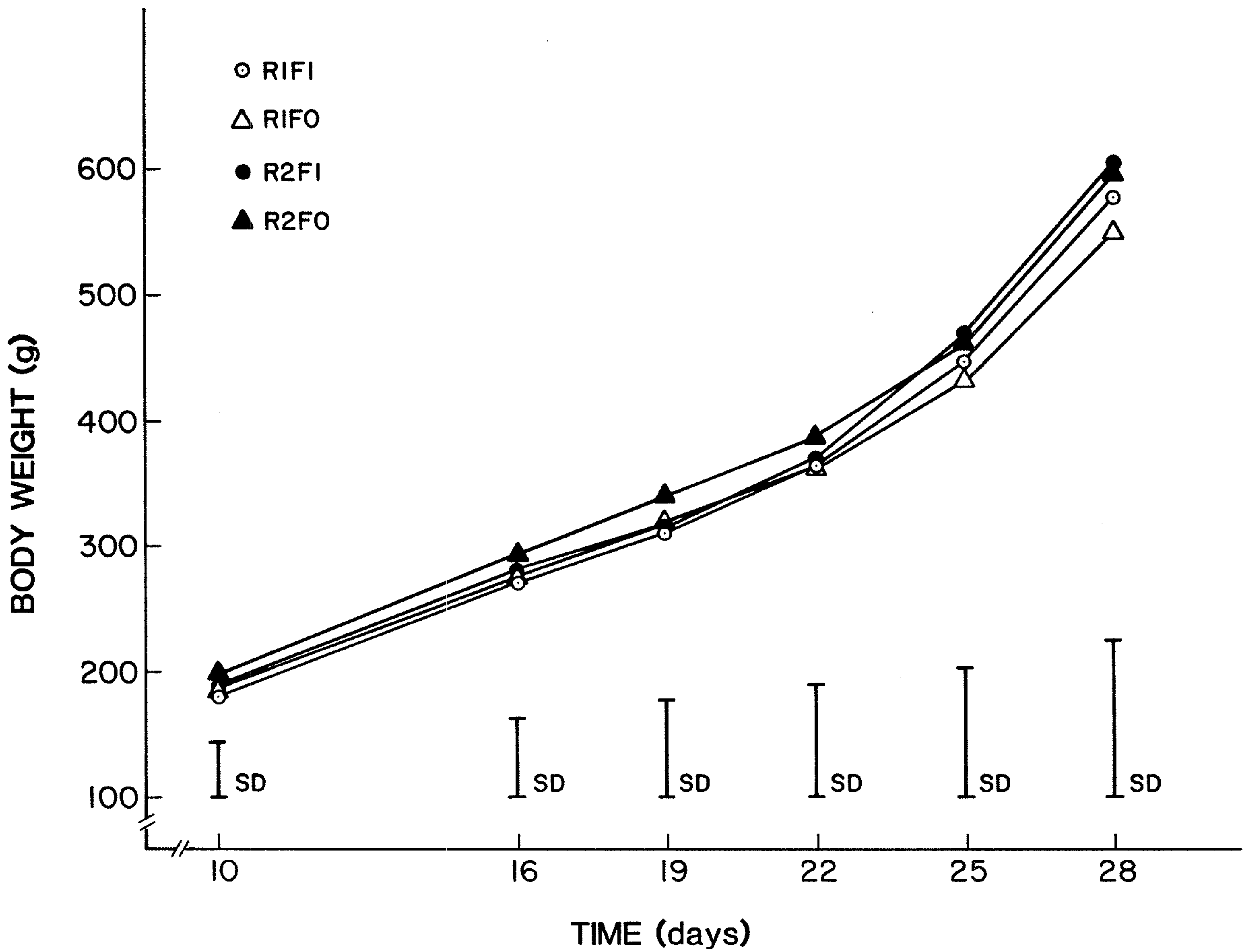


Table 23. Average individual body weight increase over time (in grams)[a]

Treatment	10D	16D	19D	22D	25D	28D	49D
R1F1							
$\bar{x}$	184	272	310	364	451	579	1429
SD	41	64	76	86	98	122	234
SE	3	5	6	7	8	10	20
R1F0							
$\bar{x}$	187	274	318	362	435	556	1420
SD	45	62	74	85	101	120	226
SE	4	5	6	7	8	10	19
R2F1							
$\bar{x}$	187	277	316	372	475	608	1455
SD	46	74	83	89	98	119	237
SE	4	6	7	7	8	9	21
R2F0							
$\bar{x}$	202	295	343	388	463	601	1494
SD	47	70	80	96	115	141	225
SE	4	6	7	8	10	12	21

[a]Arithmetic means.

Table 24. Least square means of individual body weight at three ages - ad libitum feeding trial

a) 25 days of age

Feeding regimen	Creep feed grams	Creep feed SE[a]	No creep feed grams	No creep feed SE	$\bar{R}$
R1	457	7	448	7	453
R2	479	7	457	7	468
$\overline{CF}$	468		453		

b) 28 days of age

Feeding regimen	Creep feed grams	Creep feed SE[a]	No creep feed grams	No creep feed SE	$\bar{R}$
R1	585	8	568	8	577
R2	613	8	595	8	604
$\overline{CF}$	599		582		

c) 49 days of age

Feeding regimen	Creep feed grams	Creep feed SE[a]	No creep feed grams	No creep feed SE	$\bar{R}$
R1	1438	22	1429	22	1434
R2	1439	22	1466	22	1453
$\overline{CF}$	1439		1448		

[a]Ref. table 4.

Table 25. Analysis of variance of individual body weights at three ages

Source	25 days			28 days			49 days		
	DF	SS (Type III)	PR>F	DF	SS (Type III)	PR>F	DF	SS (Type III)	PR>F
Regimen (R)	1	28040	.146	1	93570	.045	1	38532	.591
Feed supply (F)	1	36222	.061	1	37937	.114	1	9749	.764
Doe (D)	19	558914	.031	19	991033	.024	19	779029	.177
R x F	1	3726	.466	1	68	.937	1	36754	.500
R x D[a]	19	231632	.102	19	387089	.079	19	2451262	.139
F x D[b]	19	173270	.256	19	261954	.280	19	2001633	.257
R x F x D[c]	19	127696	.0001	19	199683	.0001	19	1477343	.0001
WT10	1	714741	.0001	1	968591	.0001	1	2255134	.0001
Error	507	1146991		505	1836500		449	9449013	

[a]Testing term for R and D.

[b]Testing term for F.

[c]Testing term for first degree interactions.

design of the latter was better suited for determining the dam's contribution to 49 day body weight as a replicated number of litters were tested for each doe. Therefore, the conclusion drawn here contradicts statements made in the discussion part of the force feeding trials in that market body weights likely will not improve through doe selection.

The supply of creep feed had a positive, but statistically non-significant effect on body weight at 25 days of age and by 28 and 49 days of age the effect faded (P>.05, tables 24 and 25). Weight differences were 17, 17 and 9 g, respectively. On day 49, i.e. about three weeks before marketing, the highest average body weight was 1466 grams in a group which had not received any creep feed (table 24).

The analyses of the present study demonstrate that creep feeding does not improve litter feed efficiency or cause lasting positive effects on body weight. This conclusion agrees with the one drawn earlier by Hunt and Dunkelgod (1981). Installing small troughs at nest boxes (type A) for early starter diet supply would not be economical for commercial production as these feeders do not enhance feed consumption and are not associated with significantly higher body weights at weaning. Feed spillage by some does made it difficult to evaluate the two types of outside creep feeders as far as true intake is concerned but showed that the type C feeders, which are affixed from the inside of the doe's cage, may not be practical.

The following calculations suggest that creep feeding is economically unfeasible: The number of rabbits produced annually for market by each female is estimated to be 21 for the present Canadian rabbit industry (Presch, 1983). Assuming that rabbits supplied with a preweaning starter diet keep their advantage of nine grams body weight (ref. table 23) at 49 days of age until marketing at 70 to 84 days of age and furthermore assuming that rabbits sell for $3.00 per kilogram live weight at the farm gate yearly monetary gain from the litters of one doe is $.57. If the cost of starter diet for rabbits is $340 per tonne (Hunt and Dunkelgod, 1981) and if the rabbits reared to market annually by a doe consume 2.7 kg of the creep ration[5] the feed costs ($ doe^{-1} $year^{-1}$) for starter diet alone would amount to $.93. Including the expense for specially designed creep feeders[6] the expected deficit per doe and year in the first decade is about $.96 per year at present feed and feeder prices. This analysis shows that the improvement in market weight must be greater for creep feeding to become an economical practice. A body weight increase of 116 g at 56 days, as observed by Fox and Guthrie (1968), might be sufficient; however, the authors fed the creep diet (22% crude protein) until 56 days of age. Thus, the costs for creep feed again outweigh the return for increased live weight (appendix 5).

Lang (1981a) in reviewing an article by Prud'hon and Bel (1968) found that dried milk powder (27.4% fat, 27.4% protein) might be an economical creep feed for weaning at 14 days of age. In the author's opinion supplying a starter diet may still be economical when weaning takes place

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[5]The following figures were used:
21 rabbits marketed annually from each doe
7.5 pups per litter
.9 kg starter diet consumed per litter (averaged over treatments R1F1 and R2F2 at 28 days, refer table 15a, b)

[6]$6 per feeder (type B or C), one feeder needed per doe, lifetime of feeder assumed to be 10 years.

at three weeks, but when weaning is at four to five weeks - as in the majority of commercial systems - a high quality, highly palatable single feed for both does and litters may be sufficient. The review by Lang (1981a) indicates that creep feeding of young rabbits becomes important for very early weaning since it would allow for faster rebreeding of the doe and thus a higher number of litters produced annually by each female. Under commercial conditions, however, weaning between two and three weeks of age is not yet feasible because an appropriate starter diet and sufficient knowledge in the management of very young pups are lacking. In addition, creep feeding demands an even greater input of labour in a production sector already severely deficient in mechanization.

Providing lactating does with a diet containing a good quality protein at 17% inclusion (NRC, 1977) and a high level of digestible energy (2500 kcal/kg; Lang 1981a) may allow for optimal growth of the young, not only because of the dam's improved milk yield but also because of increased feed intake by the pups compared to intake of present lactation diets. Further research should be directed towards finding a lactation ration which is most economical in terms of the weight of litters produced annually by each female. Consideration will have to be given not only to ingredients and nutrient analysis but also to pellet size and hardness and to flavoring. The tube feeding technique developed for young rabbits (refer first study) may be of use in some of the experiments.

GENERAL DISCUSSION

In the present ad libitum feeding experiment total individual creep feed intakes up to 25 and 28 days were 45 g and 87 g, respectively.[7] Only data from treatment R1F1 are used since they are more reliable. In the literature higher figures are cited. Aghina and Ladetto (1973) found that 15 to 21 day old rabbits consume 0 to 20 g of solid feed daily while pups eat 15 to 20 g per day between 21 and 35 days of age. Working with the lower figures only total intakes up to 25 and 28 days of age must have been 75 g and 120 g, respectively. In treatment R1F1 rabbits consumed slightly less starter diet up to 25 days than the force fed animals in the first study where a total of 66 g DM was intubated between days 13 and 24 (refer trial 3, study 1, rabbits intubated creep feed only). Intubated rabbits gained 24 g more than non-fed controls while the rabbits fed ad libitum (R1F1) gained 15 g more than controls. Comparing the intake levels and weight gains up to 25 days rabbits fed free choice gained proportionally as much body weight as did the force fed pups. However, force fed rabbits might have been more efficient in feed conversion as was indicated in Cohn's studies (1957, 1963). The above comparisons, including feed consumption values cited in the literature, show that free choice intake levels and body weights in the present experiment could have been higher.

It is speculated that inferior ad libitum consumption and body weight gains were most likely associated with creep diet composition and palatability. The starter diet used in our experiments contained 12.5% soybean

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[7] Refer to table 15a (treatment R1F1 only). Assume 7.5 pups per litter.

meal, 5.5% dried skim milk powder and 1% molasses. Anise oil powder had been included as a flavouring agent to enhance feed intake. Fox and Guthrie (1968) used a creep feed with similar complexity. Soybean meal (expeller) constituted 10% of the ration, yet dried skim milk powder was almost twice as high (11.5%) as in our ration. Anise oil powder was also added but Fox and Guthrie's (1968) feed did not contain molasses. The authors do not report levels of consumption; however, the observed increase in 28 day body weight due to creep feeding was the same as in the present study (17 g, refer table 24). Unless feed efficiency differed greatly between the latter two studies intake levels must have been similar.

Since a young rabbit's capacity to gain weight under normal rearing conditions is mainly limited by the amount of feed it eats (Hardmann et al., 1970), it is concluded that higher free choice intake would have resulted in higher 25 and 28 day body weights. Moreover, creep feed consumption may have been impaired by nutrient composition and palatability of the diet.

Contrary to the poor results with rabbits, major advantages of supplying piglets with a starter diet are related to early weaning. For piglets, mortality in early life was shown to decrease because of fewer losses from being crushed by the sow (Cunha, 1977). This argument is not relevant in rabbit raising. Even though unexplained early mortality in the nest box does occur, weaning at these very young ages, when the pups' eyes are still closed, is not feasible. At later ages (10 days and onward), death caused by the doe is highly unlikely since females are usually very careful with their pups.

Another advantage for supplying starter diet to piglets was the complete control over nutrients in these feeds for meeting the optimum nutritional requirements of the young (Cunha, 1977). Special reference is made to the deficiency of iron and copper in the sow's milk. However, knowledge about the nutrient requirements of suckling rabbits is limited which, in consequence, impairs the ability to devise an optimal creep feed for rabbit pups.

Supplying feed for piglets in separate feeders inaccessible to the sows is necessary in pork production since the dam will push away her young at feeding time. The behaviour of rabbits in this respect is quite different especially when feed is present ad libitum. According to our observations, does which were not on experiment (does' feeders were not elevated) never competed with their pups for feed. The young usually tried to copy their mother's feeding behaviour soon after they left the nest box. Purchasing specially designed creep feeders therefore is not absolutely necessary.

Krider et al. (1982) and Cunha (1977) suggest that creep feeding of piglets is associated with a decreased disappearance of sow feed. Our own data for doe feed intake shows that females with creep fed litters consumed on average 9.2 kg up to 25 days and 11.3 kg up to 28 days. Does with litters not supplied with starter diet consumed 8.9 kg and 10.9 kg by the respective days. Thus, creep feeding did not spare the does' diet in our study with rabbits.

The benefits of starter supply are gained from the early rebreeding of the female due to early weaning. Fox and Guthrie (1968) obtained most of their increase in profit from a higher number of litters per doe per year. The potential for increased annual production is much greater for the rabbit sector than for the swine industry since ovulation can be induced in the doe by breeding as early as one day after kindling. A female rabbit with 100% conception rate could give birth to a new litter every 46 days assuming rebreeding at 14 days, weaning at 21 days and a gestation period of 32 days. However, weaning before 28 days is not yet feasible in today's rabbit meat production system because knowledge about management of the very young rabbit is insufficient and milk replacer or starter diets are not commercially available in Canada. Moreover, producers are reluctant to wean the young before four, and often six, weeks of age or to rebreed the doe before three weeks post kindling. In pig production, on the other hand, feeding prestarter diets and weaning between three and five weeks is a widely accepted practice. The know-how in piglet rearing, the equipment and the required feeds exist in this industry, are readily available to the producer and can be used profitably under the right management. While improvements in weaning body weight (English et al.,1980) and piglet survival rate (Cunha, 1977) have been demonstrated in many studies similar improvements were not demonstrated in the present study for young rabbits creep fed ad libitum and weaned at four weeks.

The above discussion has demonstrated that creep feeding rabbits under the present weaning system (four to six weeks) lacks the sophistication and profitability of a similar program in swine production. Due to inadequate knowledge of the pups' nutrient requirements and ingredient preferences which would stimulate early feed intake it is suggested that a highly palatable and digestible lactation diet be supplied to the doe and her litter. These feeds certainly would be less expensive than creep diets. Under the present conditions of the industry such lactation diets may be a feasible compromise between enhancing the doe's milk production and encouraging early consumption of solid feed by her litter. Although the improvement in growth of the pups would not be maximal, it might be sufficient to offset the expense of feed while specially designed creep feeders are not necessary.

SUMMARY AND CONCLUSION

Two studies were conducted, the first with the purpose of developing a gastric intubation technique for young rabbits and the second with the goal of determining the benefits of creep feeding young rabbits ad libitum. The same starter diet was used in both experiments. In the first trial, force feeding of 66 g DM, between 13 and 24 days of age was found to increase 25 and 28 day body weights by 24 g and 15 g, respectively, compared to non-fed control animals. Despite physiological side effects to be expected in tube fed animals (Cohn, 1963) it is concluded that the gastric intubation method could be a useful tool in ranking different feed formulations for young rabbits.

In the second study, average individual creep feed intake was 45 g up to 25 days of age and 87 g up to 28 days (treatment R1F1 only). Body weights were 15 g and 17 g greater compared to non-fed controls at day 25 and 28, respectively. Comparing these results with those of the force feeding experiment ad libitum creep feeding could probably result in significantly increased weaning weights if intake were sufficiently high. Inadequate feed intake, assumed to be due to dietary factors, was the most probable reason for the economically unacceptable improvements in growth seen in the ad libitum feeding trial.

The merits of supplying young rabbits with a starter diet were compared to the advantages of creep feeding suckling pigs as described in the literature. In reference to the two species profitability of creep feeding depends upon differences in the present state of knowledge about nutrient requirements and management of the young, in the availability of suitable starter feeds and in animal behaviour. Creep feeding of rabbits may become important in the future if the whole rabbit meat industry assumes a more prominent role, leading to better supply of knowledge and services to this sector. As stated by Lang (1981b), feeding of milk replacers can be profitable if weaning before 21 days of age was an accepted practice. It is conceivable that under such improved conditions specialized rabbit farms would supply feed lots with weaned, 21 to 28 day old rabbits for fattening and that small increases in weaning weight could be of value.

However, with the small production units seen at present creep feeding is not economical. A high quality lactation diet may be the best solution for taking advantage of the growth potential of young rabbits for a production system which employs weaning between four and six weeks of age.

Suggestions for Further Research

Compared to other domestic species very little information is available about the nutritional requirements, feed preferences and the management of preweanling rabbits. The dietary factors that limit creep feed intake and body weight gain are largely unknown. Hence, in the context of creep feeding suckling rabbits, research in these areas is a priority.

Secondly, a lactation diet should be formulated that leads to optimal, i.e., most economical doe and litter performance. One problem that may emerge is the level of crude fibre in the diet. NRC (1977) recommendations are 10 to 12% for lactating females which may be too high for the young.

Researching the use of special creep feeds for pups should not halt because definite improvements in body weight and profits have been shown in other studies (Hardmann et al., 1970; Fox and Guthrie, 1968). If in future weaning before 28 days becomes an accepted practice, which depends to a large extent on the development of the entire rabbit meat industry, sufficient profits may be realized when feeding a high quality, well formulated starter diet prior to weaning. Attention should be given to protein quantity and quality, pelleting characteristics and flavouring to achieve maximum free choice intake by the young. At the early stages of diet research the gastric intubation method may be useful for comparing different feed formulations.

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A P P E N D I X

Appendix 1. Estimated fluid and dry matter (DM) intake per rabbit from milk and creep feed suspension (CFS) - Experiment 3

	Days of age						
	10	13	16	19	22	24	28
Mean body weight (g)	190	240	280	320	370	410	590
Doe's milk yield[a] (ml/d)	180	220	230	240	230	210	160
Milk fluid intake per pup[b] (ml)	24	29	31	32	31	27	21
Milk DM intake per pup[c] (g)	7.7	9.3	9.9	10.0	9.9	8.6	6.7
Milk fluid as % of b. wt.	12.6	12.1	11.1	10.0	8.4	6.6	3.6
Milk DM as % of b. wt.	4.1	3.9	3.5	3.1	2.7	2.1	1.1
CFS intake (ml)		10.0	17.5	25.0	32.5	37.5	
CFS-DM intake (g)		2.3	4.0	5.8	7.5	8.6	
CFS as % of b. wt.		4.2	6.2	7.8	8.8	9.1	
CFS-DM as % of b. wt.		1.0	1.4	1.8	2.0	2.1	
Total fluid intake (ml)	24.0	39.0	48.5	57.0	63.5	64.5	
Total DM intake (g)	7.7	11.6	13.9	15.8	17.4	17.2	
Total fluid intake as % of b. wt.	12.6	16.3	17.3	17.8	17.2	15.7	
Total DM intake as % of b. wt.	4.1	4.9	4.9	4.9	4.7	4.2	

[a]From data by Lebas (1968).

[b]Assuming 7.5 pups per litter as in the present study.

[c]DM content of rabbit milk assumed to be 32% (Coates et al., 1964).

Appendix 2

Sample calculation for number of pups in a litter at various ages (LN25, LN28, LN49).

Consider the record of doe #21 (appendix 3). On day 25 eight rabbits were alive. Each one of them had spent 15 days on the experiment (from 10 to 25 days of age), while rabbits #5, #7 and #9 had spent only 11, 6 and 7 days on trial, respectively. Adding up the total number of days all rabbits were on test and dividing by the number of days of the testing period one arrives at the following average number of pups per litter on day 25:

LN25 = (8x15 + 11+6+7):15 = 144:15 = 9.6

Similarly,

LN28 = (8x18 + 11+6+7):18 = 9.3

The numbers are decreasing in value which represents the decreasing influence of a rabbit on its litter mates' performance the longer it has been dead.

For LN49 only those rabbits which died between 28 and 49 days of age were considered, assuming that the effect on others by a litter mate which died preweaning would not last past day 28. Also, LN49 was only used in analyses of variables which measured some performance trait between 28 and 49 days of age. In the present example, LN49 equals 8. Supposing rabbit #2 had died on day 35 the equation for LN49 would have been,

LN49 = (7x19 +6):19 = 7.3

Appendix 3

Sample calculation for litter weight at various ages using a record from doe #21 (treatment R2F1).

	Body weight (g)						
Rabbit #	10D	16D	19D	22D	25D	28D	49D
1	190	268	322	382	466	620	1360
2	178	238	292	342	450	590	1410
3	150	237	257	307	425	560	1360
4	160	205	219	278	370	500	1210
5	104	159	133	(-----------	180	-------------	)
6	176	208	246	295	364	520	1250
7	142	(------------------	199	------------------	------------------	------------------	)
8	194	282	326	383	485	560	1370
9	124	110	(----------------	124	----------------	----------------	)
10	110	167	235	288	372	510	1250
11	136	203	233	304	442	570	1425
Actual X	151	208	251	322	422	554	1329
Total	1661	2279	2582	3079	3879	4935	11135

#5 died on day 21

#7 died on day 16

#9 died on day 17

Since a dead rabbit was not weighed before disposal its body weight on its last day of life must be estimated on basis of its litter mates' weight. For example, rabbit #5 died on day 21. The average daily gain of its litter mates between days 19 and 21 was (322-251):3=71:3=23.7 (grams). Thus the calculated weight of #5 on day 21 is 133+(23.7x2)=180 (grams). Similarly, the body weights of rabbits #7 (on day 16) and #9 (on day 17) were calculated to be 199 and 124 grams, respectively. These values are included when determining the total litter weight at various ages (refer above table).

Appendix 4

Calculating replacement values for missing data on the doe's feed consumption between kindling and day 25 (DF25)

Doe #	Litter #	DF28	Calc. feed cons. 25 to 28 days	DF25 calculated	DF25 corrected (D25 calc.-804 g)
3	3	8650	927	7723	6919
3	4	8600	921	7679	6875
4	3	13600	1457	12143	11339
6	3	13800	1479	12321	11517
11	1	10400	1114	9286	8482
11	2	10900	1168	9732	8928
14	3	11650	1248	10402	9598
15	2	12700	1361	11339	10535
15	3	8450	905	7545	6741
16	3	4750	509	4241	3437
16	4	6800	729	6071	5267
18	3	17750	1902	15848	15044
18	4	13900	1489	12411	11607

$\bar{X}$ = 9749

Calculation of correction factor:

1. Data from all does with full records were used as above to calculate from consumption at 28 days the expected consumption at 25 days. The average value for calculated doe feed consumption at 25 days was 9917 grams.
2. The average of the calculated 25 day consumption of does with missing records was 9749 grams (refer above). This calculation assumes linearity of feed intake over time.
3. The average of 25 day consumption from the actual data from does with full records was 9113 grams.
4. For does with complete records the difference between calculated and actual levels of feed intake up to 25 days is 9917 - 9113=804 (grams).

Continued ....

Appendix 4 (Continued)

5. Assuming that those does with incomplete records would show a similar difference between actual and calculated values the correction factor for the above calculated 25 day figures is minus 804 grams, i.e. the calculated consumption values are over estimations.

Appendix 5. Feasibility of feeding creep diet (22% crude protein) until 56 days

Body wt. improvement/animal at marketing[a]	.116	kg
Body wt. improvement/litter up to marketing[b]	.870	kg
Body wt. improvement for 3 litters per doe per year[c]	2.610	kg
Return for 3 litters marketed per doe per year[d]	7.83	$
Creep feed consumed/litter (10 to 28 d)[e]	.900	kg
Creep feed consumed/litter (28 to 49 d)[f]	13.400	kg
Estimated creep feed consumed/litter (49 to 56 d)[g]	4.690	kg
Total creep feed consumed/litter (10 to 56 d)	18.990	kg
Total creep feed consumed by 3 litters (per doe per year)	56.970	kg
Cost of creep feeding 3 litters per doe per year[h]	19.37	$
Cost of creep feeder per doe per year[i]	.60	$
Cost of feeding per doe per year	19.97	$
Return from body wt. improvement	7.83	$
Net profit	-12.14	$

[a]Body wt. improvement of .116 kg from creep feeding until 56 d (Fox and Guthrie, 1968) is assumed to be retained until marketing at about 70 to 84 days of age.

[b]Assumes 7.5 pups per litter.

[c]Number of pups marketed annually from each doe estimated to be about 21 (Presch, 1983).

[d]$3.00/kg live wt.

Continued ......

Appendix 5 (Continued)

[e]Average of treatments R1F1 and R1F2 (table 15).

[f]Assumed to be the same as average stock feed consumption (28 to 49 d) in present study (table).

[g]Estimated from average stock feed consumption (28 to 49 d) in present study.

[h]$340/tonne of creep feed (Hunt and Dunkelgod, 1981).

[i]Cost of creep feeder is $6.00, one feeder needed per doe lifespan of feeder estimated to be 10 years.